Editors:
Peter Stebbing
Ursula Tischner

CUMULUS THINK TANK
Publication No 1 of the Think Tank Series from the Cumulus International Association of Universities and Colleges of Art, Design and Media

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Part 3

For Tristan Maurer and the Youth of the World.

The future doesn't just happen – we create it every day.

Peter Stebbing & Ursula Tischner

Preface

At the Bratislava Cumulus Conference in 2007 one of us (Peter) had what might be called an "epiphany" experience during a presentation on car design. Consequently, I asked Eija Salmi, the Cumulus Secretary General, if I could initiate a Sustainability Working Group for future Cumulus Conferences. The first Working Group meeting aptly took place at the following conference in Kyoto, 2008. Since I knew few people who could contribute to the Working Group I asked Ursula Tischner, an expert in design for sustainability with a worldwide network of contacts, for help. As a consequence it was possible to create a program of presentations half of which were given by Japanese experts. Subsequently, we have had a lot of fun organizing and running the Sustainability Working Group programs together up to my retirement from the Hochschule für Gestaltung, Schwaebisch Gmuend.

In the autumn of 2010 the newly elected Cumulus Executive Board made the initial decision to publish a text on design for sustainability for use by both art and design students and teachers on Bachelor and Master courses. As a member of the Cumulus Board I was asked to bring the project to realization and so I promptly invited my friend and colleague, Ursula Tischner, to co-edit the publication with me. Ursula has enormous practical experience of design for sustainability, running her own agency, econcept, for sustainable design; in addition her experience includes having worked at the renown Wuppertal Institute for Climate, Environment and Energy. We agreed that she would focus on *how* to do design for sustainability (Part 2) while I would concentrate on the reasons *why* we must design for a sustainable future (Part 1) and we would both invite experts to contribute chapters. It has taken a long time, but now that we are finished I would like to particularly thank Ursula for working together with me on this exciting and we believe important project. She had the excellent idea to show-case sustainable design projects by students and we had a very large number of submissions from which we could only include a selection of 20 projects (Part 3). Together, Ursula and I would like to thank all the students for submitting their work and enrichening *Changing Paradigms*.

We would especially like to thank all our colleagues who have generously contributed chapters and to whom we are enormously grateful, they are:

Prof Dr Daniel Barcza & Bori Feher,
Moholy-Nagy University of Art and Design, Budapest, Hungary
Prof Scott Boylston
Savannah College of Art and Design, USA
Anamika R Dey, PhD Student & Prof Dr. Anil Gupta
Indian Institute of Management, Ahmedabad, India
Jose Gamboa
Slingshot Product Development Group, Sketching Lab, Gamboa Designs, Costa Rica
Prof Ezio Manzini,
University of the Arts London; Politecnico di Milano; DIS; DESIS Network
Prof Dr Dr F.J. Radermacher
Forschungsinstitut für anwendungsorientierte Wissensverarbeitung, University of Ulm, Germany
Prof Dr Armin Reller & Joshena Dießenbacher
Institute of Physics, University of Augsburg, Germany
Prof Dr Johan Rockström
Stockholm Resilience Centre, Sweden
Prof Dr Elizabeth B.- N. Sanders
Design Department, The Ohio State University, USA
Prof Dr Vandana Shiva

The Research Foundation for Science, Technology and Ecology, Dehra Dun, India
Prof Dr Cameron Tonkinwise
School of Design, Carnegie Mellon University, USA
Prof Dr Arnold Tukker
Department Industrial Ecology, Leiden University, Holland
Prof Dr Detlef Virchow,
Centre for Development, University of Bonn, Germany
& The Royal Society Population Working Group, London

In their chapters they freely share with us a wide range of insights, knowledge and experience focusing on achieving a sustainable future. The origination of the book has been done without a budget and so we are deeply indebted to the authors for their contributions.

Since the project's inception in 2010 our world has substantially changed and more than we would want to dare imagine and developments have occurred at an increasing rate. Every week the press brings further news about the environment, climate and sustainability. We have tried to integrate these developments where they have been relevant, but keeping up to date has been a continual process and would mean never finishing. Consequently, information and examples in some chapters may already have been superceded by more recent information. More importantly, we hope that this work reveals at least some of the underlying principles of our problems and strategies for solving them so that we can more easily progress towards achieving a sustainable future.

Sustainability permeates our entire existence and virtually every decision and action we make has an impact on the environment somehow, somewhere, sometime; whether we use a linen handkerchief or a paper tissue or whether we take the plane or the train. This is because our planet is more deeply interconnected than we can perceive. Sustainability is not a subject which can be taught as an add on module to the curriculum. It must permeate the entire curriculum as it does our lives. We hope that the wealth of information collected here will bring the realisation that to live sustainably is more an attitude of mind, possibly a philosophy, rather than a mere collection of facts learnt today and possibly forgotten tomorrow.

Readers may find some repetition occurring between chapters, however, we believe that this is necessary so that that the chapters can be read standing alone and complete within themselves. Furthermore, in Part One there is much reference to what is happening in the UK, this is not so much a bias but rather a source of specific examples to what is happening, much elsewhere and which is either sustainable or unsustainable. Furthermore, many quotes are cited from experts and others. Great care has been taken to ensure that all our sources are provided so that students and lecturers can easily refer to the original articles to further their own researches. We hope all our readers will find that Changing Paradigms provides a holistic starting point for learning about sustainability.

What you will find in Changing Paradigms: designing for a sustainable future:
The book is simply organized into five parts which address:
Part One: Why we must design for a sustainable future
Part Two: How to design for a sustainable future
Part Three: Student Case Studies of Sustainable Design
Part Four: Glossary of over 100 terms and concepts
Part Five: Appendices

Part One: Why we must design for a sustainable future
Part One emphasises the shift between two paradigms in design and the necessity to move from the old unsustainable, commercially defined design paradigm to a sustainable paradigm defined by the limitations of the planet. We learn how the entire planet is being placed under enormous, unsustainable pressures from Johan Rockström, but that fortunately, science is able to tell us what is happening so that we now know we must change our ways. Detlef Virchow analyzes the major pressures on agriculture which threaten our food security including the political and human rights aspects. Armin Reller and Joshena Dießenbacher review our wasteful dissipation of resources embedded into all manner of products. They describe the concepts of material histories and criticality as strategies needed to move towards circular economies for our use of resources. Vandana Shiva addresses the interaction between poverty and economics and how the measure of gross domestic product, GDP, is destroying the environment and societies in developing nations together with the problem of trans-national corporations. The final guest contributor to Part One is Franz Josef Radermacher who promotes an eco-social programme resulting from the marriage of a market economy with sustainable development to create an eco-social mar-

ket economy. Finally, in Chapter 13 we are grateful to the Royal Society, London, for giving us permission to include the summary of its People and the Planet report. The report emphasizes that population growth per se is not the core problem for the future but its combination with "*unprecedented levels of consumption*" required by our increasing numbers. Other chapters (Stebbing) on Ecosystems and Biodiversity, Water, Energy and Pollution attempt to provide an holistic perception to our problems because of their interconnectedness. Finally, the Conclusion (14) selects just nine meta-subjects for contributing to systemic change.

Part Two: How to design for a sustainable future

In Part Two readers will find the pragmatic information on how to design sustainably. The authors take us from the systems perspective (Scott Boylsten and Arnold Tukker) over radical innovation for Sustainability (Cameron Tonkinwise and Liz Sanders) to the realm of designing for sustainability and how to influence consumer behaviour by design towards more sustainable lifestyles (Ursula Tischner and Tischner & Stebbing). Then Ezio Manzini discusses the social dimension of sustainability and how it can be improved by design and innovation, and Anil Gupta introduces strategies to include low-income groups (the so called base of the pyramid) in a mutually beneficial way in design and innovation for sustainability. How design can work for disaster relief and management is discussed by Daniel Barcza & Bori Feher and finally Jose Gamboa introduces a craft based design approach focusing more on developing countries.

Across the chapters in both Parts One and Two there will be found some repetition in the material because firstly, everything is interconnected so that often the same points of reference criss-cross the chapters. Secondly, each chapter can be read as a stand alone chapter because we expect that our book will be read largely as a work of reference.

Part Three: Student Case Studies of Sustainable Design

Part Three presents many examples of student design projects. We believe that readers will find these both inspiring and instructive to see how students are applying the principles of sustainability and integrating them into their design practice.

Part Four: The Glossary

The Glossary is designed to provide complementary information to Parts One and Two and will take the reader to some of the 'outposts' of sustainability. It is a source of reference which we hope will enable our readers to perceive how sustainability is deeply interconnected into the Earth's fabric of which we are an integral part. As John Muir (2004) wrote in 1869 in his My first summer in the Sierra:

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe." We hope that the Glossary will stimulate and provide many points of departure for further investigation by students. The entries are also partly, but not completely, cross referenced and by no means is the Glossary comprehensive; a comprehensive glossary for sustainability would be encyclopaedic. This glossary is more a 'taster,' possibly for future enlargement.

Part Five: Appendices

The Appendices include The Kyoto Design Declaration which members of the Cumulus Executive Board signed in 2008 in Kyoto committing Cumulus to work towards a sustainable future. The remaining two appendices provide information as starting points for *Greening the Campus and Greening the Conference* and to which, we as educators, must all conform if we are to be consistent with what we teach. Conferences have an enormously heavy eco-footprint with delegates travelling from all over the world.

Two versions of this book

This publication is available in a print version that includes Part 1 and Part 2 as well as Part 5, and in a PDF version that includes all of the chapters and annexes. The PDF version can be downloaded for free from the Cumulus Website via this link: http://www.cumulusassociation.org/category/academics/special-publications/

Part 1

Why we must design for a sustainable future?

Peter Stebbing

1 Raison d'etre

> *"Existing institutions have ceased adequately to meet the problems posed by an environment that they have in part created."* Thomas Kuhn, 1971

1.1 What is the Cumulus Association?

Cumulus is a rare example of an association that is very much needed today, more so than perhaps its members realize. Design and art education fosters the creative and innovative potential of young people for solving a gamut of problems from the simple to the 'wicked' for the benefit of others. Never before has the World needed the human resources of innovation and creativity as much as it does today.

The Cumulus Association is an international organization with a membership of more than 200 design and art schools and universities from all around the World. The Cumulus Association's biannual international conferences facilitate the networking of its members and foster international collaborations and projects at the grass roots level between students and lecturers from different schools. Simultaneously, Cumulus possesses international creditability at both political and even at ministerial levels. Inherent in both the design and art fields and the Cumulus Association is a powerful innovative potential combining multi-disciplinary, inter-disciplinary, and international cooperation. The Cumulus Association is an art and design education community concerned, not merely with the education of students, but also with imbuing them with sustainable stewardship and care for our future environment. There can be no doubt that design and art already has a crucial role to play in creating the equitable and sustainable fulfilment of both human needs and environmental welfare.

1.2 The unique value of the Cumulus Association

"Energy, food, and water crises; climate disruption … are examples of serious, intertwined global scale challenges spawned by the accelerating scale of human activity. They are outpacing the development of institutions to deal with them and their many interactive effects. The core of the problem is inducing cooperation in situations where individuals and nations will collectively gain if all cooperate, … International institutions primarily focus on single problems, ignoring system-wide interactions." Walker and his colleagues (2009) in their paper published in the journal Science, *"advocate a renewed focus on effective cooperation … we need greater interaction among existing institutions, as well as new institutions, to help construct and maintain a global scale-social contract."* The Cumulus Association is an exception to the worldwide lack of globally active organizations, and it is simultaneously capable of fostering cooperation for and while addressing the complex problems now affecting our planet.

The Cumulus Association is superbly positioned to meet the deficits described in Walker, et al.'s lament. *"Serious global environmental problems can only be solved and a collapse avoided with an unprecedented level of international cooperation"* endorse Paul and Anne Ehrlich (2012), experts who have worked on the sustainability of mankind's future for over 40 years. Cumulus offers a well established and experienced platform for creating and fostering international collaborations in many dimensions for solving multi- and interdisciplinary problems. Furthermore, it can recruit the enthusiasm, energy and innovation of young people from all over the World. If one might be excused for hijacking the words of Ehrlich, Karieva, and Daily, (2012) *"Securing natural capital and expanding equity to rescale civilization"* Cumulus has *"tremendous potential for innovation and real-world implementation in university partnerships with non-governmental organizations (NGOs), community organizations, government agencies and, increasingly, human development organizations and businesses internationally. In many cases what is needed are boundary insti-*

tutions that serve to link science and public policy" (Miller, 2001) and we can add design education and design.

1.3 … and there is design education

Design education is increasingly concerned with system wide problems and has a crucial role to play in contributing towards mankind's sustainable development on the Earth. Sustainability should become an integral component of design education and the profession because design decisions always interact with and impact on: our material resources, water and energy, climate change, food production, nature, and ecosystems. Therefore, implicit in the concept of sustainability is the 'husbandry' or 'stewardship' of the Earth's resources and the biosphere rather than their wasteful exhaustion. Design is ostensibly concerned with the improvement of human welfare. Unfortunately, we now know that since everything is so interconnected, the drive for the goods and services which are supposed to improve human welfare and provide healthy economies are achieving the opposite (Hertwich, 2012). They are causing the deterioration of the world's biosphere and now threatening human welfare. The paradox in which design finds itself was precisely formulated by Theodor Adorno (2006) when he wrote *"There is no right life in the wrong one."* This is because the over-riding anomaly confronting design is the context within which design exists. It is the "wrong one". It is the lethal combination of the western-style brown-economy driven by neo-liberal capitalism and its sacred cow, the de-regulated 'free market' (Ahmed, 2010) for nourishing the consumer-society. The situation for design education now is an enormous challenge as it makes the transition to teaching sustainable design which is a contradiction within the neo-liberal consumer capitalist economy. Unfortunately, globalization means that the neo-liberal consumer capitalist economy has become the economic model for virtually all other cultures with the notable exception of Bhutan (Kelly, 2012).

Sustainable design and a sustainable future are no longer a matter of debate (as was falsely created about climate change (Brulle, 2013)) it is the most pressing necessity, an urgent challenge. Many, but by no means all, design schools and universities have correctly embedded the teaching of sustainability into their design courses along with the traditional core subjects of form and function, ergonomics, colour etc. A number of design schools and universities have 'greened' their campuses and administrations to reduce their institutional footprint. Unfortunately, however there are still design schools which teach sustainable design as if it were an optional module and still have to green their administrations.

1.4 The aim of our text

Our World is now changing faster than education is able to respond with new approaches and courses needed by students. Our overall aim is to accelerate the integration of sustainability into the design curriculum and stimulate the greening of educational institutions as examples of practicing sustainability. Sustainability cannot be taught as an optional module because it changes the fundamental nature of design from the inside, from its foundations. This is because sustainability is an holistic subject embracing every aspect of our lives. So the daily choices we make can be more or less sustainable. We have deliberately brought together many topics not usually included in design books, such as the issues of: water, energy, pollution, resources, disasters, biodiversity, population, poverty and food security, economics and politics etc. This is because it is useless to solve a problem in one context while unconsciously exacerbating problems in other areas such as pollution, resource exhaustion, CO_2 emissions etc. The specialist approach which has dominated western education is inadequate (Orr, 1992; Ehrlich & Ehrlich, 2010; Ahmed, 2010). We must also approach our problems with an holistic perception in order to achieve sustainable solutions. We now understand that our world is deeply interconnected through webs of relationships, many in ways which are simply not apparent to us or which we have not evolved to perceive.

Our aim is also to communicate the highly interconnected character of our world; not merely between the interacting social and economic systems but also the biosphere. This is because human activities impact on the interconnected geo-physical, chemical, and biological systems within the biosphere on which our survival depends. We need an holistic understanding of the intimate interactions of our planet so that we can treat it with greater care, respect, and caution, especially because its complexity exceeds our knowledge.

Our problems are urgently real for simple and logical reasons:

- Everything is finite.
- Our accelerating exponential demands are destroying our life support systems. A phenomenon which has been called The Great Acceleration (Steffen, et al, 2015; Steffen, et al, a. 2015).
- The interdependence of many of the Earth's natural systems means that they affect each other and consequently our future security.
- Furthermore, scientists know that a significant number of the Earth's systems (ice caps, ecosystems etc. (Kemp, 2005)) have tipping points; but no-one (not even the scientists) knows exactly how near we are to some of them. Should those tipping points be reached, systems can rapidly change into unknown and alien regimes. (Indeed, the Arctic ice cap already appears to have passed its tipping point (Pearce, 2012). The West Antarctic Ice Sheet, WAIS, has now started to melt (Joughin et al, 2014; Rignot, E. et al. (2014)) and ocean warming is causing the methane hydrates on the sea bed to melt and release methane along the east coast of the USA (Phrampus, Hornbach, 2012) and in the Arctic.)).
- the more we are able to mitigate our problems now then the safer, easier and cheaper it will be to adapt to the future consequences (Stern, 2007; IPCC, 2014). There have been consequences from our unsustainable ways and more consequences will follow. Therefore, there is a need for mitigative design, adaptive design and resilience design as broad systemic strategies.

In moving towards a sustainable future the range of design topics is infinite because sustainability touches every aspect of our lives. Design is needed for future challenges and problems associated with recycling and disassembly, food and water security, pollution, energy supply, sea-level rise, weather extremes, resource exhaustion, etc. Consequently, design education must develop curricula for mitigative design (which creates no knock-on problems such as CO_2 emissions, waste, etc.), adaptive design (which responds to the needs resulting from problems such as global warming, sea level rise etc.), and resilience design (enabling communities to withstand perturbation etc.). These and other approaches to design will not be financed by commercial commission driven by the short term profit (i.e. neo-liberal capitalism) but must be financed by public money and government agencies. For example, the damage caused by flooding requires government (tax payers') expenditure, however, if governments funded mitigative design then expenditure could be reduced. The fact that climate change and its consequences are 'externalities' of commercial activity will necessitate new ways of thinking about design activity.

In the last century problems and crises usually occurred singly with relatively eventless intervening periods and we had the resources to deal with them. In this century due to our increasing demands (Steffens, et al, a. 2015) we can anticipate problems exacerbating one another and occurring simultaneously. This is due to the interconnections between climate and food production, between food production and fossil resources, between oil and energy acquisition and transport, between transport, logistics and manufacturing, between manufacturing and resources, between gas and water supplies etc. These interactions make our complex global system vulnerable to a crisis in one area but exponentially so if two crises occur simultaneously. We need solutions for *'trans-disciplinary problems'* and many of these will lie in the field of design for social innovation, resilience and security.

Never before has the future been so unknown. This is because it is physically impossible for the current neo-liberal growth economy to continue for many more decades on our finite Earth. We live in enormously challenging and exciting times demanding: unlimited innovation, scientifically based anticipation, design solutions to complex and wicked problems, design for social change and innovation, and above all care and stewardship which will repair and increase the Earth's ecosystems and natural capital.

Albert Einstein is attributed with saying: *"The world will not evolve past its current state of crisis by using the same thinking that created the situation."* The aim of the chapters in the *Why* section is to draw attention to the impossibility of continuing our consumption of the planet and to stimulate new ways of thinking and for discovering new ways of being which are fulfilling and enjoyable for us and for those to come.

In conclusion, our primary aim is to contribute to an holistic perception which will lead us all to the same conclusion: to live and design sustainably. Henry Ford is reputed to have said about his car production: *'You can have any colour you want, so long as it's black.'* Our choice is similar: you can have any future you want so long as it's sustainable.

1.5 Sustainability redefined

We must begin by defining sustainability. The reality is that as the world population continues to grow on a planet with finite resources it compels us to do more with not merely the same but with continually less. In *Our Common Future* the Brundtland commission published a definition of sustainable "*... development that meets the needs of the present without compromising the ability of future generations to meet their own needs*", (World Commission on Environment and Development, 1987). However, we follow the quite recently revised definition of sustainable development which is the *"development that meets the needs of the present while safeguarding Earth's life support system, on which the welfare of current and future generations depends"* (Griggs, et al, 2013). The reason for adopting the revised definition is that the care of our life support system is paramount for our continued social, cultural and economic development and existence. Let us remember that there are ecosystems without economies but there are no economies without ecosystems.

1.6 Sustainability re-visualized: Economic, social, and environmental sustainability are not pillars but a trophic energy pyramid

We also adopt Griggs and colleagues (2013) new visualization of the UN's paradigm of the three pillars of sustainable development: economic, social or cultural, and environmental. (Also known as the triple bottom line.) The problem with the UN concept of 3 pillars is its inadequacy because it suggests that the three pillars are stand alone entities independent of their relationship to the other two columns supporting the table top on which human sustainable welfare rests.

Griggs and his team (2013) propose that the three entities are interdependent nested entities (as some others have also supported (e.g. Birney, 2014)) with economic sustainability nested within and dependent on social sustainability which is nested within and dependent on environmental/ecological sustainability. Indeed, this visualization is similar to the pyramid of trophic levels that exist in nature with energy passing up through the layers of the system. In nature's trophic pyramid the base layer is composed of the primary producers, plants (net primary producers: NPP), turning sunlight into biomass (on which we too all are ultimately dependent). The next layer are the herbivores and the next the carnivores and finally the top predator carnivores. Each layer towards the top becoming fewer in number being dependent on the layer below for its energy. The Griggs et al (2013) visualization of nested (trophic) layers accurately visualizes our situation and makes clear how we must take much greater care of the layer on which we all ultimately depend – Nature and ecosystems and without which there can be neither a society nor an economy.

1.7 Positive Impact Design

Design for sustainability has been concerned with reducing a design's ecological impact on the environment so that it requires less of the Earth's resources and energy. This means that a design should have the smallest possible impact (measured by the eco-footprint (Wackernagel & Rees, 1996) and eco-rucksack (Schmidt-Bleek, 2008)). However, it is still a deficit, albeit a smaller one. Designers all over the world are (hopefully) reducing the impact of their designs on the biosphere by designing more sustainably. However, since we are already deep in debt to Nature (for example, in 2014, the date when humanity exhausted nature's annual productivity budget for the year 2014 was on 19 August. After this date we were in "overshoot" (see Glossary) and consuming our natural capital (Global Footprint Network, 2014). Consequently, "sustainable" design, by making smaller withdrawals (if only we all were) from Nature's resources will still increase our debt of Natural capital albeit more slowly. The global design challenge that we all have to solve is: *how can we design (and live) and increase the Earth's natural capital?* A strategy which I call positive impact design (PID). A term which has been already used in other contexts but, I believe, not exactly in this sense. I define positive impact design as increasing the Earth's natural capital while designing, i.e. there must be more "nature" after the design than there was before the design. In the Hindu tradition of yajna (meaning sacrifice) *"If you take a tree to build you're your house, you must plant five trees for the future."* (Prime, 2002) Furthermore, *"The best thing is to take as little as possible."* Critics will claim that this cannot be done – nonetheless, we need to replace the current system (old paradigm thinking, see Chapter 2) with a truly sustainable one. Again, let us remember what Albert Einstein is supposed to have said: *"The world will not evolve past its current state of crisis ..."* Continually debiting Nature has no future. If we are overdrawn at the bank and in debit and have to make a with-drawl – however small, our debt gets bigger. We must fundamentally rethink how we design because we have to bring about systemic change.

It is calculated that we are already over-consuming the Earth's replenishable resources by 50% (or in other words we need 11/2 Earths to live as we do now (Ehrlich & Ehrlich, 2013)). We may understand this another way: *"we are in an ecological overshoot situation: it is taking 1.5 years for the Earth to fully regenerate the resources that people are using in a single year. Instead of living off the interest, we are eating into our natural capital."* (WWF, 2012) Our consumption is diminishing the natural capital that produces the annual provision of resources. Furthermore, additional natural resources will be required for an estimated 2 billion people who will have joined us by 2050! The attitude that *"natural resources are limited, and I need to take them before the're gone"* expressed by one billionaire business man (Juniper, 2013) is threatening our very future.

Second to Nature, the greatest resource that we possess is human creativity. How can we work with this resource for both human and environmental welfare to create a sustainable future? The good news is that the transition from the old paradigm (in which design played a significant role in contributing to neo-liberal capitalism economics and eco-system-depleting consumerism) to a new paradigm (focusing on design for human welfare and a caring Earth stewardship) has already begun. Furthermore, communication/digital technologies offer exciting possibilities for new sustainable and social infrastructures and the potential for maximizing cooperation, not merely between peoples but also reconnecting people and nature. The paradigm transition is fully addressed in the next chapter.

The need and responsibility for design, creativity and innovation has never been greater. Consequently, this book, *Changing Paradigms: designing for a sustainable future*, is as much about design for sustainability as the future of design itself. We must complete the paradigm change as soon as possible. Design has always been about developing new ways of thinking and doing. However, a key to the new thinking in design will be the recognition that "*As mounting research shows, the stable functioning of Earth systems – including the atmosphere, oceans, forests, waterways, biodiversity and biogeochemical cycles – is a prerequisite for a thriving society*" (Griggs et al 2013) and economy. We can no longer ignore the foundation of our existence: Nature.

1.8 Sustainability handicapped by the educational gap

The western academic tradition is one which the splits knowledge into ever smaller specializations which is one of the fundamental causes of our slowness in reacting to our problems. In 1959 C.P. Snow gave a lecture at Cambridge University entitled *"The Two cultures and the Scientific Revolution"* which caused an academic stir at the time. Snow drew attention to the cultural divide between science and literature or, we might say, 'the arts' and the separation between scientists and non-scientists and the mutual ignorance of each group of the other's field. *"This polarization is sheer loss to us all."* (Snow, 1993) and has never been resolved. However, Snow was not only merely concerned about *"how rich countries should help the poor; he was asking how the planet was to be fed and what hopes for mankind the future held"* (Collini, ed. in Snow, 1993). He was concerned that we are *"losing our sense of the future, living more and more in the existential moment, we lack a model of the future"* (Thale, 1964).

Fifty years later Snow's torch was taken up again by Paul and Anne Ehrlich (2010) in a paper entitled *"The culture gap and its needed closures"* in which they describe how individuals of advanced societies possess even a billionth of the information possessed by the society as a whole. Their concern is that *"critical parts of the gap must be rapidly bridged so that problems such as climate disruption, toxification of the Earth, loss of biodiversity and ecosystem services, and the decay of the epidemiological environment can be satisfactorily attacked. The essential need is to alter human behaviour to put society on a route to sustainability."*

The "culture gap" which the Ehrlichs identify is, despite the availability of 'knowledge' on the web, etc., the frightening and collective ignorance due to the fragmentation of knowledge into ever smaller units and 'siloed' specialisms. How many of us know how a refrigerator works or where our food comes from or how it is grown etc. "*A symbol of the scale of the culture gap is the 2008 Republican nominee for vice-president of the United States, Sarah Palin, whose vast ignorance of almost everything included thinking Africa was a country*" (Ehrlich & Ehrlich, 2010). Worse still, our compartmentalized knowledge means that even *"brilliant leaders do not see obvious and crucial connections."* As a consequence the significant connection between the Deepwater Horizon tragedy and civilization's *"ludicrous, costly, and potentially lethal continued dependence on petroleum"* went unrecognized. Implicit in the Ehrlichs' culture gap is how can either voters or politicians make decisions if they are unable to interpret a graph of CO_2 concentrations, understand how the scientific enterprise works, or do not understand resilience, tipping points, exponential growth and complex adaptive systems. The '*culture gap*' makes us enormously vulnerable, since lacking so much knowledge we make decisions which threaten our own survival due to being blind to the links and patterns of our world. Furthermore, *"the more complex and interdependent the systems and subsystems, the more vulnerable they become to design failures, since:*

a) No human designers, and this applies especially to politicians who are responsible for designing the largest human systems, can know or comprehend all the factors that need to be taken into account, and their interrelation, sufficiently to make the current set of systems work well. If complexity and interdependence increase further, the problems will be further compounded and the stability of the system further jeopardized.

(b) Those responsible for selecting the designers – the voting public in a society like the United States – are even less informed about the intricacies of the systems than the politicians who represent them. They cannot judge, therefore, which programs or social designers (politicians) to support, and in consequence they are highly likely to vote for the representatives who promise to support programs that benefit them directly and immediately – a fatal flaw in designing workable complex systems for interrelating enormous numbers of human beings with each other and their environments.

(4) The United States is probably nearing the point (it could even be beyond it) where the complexity of the systems of interdependence exceeds the human capacity to manage them, causing system breakdowns to occur as fast as or faster than any combination of problem-solvers can overcome them" (Miles, 1976).

There are two areas of closely related knowledge which are especially important for working and living sustainably:

Firstly, an holistic perception, we need to see how the whole is created by the connections and relations existing between all the parts. Rockström calls this the "hyper-connectivity" which exists between everything (Rockström & Klum, 2015). It is this connectedness and interdependence of how Nature functions which sustains and bears the weight of humanity. An holistic perception cannot be separated from understanding ecology.

Secondly, ecological-literacy, (eco-literacy) that is literacy in the sense of being au fait and having a knowledge and familiarity with ecology (Orr, 1992), its principles and the functioning of the ecosphere. Ecological-literacy embraces an understanding of the fluxes and cycles of energy and nutrients, the interactions of the inorganic with Nature and their interdependencies with the biosphere on which we all depend but so few of us understand. We might add to this the concept of "sustainability literacy" (Stibbe, 2009) because they are obviously interconnected.

Unfortunately, the increasing spread of urbanization all over the world alienates more and more of us from Nature (Worthy, 2013) so we suffer from 'nature-deficit disorder' (Louv: 2010). The alienation which began between fields of study in western academia finds its completion with our imagined independence from Nature. It is the eco-apartheid which the eco-feminist, Dr Vandana Shiva, uses to describe *"the ecological separation of humans from nature in the mechanical, reductionist worldview, which is resulting in the multiplicity of the eco-crisis that is threatening human survival – climate catastrophe, species extinction, water depletion and pollution, desertification of our soils, and acidification and pollution of our oceans. It also refers to the apartheid created between corporations and citizens, between rich and poor on the basis of the appropriation of* *the Earth's resources by a few and denial to the rest of their rights to access the Earth's gifts for sustenance of all life, including human life"* Shiva (2013).

Ahmed (2010) draws attention to the connectivity of our problems pointing out that *"An obvious question that is rarely asked, for example, is why are all these crises – in the economy, in the environment, in energy, in extremism, in demography … and in intellectual terms (reflecting the enormous gap between our scientific knowledge and the crises faced by our species) – happening at the same time?"* How can we address broadly based problems which may have a common cause or causes when we are only capable of recognizing and addressing the symptoms. The criticisms of western education by Snow and the Ehrlichs validate recommendations for an inclusive and integrated approach to creating a curriculum for sustainability largely absent in education. It is greatly to our cost that holistic thinking is neither a concept within the western academic panopoly (Fuller, 2008/2013; Orr, 1992) nor in western politics.

"… for a democracy to be successful, something other than an anarchistic mob, the universal distribution of intelligence, i.e. wisdom, knowledge, decision-making skills, is essential. Today, with modern networks of communication and connectivity, the possibility of spreading knowledge and techniques of reason among the populace is greater than ever before … Innovation and creativity come from having a whole-systems perspective, inculcated through education that recognizes a diversity of approaches … the only infinite resource we have on Earth is human intelligence" (Steel, 2012).

1.9 Sustainability handicapped by politics

It is not surprising that political decisions are often characterized by a lack of joined-up-thinking when we consider the 'culture gap' described by the Ehrlichs and the absence of holistic approach to understanding how the biosphere supports our social and economic systems. This lack of joined-up-thinking was well illustrated by the European Government's policy to substitute 10% of fossil derived petrol with bio-fuels which substantially contributed to the world famine in 2008 (Chakrabortty, 2008). And again, the craze for energy and natural gas by fracking in the western USA is exacerbating the water shortage dilemma (Goldenberg, 2013). An area which scientists have predicted will significantly suffer from drought as climate change develops.

One of the greatest handicaps to achieving a sustainable future: politicians and business leaders, is well described by Prof Friedrich Schmidt-Bleek (2007): *"The original intention of submitting to nature in order to make use of it ("knowledge is power") evolved into subjugating nature in order to exploit it. We have left the earlier successful path with its many advances and are now on the wrong track, a path of danger with incalculable risks. The greatest danger stems from the unshakable faith of the overwhelming majority of politicians and business leaders in unlimited economic growth which, together with limitless technological innovation, is supposed to provide solutions to all the challenges of the present and the future."*

Politicians suffer from inadequate information and the same educational gap as the rest of us and consequently make poor political decisions as Miles (1976) described in the quote already cited above. Furthermore, the situation is exacerbated and illustrated by the current UK cabinet (at the time of writing in 2014) which does not even include a minister who was educated either as a scientist or as a technologist. One respected journalist, following the cabinet re-shuffle commented that: *"The reshuffle pushes the coalition further towards the politics of the Tea Party Republicans"* and it is *"another sign that the right of the party – fiercely opposed to anything that prevents business from doing as it wishes – has won"* (Monbiot, 2012). As much as anything else we are also ruled by ignorance, but add to that prejudice against knowledge makes our situation very unsafe. It was only in 2015 that the American Senate agreed that climate change was not a hoax! (Anon., 2015).

1.10 Sustainability handicapped by democracy, greed and dishonesty

One might consider why, in a book on design for sustainability these points are being made. The fact is that they are an important part of the holistic explanation as to why we are where we are today with sustainability and climate change. Just as education has greatly limited our own and politicians capability to understand the ramifications of our connected world and to make appropriate decisions, so has democracy itself proved to be a substantially ineffective system.

Today it is doubtful whether we live in a democratic society? This should be understood because unfortunately, the answer appears to be 'no'. James Hansen, the NASA climate expert in protesting against the building by E.ON of another coal-powered electricity generating station in the UK, stated that democracy is no longer working because while citizens have one vote, big international companies have the enormous lobbying power of $ millions (Adam, 2009). Global corporations manipulate politicians like pawns for their own profitable interests (Monbiot, 2000; Hertz, 2001). Consequently, according to Hansen the only course remaining for the citizen is peaceful protest. Design and design education has the potential to play a powerful role by contributing to the visualization and communication of information throughout the media to enable the public and policy makers to move towards a sustainable future.

Democracy threatens its own demise with commercial deregulation opening the door for neo-liberal capitalism and commercial greed with the support of its sacred cow, the free (de-regulated) market economy. Consequently, many corporations, equipped with 'personhood' status are best equipped to pursue their single destructive focus on profit. *"Neo-liberalism is unable to view the natural world in anything other than a rationalist, instrumentalist fashion, and legitimizes the 'unlimited growth' imperative; by focusing on market mechanisms it continues to subordinate environmental and ecological issues to the competitive pressures of private sector profit maximization"* (Ahmed, 2010).

Mahatma Gandhi said *"The world has enough for everyone's need, but not enough for everyone's greed."* In January 2014 Oxfam published the shocking revelation that the world's 85 richest people are as wealthy as the poorest half of the world's population, about 3,500,000,000 (Wearden, 2014; Fuentes-Nieva, R., Galasso, N., 2014). A year later Oxfam reported at the Davos meeting that *"The combined wealth of the richest 1 percent will overtake that of the other 99 percent of people next year …"* (Oxfam, 2015).

The democratic system is fragile and can be misguided by deliberately creating a flood of dis-information. The climate change deniers and the counter-climate-change movement (Brulle, 2013) is now a textbook example which demands a new academic discipline: the determination of truth of 'www' information. The Koch Brothers, ExxonMobil and other big businesses have spent billions of dollars during the first decade of this millennium promoting the denial, debate and obfuscation of global warming to the Earth's citizens. The money they donated went to an array of institutions and 'think tanks' to publish documents denying and questioning climate change and the creation of a culture of doubt and confusion. Their aim was / is to paralyze the implementation of climate change policies which might otherwise limit their profits, especially from fossil fuels. ExxonMobil is the biggest profit generating company in the world and for example, in the autumn of 2005 reported quarterly profits of $10 billion (Monbiot, 2007). The profits came from oil. Oil's derivatives like petrol releases CO_2, the green house gas causing global warming. If we want to remain within 2°C of global warming then 80% of coal, oil and natural gas must remain underground (Up Front, 2014). The motivation for the counter-climate-change propaganda which paralyzed action for a decade is as easy to understand – profit, as it is hard to forgive. The corporate greed promoted by neo-liberal capitalism has most effectively slowed and blocked the adoption of policies which would have curbed global warming by a decade (Monbiont, 2006). Worse, their deception has already cost many people their lives.

It should be clear that one of design's challenges is to powerfully communicate irrefutable information upon which all can unanimously act. One of education's newest responsibilities is to educate students to distinguish between deceit and lies and reliable information. The web has become an indiscriminate purveyor of both and Noreena Hertz's (2014) warning and how to verify web information must now become part of the curriculum. Sustainability is not merely concerned with recycling newspapers and bottles; it demands that we also understand the politico-economic system which has made negligible progress towards securing our sustainable future.

1.11 The changing design paradigm

The term paradigm came into popular use following the publication of Thomas Kuhn's work *The structure of scientific revolution's* in 1962. Kuhn (1971) applied his theory only to science subjects because they possessed an identifiable consensus of knowledge, approach and activity which Kuhn called a paradigm or pattern. Kuhn identified observed anomalies as the drivers of paradigm changes, shifts or 'revolutions' in scientific fields. We can identify many parallels between the anomalies now driving fundamental changes in design and the kinds of anomalies described by Kuhn (see chapter 2). The Oxford English Dictionary defines a paradigm as a pattern or model and a paradigm shift as *"a fundamental change in the approach or underlying assumptions"* (Pearsall, 1998) about a field of activity.

However, Kuhn felt that subjects within the humanities were too unfocussed for his theory which was therefore limited to fields of scientific endeavour. So rather than focusing on the subject of design itself to identify a paradigm and a paradigm change I have here adopted the opposite strategy. I have focused on the changes taking place in order to identify two distinct design paradigms.

If we compare design activity and education in the '50s through to the '80s and 'even early '90s with design education today there is a substantial shift in the content of the subject matter from unsustainable to sustainable design in the 21st century. A number of authors (Sotamaa & Ahlstrom, 2008; Green, 2007; Hvid, 2006) have already referred to a paradigm shift in design and design education. Furthermore, the Cumulus Association through its conferences, global orientation and influence has even been one of the catalysts driving the paradigm shift in design education.

By the end of the last century design had produced a capability for creating wealth and waste in very large measure with little concern for the environmental costs. Nonetheless, *"During the 1980s concern over the ecological impact of everything that humankind does increased, exacerbated by disasters like Chernobyl and the discovery of effects such as the hole in the ozone layer. At the beginning of the 1980s green issues were the concern of a so-called 'lunatic fringe.' By the beginning of the 1990s green issues were near the top of every political, economic and social agenda.*
Green issues are global issues, and in addressing these issues designers are obliged to address them in a global context. Within the global ecological context, a parochial mind-set or isolationist attitude will render designers unfit to practice" (Tibbetts, 1992).

The "green issue" was not easy to respond to because of the underlying contradiction deeply embedded within design. This contradiction was succinctly observed by Eric Schneider (1992)**:** *"In the short term, of course, designers may assist their clients to supply ecologically and environmentally sound products. But the sector's lifeblood is the constant dissatisfaction with existing design solutions, and continuing consumerism. Whether design is sustainable in the long term in a situation of limited resources will most likely depend on how technology develops"* and Schneider perceptively added that *"… the very nature of the sector may have to change radically if it is to fit in a world constrained by limited resources."*

The recognition of the paradigm change in design fundamentally redefines the design curriculum. Analysis of the two paradigms (see the parallel comparison in Chapter 2) demonstrates that what is happening in design is not an evolutionary process – it is a profound schism. They are fundamentally contrasting paradigms of the world and their value priorities are based on the contrasting a-biological and biological perceptions. The old paradigm is based on the brown economy (Sukhdev, 2012) and the exhaustive use of fossil fuels and limited resources regardless of environmental degradation, ecosystem loss and pollution. Meanwhile, the new design paradigm is based on the green economy, the brown economy's antidote. UNEP has defined the green economy as *"one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive."* (UNEP, n.d.) The chasm between the two economies are so contrasting that it has been impossible for most politicians and others to either make or lead the change.

In the neo-liberal capitalist 'democracies' politicians are subjected increasingly to the major pressures of corporate lobbies which bias political decision making for the commercial benefits of corporations regardless of the electorate's wishes. This is well illustrated by the British conservative Premier, David Cameron, who in May 2010 said that his Government would be *"the greenest government ever."* However, in 2013 Cameron was attributed with using the phrase *"get rid of all this green crap"* which, if not an actual quote, provided *"certainly a fair description of the Conservatives' current stance on the environment."* (Sparrow, 2013; Allen & Hilaire, 2013). The fossil fuel industries in the UK are subsidized by £2.6bn a year while the renewable energy industries receive a fraction of this sum (Vidal, 2013). Indeed, so powerful is the fossil fuel industries' lobby worldwide that global subsidies to *"fossil fuel producers totalled $523bn a year in 2011 – dwarfing subsidies to renewable energies. For every $1 spent to support renewable energy, another $6 were spent on fossil fuel subsidies"* (Whitley, 2013). All this despite the facts that *"Fossil fuel subsidies undermine international efforts to avert dangerous climate change and represent a drain on national budgets. They also fail in one of their core objectives: to benefit the poorest. Phasing out fossil fuel subsidies would create a win-win scenario. It would eliminate the perverse incentives that drive up carbon emissions, create price signals for investment in a low-carbon transition and reduce pressure on public finances"* (Whitley, 2013). Added to which Cameron plans to stop building more wind farms and is even considering dismantling some! Furthermore, if the conservatives win the 2015 election they propose empowering local communities to block new onshore 'wind farms' (Kirkup, 2014)! Since they have now won the election we will be anxious to see what happens.

The significance of all this is to illustrate how the absence of an holistic perception, the educational gap, big industry lobbying, duplicitous politicians and neo-liberal capitalist politics all contribute to contradictory decision making and an inability to create long term political policies which could ensure a sustainable future. However, thankfully some change is happening.

1.12 The responding design and art curriculum

Today, genuine concern for sustainable human welfare is central to design. The Cumulus design education conferences provide ample evidence that the focus on the designed artifact, in whatever form, has given way to design for services, social issues and innovations for human welfare (Sotamaa, 2005). There is a move away from consumer-ownership towards sharing and consumer collaboration. There is also a move away from dependency and trust of centralized administration towards decentralization and locally independent, responsible societies (Lovins, 1977; Rifkin, 2011) and transition communities (Hopkins, 2008). These changes have a gamut of drivers which include: corruption at the highest levels in banking, politics and the trans-national conglomerate companies; discontent with globalization; increasing poverty; the exhaustion of resources; the ecological problems of pollution; ecosystem destruction, species extinctions, desertification, deforestation, climate change etc.

The digital communication technologies have enabled us all to be globally informed and have created a zeitgeist for the urgent necessity of change. The changes also open the way towards exciting new challenges for design.

One of us, Ursula, conducted a survey in January 2013 through the Cumulus Association membership in which the following question was posed to colleagues in art and design education and practice, *"What are the most Important topics for Design and Art Education in the next 5 to 10 years?"*

The response from 250 recipients, in order of importance, was clear:

1. Sustainability
2. Social Design/ Social Innovation
3. Eco-Design/ Green Design
4. Creative Entrepreneurship

The geographical breadth of this shift is also well illustrated by citing several widely dispersed design schools where design students are working to bring innovations into communities including: the Art Center College of Design, Pasadena, USA; Falmouth University, UK; Hochschule für Gestaltung, Schwaebisch Gmuend, Germany; Greenside Design Center, Johannesburg, South Africa; Politecnico di Milano in Italy, and the University of Melbourne, Australia and we know there are others. It was at the Politecnico di Milano where Prof Ezio Manzini initiated the DESIS network (http://www.desis-network.org/) for Design for Social Innovation and Sustainability. And of course further evidence of the significant changes now taking place is provided by all our contributing authors.

1.13 Behavior change is a big question; status and conspicuous consumption are unsustainable

We are now entering a new design paradigm concerned with how we change the World and bring about systemic change. But it also begs the question: how should we change ourselves? We can illustrate our problems with examples of several unsustainable human behaviours at the personal, professional and corporate levels.

The display of status is a universal and probably innate human behaviour (Brown, 1991) because it can be seen in all cultures expressed in diverse forms. However, when status is displayed by consumerism and '*conspicuous consumption*' (Veblen, 1899) it wastefully exhausts our resources and is usually harmful or worse for the welfare of both ecosystems, the environment and ourselves. An example of this prestige behaviour is illustrated by the increasing sales of SUVs, and other large format cars, the greater majority of which never see the environments for which they were supposedly designed. Another example, is the increasing consumption of meat in countries with growing economies. Throughout history prestige can be measured by the exaggerated ecological footprint required to create status symbols (pyramids, palaces, perfume, etc.).

1.14 Design offers the enormous potential for innovation which achieving sustainability will require

Design offers enormous scope for innovation and great potential for new thinking and imagining new scenarios more than most other fields because innovation lies at the core of design. Design has emancipated and democratized itself from the design studio and entered the field of social welfare and beyond and can innovate new social infrastructures unimaginable within the old design paradigm. Indeed, the severity of our situation raises the issue of systemic change and what design could contribute to bringing about substantial change.

1.14.1 Natural Capitalism (Lovins, Lovins & Hawken, 1999)

Natural capitalism is based on the proper valuation of ecosystems and the resources and services which Nature provides and which makes all economic activity possible (Visser, 2009; Lovins, Lovins & Hawken, 1999). Business practices based on neo-liberal capitalism, unconcerned with the environment, should make the transition in four major integrated shifts to natural capitalism because it cares for and values Nature. Lovins and colleagues (1999) propose that:

1. **The productivity of natural resources should be dramatically increased.** This can be achieved by basic changes in production design, technology, and developing ways to make natural resources including; energy, minerals, water, forests etc. stretch 5, 10, perhaps a 100 times further than they do today. This requires implementing far greater efficiency to reduce waste and pollution and resource exhaustion. The increase of resource productivity has already been prescribed in von Weizaecker, Lovins and Lovins book (1998) Factor Four. The book claimed that the amount of wealth that could be extracted from a resource could quadruple – hence the title. This development would require no magic wand since most of the technology already exists and simply needs to be applied to achieve this efficiency. It has been estimated that 30-50% of food produced never reaches a plate (Institute of Mechanical Engineers, 2013) and yet this is the same quantity of food which will be needed to feed the estimated extra 2 billion inhabitants on the planet by 2050. Could design contribute to solving this systemic problem?
2. **Change to biologically inspired production models.**
   "Natural capitalism seeks not merely to reduce waste but to eliminate the very concept of waste." (A caption to an illustration in the Harvard Business Review paper by Lovins, Lovins & Hawken (1999) emphasizes that: *"The central principle of closed-loop manufacturing is "waste equals food."") In closed-loop production systems, modelled on nature's designs, every output either is returned harmlessly to the ecosystem as a nutrient, like compost, or becomes an input for manufacturing another product. Such systems can often be designed to eliminate the use of toxic materials, which can hamper nature's ability to reprocess materials."*
   These ideas became popularized several years later with the phrase *"Cradle-to-cradle"* which was the title of a book by William McDonough and Michael Braungart' (2002).
3. **Move to a solutions-based business model.**
   The solutions based model abandons the classical design response and the production of an artefact and considers the user's need and well being in terms of a new set of values. So, for example, a consumer who requires illumination could purchase lighting as a long term service from a provider instead of buying a lamp and light bulbs.

4. **Reinvest in natural capital**
   We must now design in ways which will increase our natural capital and restore and sustain our ecosystems. *"Ultimately, business must restore, sustain, and expand the planet's ecosystems so that they can produce their vital services and biological resources even more abundantly"* (Lovins, Lovins & Hawken, 1999). Currently, our ecological footprint exceeds the planet's renewable resources by over 50% (Sukhdev, 2012). That means we are on a course of diminishing returns.

1.14.2 "Borrowing"

In referring to human enterprise Barry Commoner (1972) observed *"That the productive system as a whole "borrows" from the ecosystem and incurs the "debt to nature" represented by pollution is an immediate saving for the produce."* Over 35 years later this "debt" has now been quantified by the Trucost Agency. Trucost conducts research into the economic consequences of our dependency on natural capital. Currently, the Agency (2013) reports that we are damaging and polluting the environment and destroying ecosystems (our natural capital) valued at $4.7 trillion every year. This is the debt of destruction to our natural capital that commercial activity incurs and with which design is intimately involved.

Our use of the Earth's resources has now become an ethical issue in the new design paradigm because firstly, they are finite and secondly, pollute the environment when thrown away. The respect for sharing the Earth and its provisions is a fundamental character of many traditional societies around the World and which the western "me/I-consumer" society has lost. Therefore we must move towards the ethical perception and responsibility of *"BORROWING"* resources. This is because implicit in the concept of *"BORROWING"* is the ethical responsibility of returning what has been borrowed. If the materials in a design cannot by returned for recycling when the design is discarded then other materials must be selected which can be recycled. If we cannot borrow what we need for creating a design then the question is: can we ethically take it?

1.14.3 We must all become Earth Stewards

The first sustainable designer, Victor Papanek (1971), wrote in his milestone classic *"Design for the real World,"* that: *"There will always be men like Buckminster Fuller who spend 100 per cent of their time designing for the needs of man. Most of the rest of us can't do that well, but I think that even the most successful designer can afford one tenth of his time for the needs of men. It is unimportant what the mechanics of the situation are: four hours out of every forty, one working day out of every ten, or ideally, every tenth year to be spent as a sort of sabbatical designing for many instead of designing for money."* No-one can deny the necessity of designing for what has more recently been called the other 90% (Smith, 2007). However, this will be for little effect if we neglect our life support system: Nature. We need to design the care of Nature into our lives. In fact we all need to become Earth Stewards so that through a variety of activities we increase the World's Natural Capital, its ecosystems and biodiversity. A tithe is a reasonable ticket to pay for securing our life support system, the Earth and its ecosystems on which our survival depends. The aim of Earth Stewardship is not merely concerned with caring for existing ecosystems but with repairing and increasing damaged and lost ecosystems.

In addition to the proposals here for the curriculum for the new design paradigm:

- Borrowing,
- Natural Capital,
- Positive Impact Design
- Earth Stewards (and devoting a tithe of our time)

There are a number of other suggestions which will be described in the concluding Chapter of Part One, 1.14.

1.15 Conclusion

Traditionally, in the old design paradigm defined by neo-liberal capitalism, design has been largely an activity commissioned by commercial clients for economic productivity, profit and growth. Commerce and corporations are not particularly concerned to pay for the needs of achieving a sustainable future unless it brings significant profits. We already know that achieving a sustainable future has been hindered by powerful corporations who see sustainability as eroding their profits. Corporations act through powerful lobbying, donating funds to political parties to obligate future decisions for their advantage (i.e. bribery) while others have spent billions to spread false information (Brulle, 2013) to block policies that would mitigate global warming. Meanwhile worldwide duplicitous politicians, who pretend to be concerned about green house gas emissions, subsidize the fossil fuel industries 6 times more than the renewable energy industries (Whitley, 2013).

Neo-liberal capitalism and GDP do not create the economic context for achieving a sustainable future (Indeed, dealing with disasters increases GDP!) because they drive the destruction of the ecosphere. However, despite the political betrayal of the public, a new economy is currently evolving driven by the grass roots which will provide the context for the new design paradigm. This is already starting to happen, and is well illustrated by design for social welfare commissioned by local government (Rawsthorn, 2008). However, design must be enabled to address many issues to catalyze a sustainable future such as:

› designing resource cycles and their implementation for more materials.
› designing for adapting to climate change.
› designing for resilience against climate disturbance within communities.
› designing for promoting ecological literacy and behavioural change.
› designing for social innovation for a sustainable future.
› designing for the mitigation of environmental problems.
› … etc.

At this point the neo-liberal capitalist will pose the question 'who will pay?' since it is not apparent to those with old paradigm thinking how profit will be generated. However, not preparing ourselves for these problems (Stern, 2007) will be far more expensive than the costs of preparing for them. Alternatives are already being found where human and environmental welfare are valued more highly than the profits of neo-liberal capitalism.

"To change something, build a new model that makes the existing model obsolete" was Buckminster Fuller's advice. Happily, the new model or paradigm is already developing at the grass roots; it is not being lead by political leaders. A new economic model is evolving in many diverse ways, ways which do not so often make headlines, but which support the new design paradigm. For example: transition towns, cooperative consumerism, the Honeybee Network, Club of Rome, DESIS, community supported agriculture, Earth Day, Greenpeace, Incredible Edible, Post Carbon Institute, Union of Concerned Scientists, (see Glossary) etc., etc.

The themes which are proposed and described here for design education will hopefully start to provide a basis for an environmental / ecological-literacy, perhaps even a sustainable empowerment. Knowledge of sustainability is rather like a fabric due to its many interconnections so that *"When we try to pick out anything by itself, we find it hitched to everything else in the Universe"* John Muir (2013).

1.16 The UN Secretary-General Ban Ki-moon re-defines sustainable development at the World Economic Forum in Davos, 28 January, 2011

We conclude this opening chapter with some remarks by the UN Secretary-General Ban Ki-moon on 28 January 2011, to the session on redefining sustainable development at the World Economic Forum in Davos. His words are most fitting for our text and we quote them at length. The UN Secretary-General Ban Ki-moon said:

"For most of the last century, economic growth was fuelled by what seemed to be a certain truth: the abundance of natural resources. We mined our way to growth. We burned our way to prosperity. We believed in consumption without consequences.

Those days are gone. In the twenty-first century, supplies are running short and the global thermostat is running high. Climate change is also showing us that the old model is more than obsolete. It has rendered it extremely dangerous. Over time, that model is a recipe for national disaster. It is a global suicide pact.

So what do we do in this current challenging situation? How do we create growth in a resource-constrained environment? How do we lift people out of poverty while protecting the planet and ecosystems that support economic growth? How do we regain the balance? All of this requires rethinking.

Here at Davos – this meeting of the mighty and the powerful, represented by some key countries – it may sound strange to speak of revolution. But that is what we need at this time. We need a revolution. Revolutionary thinking. Revolutionary action. A free market revolution for global sustainability.

It is easy to mouth the words "sustainable development", but to make it happen, we have to be prepared to make major changes – in our lifestyles, our economic models, our social organization and our political life. We have to connect the dots between climate change and what I might call here WEF – water, energy and food ...

... But as we begin, let me highlight the one resource that is scarcest of all: time. We are running out of time. Time to tackle climate change. Time to ensure sustainable, climate-resilient green growth. Time to generate a clean energy revolution.

The sustainable development agenda is the growth agenda for the twenty-first century. To get there, we need your participation, your initiative. We need you to step up. Spark innovation.

... In an odd way, what we are really talking about is going back to the future. The ancients saw no division between themselves and the natural world. They understood how to live in harmony with the world around them. It is time to recover that sense of living harmoniously for our economies and our societies.

Not to go back to some imagined past, but to leap confidently into the future with cutting-edge technologies – the best science and entrepreneurship has to offer – to build a safer, cleaner, greener and more prosperous world for all.

There is no time to waste."(UN Secretary-General Ban Ki-moon, 28 January, 2011, World Economic Forum, Davos)

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Peter Stebbing

2 The paradigm shift in design

> *"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."* Buckminster Fuller

2.1 Introduction

Today we face the biggest challenges that mankind has ever confronted. They are of such a magnitude that scientists have even named the current geological age the Anthropocene (Crutzen & Stoermer, 2000). The reason is that our species has become so numerous and such a force that we are equal to many of nature's other forces because we are similarly capable of changing the Earth's environment. The wonderful news is that science has provided us with the knowledge of the pressures that we are exerting on the Earth's systems (see Rockström, Chapter 4). However, it is hard to understand the lack of any significant political, economic or social action to either moderate our destructive consumer behaviour or mitigate and adapt to the changes already taking place. Furthermore, we know that there are more changes to come.

2.2 The Design Revolution

Design is a powerful tool for creating both innovation and change and has enormous potential. On the one hand we can recognize that design has substantially contributed to the problems we now face but on the other it has enormous potential to help resolve these problems. Probably, the best news is that design has already begun to seriously address these problems over the last two decades or so.

Design has always been an evolving field primarily responsive to the needs of manufacturers, industry, and commerce. However, despite its potential for development, design education is slowly integrating sustainability throughout its curriculum. Sustainable design is still often treated as an additional option to the design curriculum; while its deeper significance has still to be recognized. Sustainable design is actually a revolution in design thinking because designers must profoundly revise how they work. This is because design now requires substantial additional knowledge, new attitudes, strategies, techniques and practices to be integrated into design practice. Indeed, the designer is no longer primarily concerned with the design of an artefact, be it 2-, 3-, or 4-dimensional and how it interacts with the user target group and their immediate context. The designer now has to also consider how their design will relate to and interact with the biosphere beyond! Design has changed from a linear process to a cyclical process. It has changed to a process whereby the resources required for a design must now be given attention upstream and downstream of the creation and lifespan of the design. Ultimately, the resources must be returnable and reusable. This is the paradigm revolution. Regardless of the form it takes, a design has to be holistically integrated into our world's environment and not merely made to fit within the limited context of the kitchen, office or hospital etc.

In order to more fully appreciate what is happening in design we turn to the work of the science historian, Thomas Kuhn, who wrote *The structure of scientific revolutions* (first published in 1962 and revised 1970). We will examine what is happening in design by reference to the terms paradigm and paradigm shift which Kuhn proposed. Today the term paradigm is loosely used, however, Kuhn's work enables us to analyze and consider the changes occurring in design more deeply. Change in design is normal due to its innovative character, however, I posit that the scale of the current paradigm shift from 'design' to 'sustainable design' has never before occurred. Sustainability entirely permeates the character of design activity. Sustainability demands ethical design practices based on the recognition of our dependence on the world's finite environment, finite resources and finite space.

Some might argue that the digital technology caused a revolution in design; yes, certainly in the mechanics of design but it has not raised the moral questions of a magnitude posed by the necessity for sustainability. Furthermore, computers and the information technologies have substantially added to our environmental problems with their increasing turnover and demands for mineral resources and increased production of waste. Indeed, it is sustainability which questions the ethics of the digital technologies and their limited ability to standardize even plugs and sockets … not to mention printers! After all, the profitability of the digital industries stems significantly from the design for obsolescence.

2.3 What is a paradigm?

Thomas Kuhn (1971) made famous the term 'paradigm' to describe a field of scientific endeavour. *"A paradigm is an accepted model or pattern"* (Kuhn 1971, p.23) … of thought, embracing the laws, theories, procedures, orientation and the underlying assumptions shared by a scientific community working in a particular scientific field such as genetics or quantum mechanics.

2.4 What is a paradigm shift?

When increasing anomalies begin to be recognized in a field of science and which are incompatible with the existing paradigm (state of the knowledge) a *"revolution"* occurs and the … *"Failure of the existing rules is a prelude to a search for new ones"* (Kuhn, 1971, p. 68). A crisis starts to develop and opposing schools of thought argue the issues (hence scientific revolution) to determine *"… which paradigm should in the future guide research on problems many of which neither competitor can yet claim to resolve completely"* (Kuhn, 1971, p. 157) but which can account for the anomalies. However, *"To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it is confronted"* (Kuhn, 1971, p.17). Kuhn's raison d'etre for identifying the 'paradigm' was to make the anomalies readily apparent against the backcloth of the paradigm itself and also to clarify the scientific field's shift to a new paradigm. An example of such a paradigm shift in science is that which took place in physics from Newtonian to Einsteinian mechanics. Kuhn proposed that such revolutions could only occur in science because a paradigm was characterized by a consensus of accepted practice and knowledge which was not to be found amongst the arts and the humanities.

2.5 Design's lack of consensus

Kuhn explained that fields such as *"music, the graphic arts, and literature … history, philosophy, and the social sciences"* lack a consensus of knowledge, etc. necessary for identifying a paradigm. This is due to the *"immense variety of problems"* and the *"number of competing and incommensurable solutions to these problems"* which ultimately can only be evaluated by each individual for themselves. Lawson (1990), writing in *How designers think; The design process demystified*, confirms Kuhn's opinion stating that *"Since design problems defy comprehensive description and offer an inexhaustible number of solutions the design process cannot have a finite and identifiable end."* Furthermore, Lawson writes that for design *"There is no infallibly correct process."*

The well known German design theorist, Bernhard Burdek (1998), in reviewing the proceedings of a design conference in Helsinki entitled *"No Guru, no method? – discussion on art and design research"* confirmed that design has no identifiable paradigm: *"Over and over again designers ask themselves what on earth design actually is and how it should be defined – seeing it is caught between art and technology for example. And then they go back and start all over again at the beginning. This means that any progress made by the discipline is doomed to proceed at a snail's pace. What remains is a feeling of considerable discomfort, and the question: after as much as 100 years, are we still at the starting point as far as this particular discipline is concerned? When will those in design finally start to take each other into account, to allow for a process of continuity, and to make real progress?"*

Lawson (1990) posed the question *"Do we really need a simple definition of design or should we accept that design is too complex a matter to be summarized in less than a book?"*

2.6 So if there is no consensus about design, why are Kuhn's paradigms and paradigm shifts relevant for design?

Although there is no consensus about the nature of design, nor even a simple definition, let alone anything that could be called a design paradigm, why is Kuhn's work so important for design? The reason, I believe, is that his approach enables us to identify both the trajectory and enormity of the change that is taking place in both design and design education. Kuhn's concepts help us to identify the **shift** in design and thereby the old and the new design paradigms. As a consequence we can catalyze the transition that we must all adopt to move to the new sustainable design paradigm from the old design for consumption paradigm.

2.7 Reversing Kuhn's strategy to move forward

Kuhn's strategy was primarily focused on identifying the paradigm of a field of science so that the anomalies should be easily apparent. However, by adopting the opposite strategy and focusing on the anomalies themselves enables us to clearly identify design's contrasting paradigms. In other words by examining the direction of the change we can see the paradigm which design is leaving and where it is going to. So that if we consider design activity for the period from about the 1930s through to the 1980s there was no regard for resources, which were considered to be inexhaustible (old paradigm), or awareness of sustainable design. If we now compare it to the period from the 1990s to the present day then we see a clear transition within design activity because sustainability has become a central concern (new paradigm).

In the old paradigm design was characterized by: contributing to and promoting consumerism, obsolescence (Packard, 1967), commerce, wealth and waste; was environmentally blind; and a product's life was linear. If resources were considered at all they were perceived of as being limitless along with economic growth. Meanwhile, in the new paradigm, designers aspire to design for 'quality of being' rather than 'quantity of having' and with achieving a sustainable consumerism. This entails a circular use of finite resources due to environmental awareness and the aim of securing a sustainable future. I posit that this total contradiction between the old and the new design paradigms is the fundamental "anomaly" which defines the paradigm shift in design activity.

We will compare and contrast these two paradigms because design is still in the shift phase from the old to the new paradigm. The old design paradigm actually contributed to the anomaly through its lack of awareness, unsustainable attitudes, wasteful practices and pandering to a throw-away-society. This is the core problem which the new paradigm is concerned to resolve so as to secure a sustainable future. Design is in the process of recreating itself to become a wholly sustainable and ethical activity. Unfortunately, the old design paradigm continues for the sake of profits and is the brake to a sustainable future throughout much of the commercial world.

2.8 According to Kuhn: … characteristics of anomalies, paradigm 'shifts' and paradigms

Let us consider some of Kuhn's statements concerning anomalies, paradigm shifts and paradigms and see how they correlate to the field of design. (Where Kuhn writes 'science' or 'scientists,' we may read 'design' and 'designers.')

2.8.1 Kuhn On Anomalies

> *"Discovery commences with the awareness of anomaly, i.e., with the recognition that nature has somehow violated the paradigm-induced expectations that govern normal science."*

We can translate this from science to design activity. For example, the old design paradigm was concerned with designing consumables or new "stuff" for the short-term benefit of the consumer society, unconcerned about the anomalies of:

1. the consumption of materials.
2. the pollution caused by manufacturing processes.
3. 'stuff' being thrown away as waste disposed of in landfill and otherwise causing further pollution.
4. the environmental impact (eco-footprint and eco-rucksack).

Ultimately, these anomalies impact on consumers which are not to their benefit in the long term.

Let us now continue with the quote from Kuhn: *"It then continues with a more or less extended exploration of the area of the anomaly."*

We might consider that the exploration into the sustainability of the anomalies just listed and the knowledge which we now possess provides sufficient reasons to change from earlier design practice to sustainable design. Kuhn continues: *"And it closes only when the paradigm theory has been adjusted so that the anomalous has become the expected. Assimilating a new sort of fact demands a more than additive adjustment of theory, and until that adjustment is completed – until the science has learned to see nature in a different way – a new fact is not quite a scientific fact at all"* (Kuhn, 1972, p 52-53). Today, many designers now recognize the demands that design must operate sustainably and should be holistically compatible with the environment, rather than merely benefiting the consumer's short term needs. Unfortunately however, designers remain beholden to their clients' wishes be they sustainable or otherwise.

> *An "Anomaly appears only against the background provided by the paradigm. The more precise and far-reaching that paradigm is, the more sensitive an indicator it provides of anomaly and hence of an occasion for paradigm change."* (p. 65)

The big anomaly for design is that design is supposed to be concerned about human welfare. Many designs do indeed make life more comfortable. Unfortunately, we are so successful at designing and producing comfortable 'stuff' (Leonard, 2010) that we are destroying the biosphere on which human welfare depends. This is the biggest anomaly: the old design paradigm is concerned with human welfare in the short-term micro-context while ignoring the macro-context and the damaging externalities caused to the biosphere and which affect many if not all. The new design paradigm is concerned to design for both human and environmental welfare-the long-term macro-context. We might call this the 'Adorno anomaly' because, adapting his words *'There is no right design within the wrong one.'*

2.8.2 Kuhn on Shifts

> *"The transition from a paradigm in crisis to a new one from which a new tradition of normal science can emerge is far from a cumulative process, one achieved by an articulation or extension of the old paradigm. Rather it is a reconstruction of the field from new fundamentals, a reconstruction that changes some of the field's most elementary theoretical generalizations as well as many of its paradigm methods and applications. During the transition period there will be a large but never a complete overlap between the problems that can be solved by the old and by the new paradigm. But there will also be a decisive difference in the modes of solution. When the transition is complete, the profession will have changed its view of the field, its methods, and its goals ... Others who have noted this aspect of scientific advance have emphasized its similarity to a change in visual gestalt ..."* (Kuhn, 1971, p. 84)

(The best example of which is the two opposed faces-candlestick gestalt, one sees either the two faces or the candlestick because it is perceptually impossible to see both simultaneously.)

Some of the fundamentals embraced by the new design paradigm include the recognition of:

› finite resources change the perception of a product's 'life' from the linear model: design – production – consumption – throw away, to the cyclical model: the loop or circular economy (Stahel, 1981) popularly known as 'cradle-to-cradle.' Ethically, resources are 'borrowed' and therefore the designer is under an obligation and responsibility to facilitate their return for continual use.

› the throw-away-culture also assumes an endless resource of space for the disposal of waste. However, there is no 'away' on the Earth and the concept has led to pollution and the poisoning of our environment. The plastic waste in the oceans (Amos, 2015; Jambeck, et al. 2015), ground down by wave action to the size of plankton (micro-plastics: <5 mm), and being ingested by filter feeders enters the food-chain and continues on its way to our own plates (Thompson, 2009). A phenomenon we might call *"boomerang disposal"*.

- ecological footprint and ecological rucksack, Surface Input Per Service unit (SIPS), Material Intensity Per unit of Service (MIPS), are all concepts to help reduce environmental damage and the waste of resources (see Glossary).
- dematerialization. It has been calculated that the western lifestyle must dematerialize its consumption by a magnitude of 10 (Schmidt-Bleek, 2008; Weizsäcker, et al. 2009).
- the need for mitigative design (Kruse, 2006). That is design that will not contribute or create problems such as resource exhaustion, increasing energy demand, pollution and waste. Sustainable design means design where care has been taken to reduce the design's eco-footprint. However, every eco-footprint contributes to the deficit of our natural capital. What is urgently required is '*positive impact design*' so that the by-product of design activity is the creation and increase of the Earth's natural capital.
- the need for adaptive design (Kruse, L., 2006) to meet the challenges of the changes without creating positive feedback. For example, keeping cool in cities without expending energy.
- the need for resilience design. *"Resilience is the capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop. It is about the capacity to use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking. Resilience thinking embraces learning, diversity and above all the belief that humans and nature are strongly coupled to the point that they should be conceived of as one social-ecological system"* (Moberg & Simonsen, 2011). Resilience to disturbance can be achieved through stronger social networks (ecometrics (Sampson, 2012; Sampson, 2013) see Glossary). The digital technologies have a key role to play in the creation of diverse social networks etc.
- Design for Social Innovation and Sustainability. One network, whose mneumonic, DESIS has been initiated and pioneered by Prof Ezio Manzini and has significantly contributed to the awareness of design for social welfare. In the 21st century a distinctly new development has substantially moved design towards solving people problems in the social context. Furthermore, it also involves the democratization of design whereby people are helped towards solving their own problems (IDEO, 2011). Design for social and community innovation has a key role to play in developing the resilient capability of societies to survive disasters, poverty and other problems. Throughout the world central government shows itself to be increasingly unwilling to provide social services due to economic cutbacks consistent with neo-liberal policies.

> *"To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it is confronted."* (Kuhn, p.17)

The new paradigm is characterized by sustainable design which is committed holistically to the consumer's welfare and recognizes the limitations of resources and land space. In contrast, the old design paradigm contributes to the exploitation of the consumer, the consumption of resources, the creation of waste and pollution and is unsustainable.

> *"paradigm changes do cause scientists* [i.e. designers] *to see the world of their research-engagement differently."* (Kuhn, p.111)

Designers regard materials differently in the new paradigm compared to the old paradigm when they were perceived of as being in endless supply with little concern as to what happens to the product at the end of its life (Packard, 1967). However, if materials are in limited supply and should be available for future generations then the use of materials becomes an ethical issue. In the new paradigm a designer actually borrows the materials for the manufacture of a product and her concern must include designing for the materials re-use. (Unfortunately, design for disassembly seldom occurs in the design curriculum.) Furthermore, the recognition of the eco-footprint fundamentally changes the design approach compared to the old paradigm unconcerned with sustainability but with increasing production and consumption.

2.8.3 Kuhn on Paradigms

> *"Often a new paradigm emerges, at least in embryo, before a crisis has developed far or been explicitly recognized."* (Kuhn, p.86)

Many regard the first important warning of our sustainability predicament was the landmark publication of a report to the Club of Rome by Meadows, Meadows, Randers & Behrens entitled the *Limits to Growth* (1972) followed by the Report by the World Commission on Environment and Development led by Gro Brundtland which published *Our Common Future* in 1987. However, before these laudable milestone publications appeared, a number of authors had already published perceptive publications concerning our sustainable future. Fairfield Osborn had published *Our Plundered Planet, can Earth be saved?* in 1948. Osborn wrote that "*… all the productive elements of nature have to be thought of in relationship of one to another. As far as habitable and cultivable portions of the earth's surface are concerned, there are four major elements that make possible not only our life but, to a large degree, the industrial economy upon which civilization rests:*

- *water*
- *soil*
- *plant life, from bacteria to forests*
- *animal life, from protozoa to mammals.*

The last two of these elements, being alive and capable of reproduction, are referred to by conservationists as "renewable resources.""

Authorship about sustainability could not be more succinct. Subsequently, Osborn published The Limits of the Earth in 1954. In 1949, another author, William Vogt expressed his concerns about our sustainable future, finite land resources and the demands of population in *Road to Survival*, in which he observed that *"man is a biological creature subject to biological laws, and the first of these is that he cannot live without plants."* In 1954 Harrisson Brown, a geochemist, provided a detailed analysis surveying the whole problem of mankind's future in *The Challenge of Man's Future* which he followed up with a later study published in 1977, *The Human Future Revisited*. He concluded that *"Were there to be a regrouping of society into smaller settlements and smaller industries, and were each to achieve some real measure of self sufficiency, the resilience of society as a whole would increase enormously … As this process goes on, the responsibilities, pervasiveness, and complexities of central governments would be correspondingly lessened, eventually to be concentrated primarily upon the broadest of national problems and upon global ones."* This proposal for decentralization appears now, in 2014, to be becoming a reality as, for example, the EU government begins to consider returning some decision making to the regions and Scotland and the Catalan region want self-rule. Furthermore, Michel Lebrun, who is President of the Committee of the Regions in the European Union also *"favours greater autonomy for regions and results in an effective governance, improving service delivery to citizens and enhancing democratic stability"* based on Belgium's decentralized system (EurActiv, 2014). Brown's proposals are also partially echoed in Jeremy Rifkin's (2011) *Third Industrial Revolution* too.

In the -60s, the social commentator, Vance Packard, in the *Hidden Persuaders* (1957) and in the *Waste makers* (1967) critically revealed how consumption, obsolescence and bank credit were used to keep consumers purchasing regardless of waste. In a time when raw materials were considered inexhaustible he was already concerned about vanishing resources.

The embryonic start for sustainable design was Victor Papanek, who in 1971 published *Design for the Real World* and provided the most complete concept for sustainable design. Looking back to that time, his writing now appears visionary. Papanek was writing during the hippy movement which provided roots for the 'green' movement which was on the fringe during the 1980s. However, by the end of the -80s much legislation was already being introduced in response to 'green' issues and environmental protection which were increasingly recognized as major concerns (Tibbetts, 1992).

> *"The existence of the paradigm sets the problem to be solved; often the paradigm theory is implicated directly in the design of the apparatus able to solve the problem."*
> (Kuhn, p. 27)

The new paradigm of sustainable design clearly identifies many of the problems to be solved; problems that were neither perceptible nor of concern within the old design paradigm. Furthermore, there is now a significant literature describing conceptual design tools for designing sustainably. The 'new' design literature is well illustrated by just a few examples:

- IDEO, (2011) *Human centered Design toolkit*
- Chick, A., Micklethwaite, P. (2011) *Design for sustainable change*
- Thorpe, A. (2007) The designer's atlas of sustainability
- Fuad-Luke, A. (2002) *The eco-design handbook*
- Tischner, U., Schmincke, E., Rubik, F., Prösler, (2000) *How to do eco-design?*
- Wackernagel, M., Rees, W. (1996) *Our ecological footprint*
- Orr, D.W. (1992) *Ecological literacy*
- Papanek, V. (1971) *Design for the real world*
- Papanek, V. (1995) *The green imperative*

> *"Paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute."* (Kuhn, p. 23)

The old design paradigm contributed to profligate waste, contributing to the development of the throw-away-culture, pollution and landfill, whereas the 'new design paradigm,' defined by sustainability, is concerned with conserving materials and resources and mitigating pollution and waste. Unfortunately, there are many instances where the throw-away culture continues and where the plastic bag has become an icon of our wasteful society together with the 'carpets' of plastic waste gathered in the oceans by gyres.

> *"The new paradigm implies a new and more rigid definition of the field."* (Kuhn, p.19)

Despite not being possible to arrive at a consensus about the nature of design activity, nonetheless, it is perfectly clear that designing sustainably demands a greater knowledge for what has to be designed and how. This is because of the knowledge of impacts on the environment and global warming etc. Consequently, there are many more strategies, concepts and cognitive design tools for designing sustainably which students and designers must now know, and illustrated by:

- new eco-design methods integrating detailed eco-information which was never previously considered in the old design paradigm.
- the ecological-footprint, or simply footprint, which is the ecological cost of a product in terms of the land area required to produce that product (Wackernagel & Rees, 1996).
- the ecological-rucksack is the total quantity of materials e.g. mineral ore for the extraction of minerals for example for a computer that are taken from nature *"On average, every kilogram of industrial product carries approximately thirty kilograms of nature around with it"* (Schmidt-Bleek, 2008).
- life-cycle-analysis (LCA) is an *"systematic inventory of all materials and energy flows which enter and leave a product system. The product system encompasses all processes along a product's and all its component's life cycles which are necessary to fulfill a defined function"* (Tischner et al, 2000).
- or MIPS (Material Input Per unit of Service). *"The material input (MI) includes all the natural raw materials which are moved and used in order to produce, use, transport, and dispose of material goods: sand, water, coal, earth, ores, rapeseed, and trees – in short everything that we need from the ecosphere."* (Schmidt-Bleek, 2008).

In order for design activity to become sustainable metrics will play an increasingly important role so as to minimize a design's footprint. This will enable comparisons to be made between proposed design options for the energy and materials required during a design's life-cycle.

The extra knowledge and methods, their acquisition and the additional time required to design sustainably will undoubtedly slow the shift from the old to the new paradigm. Education has become enormously bureaucratic and so it will take time to integrate sustainability throughout the design curriculum.

> *"In the process of being assimilated, the second [paradigm] must displace the first."* (Kuhn, p.97)

The necessity and unarguable logic that our cultures must become sustainable confirms that sustainable design must completely replace unsustainable design. However, in the broader economic context the selfishness and ignorance which abounds will certainly hinder the process of sustainable design being assimilated. For example, many politicians and businessmen think that it is not possible to be green and simultaneously be profitable (Leahy, T., 2008). Consequently, the short term profit motive will be the biggest handicap, however, where businessmen like Tesco's CEO Sir Terry Leahy, are prepared to take a longer term view then such positive attitudes will certainly catalyze the progress towards a sustainable design 'paradigm.'

It should be mentioned that a tragic hindrance to combating CO_2 emissions and global warming in the USA are the billions of dollars donated, some anonymously, by business moguls towards blocking actions to mitigate climate change. The money often goes through secretive networks to institutions, 'think-tanks' and advocacy groups whose authors write books, articles and reports discrediting climate science and denying climate change (Brulle, 2013; Goldenberg, 2013; Goldenberg, 2014). Brulle has called this the *counter-climate-change-movement*. In the UK a similar action is led by a so-called 'educational charity' called the Global Warming Policy Foundation which has lobbied for canceling *"subsidies for alternatives to fossil fuels and to abandon the UK's emissions reductions targets"* (Ward, 2013). Meanwhile, the CO_2 concentration in the atmosphere continues to rise and during 2013 400ppm was recorded for the first time at the Mauna Loa Observatory on Hawaii since Charles Keeling started recording the atmosphere's CO_2 content in 1958. Scientists now consider that global warming with an average temperature of 4°C is a very strong likelihood by the end of this century (World Bank, 2012). One of the most rapidly warming regions of the world is central West Antarctica where it is reported that there has been an "*... increase in annual temperature between 1958 and 2010 by 2.4±1.2°C, establishing central West Antarctica as one of the fastest-warming regions globally*" (Bromwich, et al, 2013).

2.9 The old and the new design paradigms compared

I now summarize what appear to be the characteristics of the old design paradigm and which have significantly contributed to a 'kuhnian anomaly,' in this case unsustainability, and compare it with the new design paradigm.

2.9.1 The Old Design Paradigm

The old design paradigm is characterized by:

1. The future of the planet is not a design concern.
2. The milieu in which design operates is within neo-liberal capitalism and the 'brown' economy based on the exhaustive use of: fossil fuels, and limited resources regardless of resource exhaustion, environmental degradation, ecosystem loss and pollution.
3. The "tragedy of the commons" (Hardin, 1968) and resource exhaustion is not a design concern.
4. "Overshoot" of natural resource use is not a design concern.
5. Economic growth is perceived of as being unlimited according to the prevailing ideas of economics.
6. Resources are perceived of as infinite and therefore ...
7. Obsolescence is a manufacturing/design strategy to maintain and increase sales (Packard 1967), achieved by:
   - poor manufacturing, materials and design facilitate breakage.
   - deliberate (annual) style change a status symbol.
   - introduction of innovations outdating earlier models.
   - credit readily available with credit cards or payment by instalments.
8. The ecological footprint (Wackernagel & Rees, 1996) and the ecological rucksack (Schmidt-Bleek, 1993) were unavailable concepts until the -90s
9. A product's disposal is of no concern to design.

   Design is a part of a linear process beginning with the creation and promotion of the design up to its purchase by the consumer when the designer's commitment stops and disposal is the consumer's problem ('cradle to grave').

10. Design for repair is too costly. Cheaper to buy a new one. Neither re-use nor recycling are considered (despite being practised during World War II, of course).
    Design for disassembly is un-necessary (since resources are unlimited) except maybe for possible maintenance.
11. Products are thrown away when broken or finished with (ending in landfill) because they are too costly to repair (and/or infrastructure of repair no longer exists or it is as expensive as a replacement) and a replacement carries the prestige and status of the new. (Packard, 1963)
12. Unlimited space for throwing away broken and unwanted consumer goods (so long as "out of sight, out of mind"). The phenomenon of 'fly-tipping' develops where consumers dump their rubbish somewhere, usually in the countryside, well away from home (Vaughan, 2014) causing pollution.
13. Design activity is largely focused primarily on material artefacts, 'stuff': products, packaging, and the advertising, media and communication etc. encouraging consumer possession, mass consumption, and increasing sales. Consumer welfare is secondary to commercial welfare and design is valued as a significant contributor to GDP (Gross Domestic Product).
14. Design is an integral part of business activity for the welfare of the company and the increase of profits, demand, sales, and ultimately mass consumerism and economic growth.
15. Designers know what consumers want through motivational research, market research, and behavioural psychology. Some subversive strategies developed (television advertising) to achieve increased sales.
16. Design can only be done by experts, i.e. designers may also work with marketing experts.
17. Consumers are perceived as knowing nothing about design and are not involved in the design process. They are the subjects of market research. Social feedback is not wanted except perhaps in the "act of buying".
18. The potential of the digital technologies is not yet generally available.
19. The context for a design is perceived to be related to its immediate environment: home, office, hospital, etc.
20. Globalization is an unknown concept.
21. Sustainability science is unknown.

2.9.2 Design's unifying concept: Sustainability

> *"paradigms determine large areas of experience at the same time."* (Kuhn, p.129)

Evolution is the all-bracing concept which not only makes biology a cohesive subject but also makes it coherently understandable. The famous biologist Theodosius Dobzhansky (1973) wrote an essay entitled: *"Nothing in Biology Makes Sense Except in the Light of Evolution."* In design sustainability performs a similar unifying role because unsustainable design is not compatible with human or environmental welfare. Unsustainable design can only be concerned with profit and gain at the expense of the biosphere on which human welfare depends. I posit that by examining design through Kuhn's concepts of paradigms and anomalies leads us to the overwhelming conclusion (to modify Dobzhansky's phrase) that *"Nothing in design makes sense except in the light of sustainability."*

2.9.3 New Design Paradigm

Summarized below is a simplified perception of the new design paradigm compared point for point with the old paradigm above.

1. The future of the planet and sustainability have become critical design concerns.
2. The milieu in which design now operates (as well as the brown economy) is the 'green' economy which is defined by the Green Economy Coalition (Green Economy Coalition, no date) as *"a resilient economy that provides a better quality of life for all within the ecological limits of the planet."* While UNEP (2011) has defined the green economy as *"one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient, and socially inclusive."* Unfortunately, the unsustainable growth demand-

ed by neo-liberal capitalism continues to dominate economies while the new paradigm pursues sustainability and green economics.

3. The *"tragedy of the commons"* (the 'commons' are those parts of the biosphere, such as the oceans and the atmosphere, which although they belong to no-one, they actually belong to everyone (Hardin, 1968)) and the damage, pollution to the environment, and destruction to the atmosphere, the oceans, water tables, forests, fisheries, soils and desertification etc. are major issues in which design activity is clearly implicated along with commerce and industry (Papanek, 1971). The agency Trucost (2013) calculate that each year commercial and industrial activities damage, destroy and pollute our biosphere and ecosystems to a value of $4.7 trillion ($4,700,000,000,000).
4. "Overshoot," the over-consumption of renewable resources, is a serious concern for design because we are currently over-consuming the Earth's natural capital which annually provides renewable resources. We now use the resources of 1.5 Earths (Ehrlich & Ehrlich, 2013), which means we are now living on diminishing returns because we are consuming our 'natural capital'. *"Only about 1% of all materials mobilized to serve America is actually made into products and still in use six months after sale"* (Lovins, Lovins, Hawken, 1999). Furthermore, Trucost (2013) estimates that *"3 billion new middle class consumers by 2030 will cause demand to grow rapidly, while supply will continue to shrink. The consequences in the form of health impacts and water scarcity will create tipping points for action by governments and societies."* Shrinking supply will cause prices to rise. Tainter (2009) writes that *"In undertaking to study the collapse of any complex society, these conditions should be looked for"*:
   - *"benefits constant, costs rising*
   - *benefits rising, costs rising faster*
   - *benefits falling, costs constant*
   - *benefits falling, costs rising"*

   Tainter quotes Barnett & Morse (1963) "No society can escape the general limits of its resources, but no innovative society need accept Malthusian diminishing returns."
5. Economic growth is limited by our finite planet is a recognized fact.
6. Resources are finite and there are new design strategies for resource conservation and management.
7. Design for obsolescence (Packard 1967) is not a sustainable design strategy and is unethical since obviously it wastes resources.
8. However, the ecological footprint and the ecological rucksack are new strategies enabling designers to:
   - choose suitable materials with the smallest ecological cost.
   - dematerialize by reduced but optimal use of the materials.
   - thereby maximize a resource's productivity.

   (Wackernagel & Rees, 1996; Schmidt-Bleek, 1993; von Weizsäcker, et al, 2009)
9. A product's disposal becomes a central design issue just as much as its function. Therefore, design is concerned with a cyclical *"closed-loop production systems, modeled on nature's designs, every output either is returned harmlessly to the ecosystem as a nutrient, like compost, or becomes an input for manufacturing another product. Such systems can often be designed to eliminate the use of toxic materials …"* (Lovins, Lovins, Hawken, 1999). Therefore design is concerned with the re-use of materials in a 'loop economy' originally proposed by Walter Stahel (1982) and which he referred to as 'cradle back to cradle.' The well known derivative of this term was subsequently popularized by McDonough & Braungart, (2002).
10. Design strategies in addition to recycling include: reduce, repair, and reuse so as to increase resource productivity and slow resource exhaustion. Furthermore, the material efficiency of a design should be maximized and the quantities used reduced as much as possible to conserve our resources (de-materialization). A key strategy on saving resources is that of *'lean thinking'* (Womack & Jones, 1997) identifying where there is waste, muda (Japanese), in any form (time, materials and energy, etc.) and removing it from the production process.

11. A product is a material resource for recycling which should be designed for modular disassembly to enable repair and the easy re-use of the different materials.
12. Land for rubbish disposal is increasingly limited (landfill). Seepage of chemicals and toxins etc. from dumped waste pollutes rivers and water-tables. There is *"no away"* to throw rubbish because it eventually is likely to cause pollution. Plastic rubbish now pollutes every ocean and plastic micro-particles can be found on the shores of all continents. *"About eight million tonnes of plastic waste find their way into the world's oceans each year, say scientists"* (Amos, 2015).
13. Design for consumer goods is no longer central to design which is increasingly concerned with design for human and ecological welfare, social innovation and sustainability e.g. cooperative consumerism transition towns, community housing, urban food production, self-help welfare, etc.
14. Design activity spreads out from commercial commissions and becomes concerned with design for social services and human welfare.
15. Design is a multi-disciplinary team activity of experts (e.g. including ethnologists, anthropologists, ergonomists, sociologists, materials experts, etc.) and increasingly involving consumers and users in the design process.
16. Design has partially emancipated itself from commerce and contributes to the welfare of the consumer. Consequently, it also develops new problem solving strategies involving a broader range of stakeholders as design becomes partially emancipated from the design studio and its use democratized for the social milieu, social welfare, "doing good," NGOs, social welfare, community groups, design for social innovation and sustainability (DESIS) throughout the world especially developing countries (IDEO, 2011) and the other 90% (Smith, 2007). As a problem solving strategy design is also infiltrating other disciplines.
17. Consumers are often directly involved in the design process and sometimes from the beginning.
18. Digital technologies and design offer great potential to community groups especially in developing countries; for example, enabling poor farmers to get the correct prices for their produce; monitoring and diagnosing crop pests; organizing self help following a disaster and strengthening group resilience.
19. The context for a design and its connectivity is now recognized to be the environment of the whole Planet.
20. Globalization has altered design consciousness in several ways: awareness of resource supply chains, exhaustible supply of resources, ethical aspects of resource supply (including:
    - child & sweat-shop labour,
    - illegal deforestation & timber supply,
    - pollution in countries with legislation loopholes,
    - illegal mineral supply
    - environmental destruction,
    - biodiversity loss and species extinctions
    - etc.)
21. *Sustainability science* (Kates, et al 2001) emerged and coalesced into a field of study from the recognition of the interacting impacts of society and economics on the environment.

2.10 Sustainability science emerges

The new sustainability agenda that was emerging during the last two decades of the twentieth century *"much of the science and technology community became increasingly estranged from the preponderantly societal and political processes that were shaping the sustainable development agenda"* (Kates, et al., 2001). However, by the beginning of the new millennium a transition was occurring involving collaborations between networks of independent scientists, scientific academies, NGOs etc. around the world as well as international scientific programs.

"A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions between nature and society. Such an understanding must encompass the interaction of global processes with the ecological and social characteristics of particular plac-

es and sectors. The regional character of much of what sustainability science is trying to explain means that relevant research will have to integrate the effects of key processes across the full range of scales from local to global. It will also require fundamental advances in our ability to address such issues as the behavior of complex self-organizing systems as well as the responses, some irreversible, of the nature-society system to multiple and interacting stresses." Kates and colleagues conclude that: "*Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information*" (Kates, et al 2001) clearly implicating a crucial role for design and art in its widest sense.

Core questions for sustainability science

Kates and his colleagues (2001) suggest a number of core questions concerning the basic interactions between nature and society which should be addressed. There is much where design can play a key role and I quote these questions as formulated by Kates, et al. (2001) because of their importance and relevance for design.

- "How can the dynamic interactions between nature and society – including lags and inertia – be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
- How are long-term trends in environment and development, including consumption and population, reshaping nature – society interactions in ways relevant to sustainability?
- What determines the vulnerability or resilience of the nature-society system in particular kinds of places and for particular types of ecosystems and human livelihoods?
- Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?
- What systems of incentive structures – including markets, rules, norms, and scientific information – can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?
- How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?
- How can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?"

Sustainable design is a misnomer or oxymoron

Sustainable design is, in a sense a misnomer or oxymoron (see chapter 18 by Elizabeth Sanders), because there can or at least should be no other kind of design. Design has a core of basic attributes: efficient function, be ergonomic and a pleasure to use, possess good form, have the smallest possible ecological footprint and so far as possible be recyclable and require minimal running costs, etc. Therefore any definition of design in the new paradigm must embrace sustainability as a core component negating the need to refer to design as sustainable design. Consequently, we can identify and name unsustainable design as characteristic of the old design paradigm.

2.11 The speed of the paradigm shift and its brakes

Finally, we must realize that the two design paradigms, the old and the new, currently co-exist and the complete transition to the new paradigm is not going to be fast due to reasons motivated by personal gain in diverse forms. This is a battle that the we and grass roots has with politicians (and also CEOs of many large corporations) who demand economic growth on the one hand and are ineffective in dealing with climate change and sustainability on the other. In the UK the "*Green Party leader Natalie Bennett blamed the Government for the increase in climate change doubters. She said: "When the government is so clearly failing to act on climate change, or take seriously its obligations under the Climate Change Act, it's not surprising that the level of doubt about climate change has risen. "Of course, however, the 72 per cent of the public who acknowledge the climate is changing are backed overwhelmingly by the scientific evidence*" (Bennett, 2013). Meanwhile, the US Senate has at last recognized that climate change is not a scientific hoax! (Anon, 2015). In addition politicians frequently follow contradictory strategies depending on the power of conflicting corporate lobbies. The German Chancellor, Angela Merkel who apparently supports renewable energy contradicts her own policies by blocking EU legislation to lower the limits on emissions for luxury cars in order to protect the German car industry. In addition the German Government substantially subsidizes its fossil fuel industries as do Russia, the USA, the UK, and Australia. The transition to the new paradigm will be a slow process with continuing support for old paradigm economic growth, profits, together with political ineffectiveness, and contradictions.

Business and industry is similarly inconsistent. At worst this includes the lobbying by very rich business moguls and others (e.g. Koch Brothers, ExxonMobil etc.) spending billions of dollars promoting the counter-climate-change-movement already mentioned (Brulle, 2013). The result of their deceitful activities has delayed action to reduce emissions by a critical decade (Monbiot, 2006). Meanwhile, CEOs with short term perspectives continue to pursue maximum profit margins working within the old paradigm. The trillions of dollars of the collective profits of many of the larger companies is achieved simply by environmental destruction (TRUCOST, 2013). However, a range of industries claim to be green (greenwash) whilst others actually are because they have recognized the market value of being honestly green. On the smaller scale the institutional adoption of sustainable management strategies is slow due to the extra work to integrate a sustainable administration based on the new knowledge base (the new paradigm). This is well illustrated in education where some universities and design schools have adopted a sustainable administration according to international standards e.g. the Eco-Management and Audit Scheme (EMAS) while other institutions only manage to recycle paper. These are some of the forces working against sustainability and slowing down the transition to the new design paradigm.

2.11 Conclusion

The rest of us who are concerned to care for the Earth and create a beautiful green tomorrow should not be downhearted. Despite the power and duplicity of many politicians and greedy capitalists there is an enormous counter power at the grass roots around the world. It is a growing consciousness and making enormous social progress despite not commanding the news headlines as often as politicians and CEOs. Change is being created by the massive repetition of small acts carried out by many individuals, small and medium sized groups and even some large ones. So here are some examples of a few the stakeholders, many not so prominent, creating the shift towards the new sustainable paradigm:

- Architects of change
- Tree people (http://www.treepeople.org/)
- Tree Guardians (http://treeguardians.org/)
- Unions of concerned scientists (www.ucsusa.org/)
- Greenpeace
- Business for social responsibility
- Bumblebee Conservation Trust
- Bioneers
- Water Footprint Network
- Rocky Mountain Institute
- Friends of the Earth
- World Wildlife Fund
- World Watch Institute
- etc.

At the individual level we must all recognize the challenge to change our own behaviours to complete the paradigm shift.

Unfortunately, “The designer is not in practice allowed so much freedom to question the wider pattern of reasoning behind the decision to manufacture a particular product ...” or design (Baynes, 1967). Ultimately, the designer will be confronted with choosing between:

1. trying to persuade the client of the advantages of producing a sustainable design, for both the benefit of the consumers, the company image and the environment.
2. should the company remain unconvinced in creating a sustainable design then the designer could accept the commission against her own better knowledge and ethical conscience.
3. or she could turn down the commission on ethical and unsustainable grounds.

The last option is not an easy choice for the freelance designer, however, the better informed we are about planet’s situation then the more likely we are to be successful in the first option.

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Peter Stebbing

3 Why we have to design for sustainability – the new paradigm, schesiological links and externalities

"This we know
All things are connected
like the blood which unites one family …
Whatever befalls the earth
befalls the sons and daughters of the earth.
Man did not weave the web of life;
he is merely a strand in it.
Whatever he does to the web
he does to himself." Ted Perry, inspired by Chief Seattle

"Being ecologically literate, or 'ecoliterate', means understanding the principles of organization of ecological communities (i.e. ecosystems) and using those principles for creating sustainable human communities." Fritjof Capra, 1997

3.1 Introduction

In the second chapter we identified two distinct design paradigms. The old unsustainable design paradigm rooted in the perception of an economy based on infinite growth and infinite resources. The newer design paradigm, characterized by sustainability, living with finite resources, the elimination of waste and pollution and the maintenance of the world's ecosystems and environment; none of which were ever considerations of design in the first paradigm. In this chapter we summarize why we must pursue the second design paradigm and the following chapters will address particular issues in more detail. We hope that in addition to providing specific knowledge for designing sustainably in design will also enable us to discover an holistic awareness towards living sustainably.

The reasons why we must design sustainably are simple although often perceptually obscure. This is because design activities' impacts usually extend along chains of linkages well beyond traditional design activity (old design paradigm). Today, our developing understanding of the Earth's interconnectedness between environmental, social and economic systems has improved enormously. We can read in the journal Nature, for example; that the Central American spider monkey *(Ateles geoffroyi)* is threatened by the western habit of coffee drinking. 'Designer' coffee machines come in all shapes and sizes to high prestige models using coffee capsules to simple filters. Coffee consumption supports trade, trade supports resource extraction, resource extraction drives loss of habitats due to their replacement by plantations (Hertwich, 2012). Furthermore, it has been recognized that German imports threaten at least 18 species worldwide while exports for foreign consumption from Malaysia threatens 70 of its own endemic species (Hertwich, 2012). These examples are a fraction of the bigger picture because *"Human activities are causing Earth's sixth major extinction …"* (Lenzen, et al, 2012). In a recent paper by Pimm and colleagues (2014) they report that the *"Current rates of extinction are about 1000 times the likely background rate of extinction. Future rates depend on many factors and are poised to increase"* (Pimm, et al, 2014).

3.2 We must design sustainably …

We must design sustainably …

› to stop the extinction of species, the decimation of animal populations and the destruction of biodiversity and ecosystems on which our survival depends through ecosystem services. Only 48% of vertebrate animal populations worldwide (not species in this case) continue to exist since 1970 (WWF, 2014).

› to save water and protect the water cycle and save water from pollution.
› to conserve material resources both organic and inorganic.
› to conserve energy resources.
› to leave fossil fuels (stranded assets; Ansar, et al. 2013) in the ground as their use emits green house gases. CO_2 emissions have now reached 400ppm, a proportion which has not occurred since at least 800,000 years *("The carbon dioxide (CO_2) content of the atmosphere has varied cyclically between ~180 and ~280 parts per million by volume over the past 800,000 years, closely coupled with temperature and sea level"* (Tripati, et al. 2009)).
› to stop as soon as possible and reduce green house gas, aerosol and particulate emissions and atmospheric pollution which cause global warming.
› to stop marine pollution, ocean warming and acidification.
› to save food.

All of these reasons are irrefutable. However, is there a simpler way of thinking about them and working towards solving them through design? I think this has been clarified for us by Barry Commoner (1972), a renown pioneer of the 1970s environmental movement who substantially contributed to public awareness about the ecological crisis with his book *The closing circle* published in the early -70s. He formulated four fundamental ecological laws which remain universally valid. Furthermore, to the question above *"why we must design sustainably"* his principles provide the *"because …*

Everything is connected to everything else … *and consequently, design affects other parts of the biosphere.*

Everything must go somewhere … *and what we design to be manufactured, if not re-used is thrown away in landfill, or finds its way (down rivers) to the oceans.*

Nature knows best … *and so we need to cooperate with Nature rather than attempt to rule it.*

There is no such thing as a free lunch … *extracting the raw materials (fossil fuels, minerals, wood, etc.) comes with a cost of damage to the biosphere."*

Commoner's ecological laws may be regarded as summarizing four reasons for designing sustainably (new paradigm) and are simultaneously the 'kuhnian anomalies' (Kuhn, 1971) of the old design paradigm. Perhaps, unusually for a book on design we shall venture into the biological significance of Commoner's ecological laws in order to develop a perception of ecological literacy. However, we add a fifth law which contradicts the pervasive economic dogma on which the world's commercial systems are based and which regards the Earth's resources as limitless, of course they are not and therefore the fifth law must be:

Everything is finite … which confirms that there are *Limits to growth*. The fifth principle was the subject of the study *Limits to growth* published for the Club of Rome in 1972 written by Meadows, Meadows, Randers, and Behrens (Osborn, 1954; Meadows, Randers, and Meadows 2004).

Those of us who have flown know that in an aeroplane there are rules which have to be followed for the safety of all the passengers and so smoking is prohibited. Similarly on spaceship Earth (Fuller, 2008/2013), we, the passengers must also know how to behave because otherwise we will endanger our own safety. Ecological literacy is understanding the interconnectivity and rules of the world as an holistic life supporting system – the ecosphere. Consequently, it is the key to understanding sustainability. Muir (1911) wrote that *"When we try to pick out anything by itself we find it hitched to everything else in the Universe."* Muir's poetic words strike to a fundamental truth essential to the new design paradigm which is best supported by some understanding of how nature works.

Commoner (1972) observed that *"it is difficult to ignore the embarrassing fact that the final generalizations which emerge from all this – the four laws of ecology – are ideas that have been widely held by many people without any scientific analysis …"* Commoner draws attention to the classic American writers including Whitman, Twain, and Thoreau and their wisdom about nature and the need for human harmony with nature. Furthermore, many other peoples around the World who have long identified the significance of their interconnectedness and harmony with nature including the Mapuche and Quechua peoples of the Andes, (Heyd, T., 2005), the Sami of Lapland (Tisdall, 2010), the Buddhists (Batchelor & Brown, 1992) and the Kogi of Colombia (Ereira, 1990).

In their simplicity Commoner's laws embrace a gamut of sustainable practicalities for integration into the design curriculum and design practice. These five laws are the irrefutable anomalies for the old design paradigm and we shall now examine them with some examples.

3.3 Everything is connected to everything else.

Our difficulty in understanding the underlying interconnectedness of our world is partly a matter of a false perception. The western academic tradition has *"fractured knowledge into manageable bits and pieces"* (Orr, 1992) and separated it into two major groups: the humanities and the sciences (Snow, 1993). Thomas Kuhn concurs, *"Normal science is a strenuous and determined attempt to force nature into the conceptual boxes supplied by professional education"* (Goldsmith, 1996). These 'boxes' such as physics, chemistry and biology and their 'sub-boxes' have created in the western academic tradition the fundamental difficulty of recognizing the deeper connections which transcend disciplines and are the links which harmonize our world. Buckminster Fuller (2013) also warned us of the danger of overspecialization because it leads to an inability to adapt.

The western system of education requires a substantially more integrated curriculum (Orr, 1992; Ehrlich & Ehrlich, 2010) to develop the skills for anticipating the consequences resulting from decisions. A prime example of a fiasco created by this inability was made, no less, by the European government. It did not anticipate the consequences of replacing 10% of petrol with bio-ethanol with the purpose of reducing CO_2 emissions. However, when it emerged that the measure would increase emissions then the European government, at least partially, reversed its strategy replacing only 7% of petrol with bio-ethanol! Meanwhile, the USA's adoption of this strategy contributed to food price increases around the world due to land, that was previously used for growing food crops, changing to growing crops for bio-ethanol.

What does Commoner's first law mean for design? It means that our existence and the gamut of our activities, both work and play, what we consume and what we do throughout our lives impacts on the biosphere – our environment, somehow, somewhere, sometime. This is because, as the first law states, *"Everything is connected to everything else."* This principle was succinctly visualized in a diagram published in the journal *Science* (Ayensu, E., et al., 1999) which shows the linkages and interdependencies between the ecosystems providing food, freshwater, forest products, biodiversity, and climate change. The linkages between these major ecosystem goods and services which are coupled with other driving forces such as climate change means that significant change in one area will impact on another.

For example, if a lot of freshwater is used for fracking then it will not be available for irrigation and food production due to either it being polluted with fracking chemicals, if it returns to the surface, or unavailable if it remains deep underground. And again if land is used to grow crops for bio-ethanol production then it cannot be used for producing food. If forests are cleared for food production then they cannot sequester CO_2 nor perform ecosystem services such as stopping soil runoff, etc. This is the challenge of our finite ecosystem resources, how best to use them when the demand is for more of all of them.

So what does this have to do with design? Everything. The products which designers create are another demand for resources (wood, water, minerals, energy, etc.) contributing to the burden on ecosystem goods and services. Therefore, we must automatically question design decisions with *"but what then?"* (see 'schesiology' in the Glossary) leading us to identify the ecological costs and impacts of our decisions: How much energy is required whilst researching and working on computers? How much water is used in the production process? Where will the wood come from for the design? What are the ecological costs of transporting materials and product distribution? etc. The new design paradigm includes many procedures, for example: life cycle assessment (LCA), the *"material intensity per unit of service"* or MIPS (Schmidt-Bleek, 1993) and the 'ecological rucksack' etc. which help designers to consider the ecological costs of their designs. If we recognize our dependence on the environment we can modify our behaviour, and help mitigate environmental problems. Understanding this is the foundation of ecological- or environmental-literacy (see Glossary). It is unfortunate that we ourselves seldom witness the impacts or externalities resulting from many of our decisions. Consequently, the good news is that the new design paradigm makes us aware in ways never previously considered by the old design paradigm. Strategies including lean thinking, dematerialization of design, replacing products with services and so on … are all aspects of the new design paradigm. We must not only design innovatively but innovate new ways of thinking into designing.

We are an integral part of the ecology of the biosphere, the envelope surrounding the world that contains and sustains life. Ecology includes the study of the relationships of living organisms with one another, and with their environment. Ecology is concerned with three levels of enquiry: the individual organism, the population (of the same species) and the community consisting of populations of different species. We are connected to the biosphere in several ways: by the flows of materials through us (water, nitrogen etc.), by webs of dependence and dynamic and oscillating balances.

3.3.1 Flows and cycles

We are interconnected to the biosphere by the flows and cycles occurring in – and supported by the biosphere. We should understand:

› how materials cycle and energy flows through the systems of organisms.
› the interdependence of organisms through food-chains and behavioural interactions.
› how those systems or ecosystems provide us with the essentials which sustain our lives.

If we understand enough about how the Earth functions then we can know enough to not only avoid damaging or breaking these flows but also learn how to care for the Earth's systems so that we do not threaten our own existence. Consequently, you will perhaps find more here about ecology and biology than is usual in a design book.

Solar power drives the cycles on which life depends with all organisms themselves participating in various ways in the bio-geochemical cycles. The most important cycles include the hydrological cycle, the carbon cycle, the nitrogen cycle and the phosphorus cycle.

Solar energy drives the process of photosynthesis enabling algae and plants to grow and create the biomass (net primary product or NPP) which is the starting point for all food chains. *"Net primary production – the net amount of solar energy converted to plant organic matter through photosynthesis"* (Imhoff, et al, 2004). (There are a few exceptions of organisms living independently of solar energy such as the communities of marine organisms living around hydrothermal vents on the dark and deep ocean floor). Therefore, nearly all organic existence depends on the simple recipe in which:

carbon dioxide	+	water	+	light enables photosynthesis to create	>	glucose	+	oxygen
$6CO_2$	+	$12H_2O$	+	sunlight acting on chlorophyll	>	$C_6H_{12}O_6$	+ $6H_2O$	+ $6O_2$

The simple formula confirms that photosynthesis crucially depends on water. Water is an essential resource which is in increasingly short supply, nonetheless, since it cycles we potentially have an eternal cycling supply but of a finite quantity. Water evaporating from the sea's surface forms clouds which falls as rain on both land and sea. On land water is taken up by plants from which it evapotranspires or runs off into streams and rivers to once again reach the sea. Alternatively, it may seep into the ground where it may collect in aquifers.

Hydrologists believe water supply has already reached *"peak ecological water"* (Palaniappan & Gleick, 2009). Nature, i.e. organisms and ecosystems also need water to exist and provide us with ecological services. Consequently, we must ensure that besides whatever water we need that there is enough water for Nature too. Consequently, the term *"peak ecological water"* refers to the maximum amount of water which can be used by humans without limiting Nature's needs. Palaniappan and Gleick (2009) explain that *"As human appropriation of water increases, the ecological services that water provides decrease. Once we begin appropriating more than "peak ecological water," ecological disruptions exceed the human benefit obtained. Defined this way, many regions of the world have already surpassed "peak ecological water" – humans use more water than the ecosystem can sustain without significant deterioration and degradation"* and disruption to the ecosystem services on which we depend. Currently, Brazil is *"experiencing a third consecutive year with soaring temperatures and rainfall patterns well below historic records"* (Whately & Lerer, 2015). Worse still, California is also (Feb. 2015) experiencing *"the most severe drought in the last 1200 years, with single year (2014) and accumulated moisture deficits worse than any previous continuous span of dry years … In terms of cumulative severity, it is the worst drought on record (-14.55 cumulative PDSI), more extreme than longer (4- to 9-year) droughts"* (Griffin & Anchukaitis, (2014).

Carbon is also continually cycling in the biosphere and organisms play a key role in the flows of carbon, not only physiologically through respiration and photosynthesis but also in their composition. Similarly, organisms are participants in the circulation of nitrogen and phosphorus. The maintenance of all these cycles and flows through the biosphere not only links organic life with the Earth's inanimate geo-physico-chemical systems but are essential for life's continuation.

Food chains are flows of energy and nutrients commencing with the capture of the sun's energy by photosynthesis to create biomass (plants), the energy ascends a ladder of organisms through what biologists call trophic (connected by nutrition) layers. For example, the primary producers are algae and grasses capturing the sun's energy to create biomass. The next trophic layer are the herbivores feeding on the primary producers and the herbivores are preyed upon by carnivores. A food chain, illustrating 4 trophic layers can be exemplified as follows:

sun's	>	grass	>	grass-hopper	>	shrew	>	owl
energy		**producer**		**primary consumer**		**secondary consumer**		**tertiary consumer**

Our responsibility is to understand and care for the maintenance of the myriad interactive ecological networks, and the trophic layers nested within each other (Bastolla, 2009) and operating on different time scales and which constitute ecosystems.

3.3.2 Keystone species & webs of dependence

We are connected to the biosphere by the webs of relationships which exist between us and other organisms. We must be attentive to care for these webs of relationships which permeate and form ecosystems. Some species in an ecosystem are of critical significance to its maintenance and are the ecosystem's 'Achilles' heal.' These are known as 'keystone' species because they hold an ecosystem together and it is not always possible to know which species these are until, for some reason, they disappear causing the ecosystem's collapse.

The oak is a familiar tree in many countries and also a keystone species. Certainly hundreds even thousands of different species depend on oaks for a small, or essential role in their lives. Many species of lichens, mosses, and other epiphytes live on oaks and at least 5,000 species of insects depend on oaks for at least a part of their life cycle laying their eggs, pupating and feeding on the oak. In turn these insects are parasitized or eaten by many other animals. The numbers of other species which oaks support varies regionally but a study in Santa Monica, USA, lists:

- 58 species of amphibians and reptiles
- 105 species of mammals
- 150 species of birds (see Sources: Oaks).

The acorns of the European oaks are spread by jays and an individual jay may bury between 4,500-11,000 in a year! The acorns, forgotten by the bird, have a greater chance of germinating since the jay buries the acorns at a depth perfect for their germination which helps to extend forest cover. Jays play a key ecosystem service which if performed by humans has been estimated to cost between $200,000-950,000 per pair of jays (Hougner et al, 2006). Meanwhile, the acorns that remain on the ground where they fall provide food for many mammals such as voles and squirrels. Ivy grows up the oak's trunk providing nesting opportunities for small birds and lichens and mosses grow on the bark, providing nesting opportunities and materials. Larger birds, such as woodpeckers and owls may nest in the oak, especially when cavities develop in old and rotten trees. The holes, weakening the trunk, enable fungi to grow, causing the tree to rot and eventually to collapse. On the ground fungi begin to break down the wood and it becomes covered in mosses. Under the trunk's bark beetle larvae develop and the dead oak becomes a host to a new community of organisms as it rots down.

This incomplete vignette of life supported by an oak tree in a temperate wood or copse illustrates some of the things we might observe. However, what we cannot see is the oak turning the sun's energy into biomass by photosynthesis. Water is drawn up by transpiration from the roots and evaporates (evapotranspiration) from the leaves adding water to the hydro-cycle. The oak also contributes to other cycles essential for our functioning biosphere; the oxygen, carbon and nitrogen cycles.

The question arises as to how is the oak tree connected to us? This is by the provision of ecosystem services, these may include:

- forest soils created by rotting leaves and wood purify water,
- deep forest soils also store water and help to recharge aquifers,
- help maintain the water cycle and stabilizing the local climate,

- forest canopy and leaf litter protects soil from the erosive power of rain,
- tree roots bind soil and provide conduits for water to enter the soil recharging aquifers but preventing flooding (research shows that *"soil infiltration rates were 67 times greater in plots planted with trees compared to grazed pasture. The results illustrate the potential use of upland land management for ameliorating local-scale flood generation …"* (Marshall, et al. 2014)).
- the tree's biomass removes (sequesters) carbon from the atmosphere,
- air purification (filtering particulates and detoxification),
- provides dye,
- and obviously timber. (Chivian & Bernstein, 2008)

The Chadwick Arboretum at the Ohio State University provides information about the trees on its campus. An overcup oak *(Quercus lyrata)* with a crown diameter of 11.8 meters (39 feet) provides an annual ecological benefit valued at $504.33 which includes:

- Storm water mitigation $173.76
- Reduced atmospheric carbon $25.90
- Energy (Heating/Cooling) $87.97
- Air quality value $10.96
- Aesthetic / History $205.74

(see Sources: Chadwick Arborteum)

We can see from our, albeit, incomplete look at an oak tree, how it is woven into a web of connections and flows cycling at different scales of both time and dimension.

Another keystone species is the African elephant. About 34,000 elephants (or 7% of the African population) are killed by poachers every year. Scientists believe they could be extinct in 100 years (Morelle, 2014). Elephants are a 'keystone' species because they maintain the grasslands on which many species of Africa's herbivores and their predators depend. Elephants pull down trees so that the succession of grassland to scrub is restrained (SOS Elephants, 2010) thereby maintaining the grasslands. They create waterholes which benefit other species and elephant dung recycles nutrients and disperses seeds. If the elephant disappears from the African continent it will substantially change African ecosystems. It is estimated that between the two World Wars the African population of elephants was about 7-10 million, today the population has fallen to around 300,000 due to extensive ivory poaching and the expansion of human settlement reducing the elephant's habitat (SOS Elephants, 2010).

3.3.3 A simple dynamic balance

An ecosystem's complexity enhances its stability but its apparent balance is not static, it is dynamic, continually oscillating. Lets briefly consider a classic ecological example; the relationship between three species; grass, rabbits and foxes. In the spring the grass grows and a population of rabbits increases as do the foxes which feed upon the rabbits. As the numbers of rabbits drop due to predation by the foxes so too does the fox population – like a self regulating system. In the autumn rabbit numbers may fall due to the grass dying off. If for some reason all of the rabbits die out (due to the introduction of myxomatosis) then the fox population will die too, and the system will collapse. Furthermore, if there were no rabbits then the grass meadow would give way to a 'succession' of new plants invading the area (and a plant 'succession' would begin) as there would be no rabbits to inhibit the growth of small saplings. Normally, an ecosystem consists of a community of different populations of species all interacting with one another and maintaining a dynamic balance.

3.4 Everything must go somewhere

Waste did not exist on the Earth until mankind changed from a hunter-gatherer to an agrarian lifestyle. Nature does not produce waste. Waste is therefore a defining character of our species, particularly in developed cultures! In nature a major link between organisms is due to one organism's body or waste nourishing another organism's need. As a consequence of millions of years of co-evolution all the chemicals produced by organisms are compatible within the Earth's system, the biosphere and its inhabitants.

The continuum or hierarchy of life with which ecology is concerned: the levels of the individual organism, populations of the same species and the community, populations of different species, also continues in the opposite direction, from the individual organism to its organs, tissues, cells, cell organelles and the molecules of which they are made. The connections of an individual cell are extraordinarily complex, both within the cell and through its interactions within the body. In biology this understanding of the hierarchy is defining character of the subject and we can see that there is a continuum in which the units at one level combine to create a unit at a higher level (Russell, 1982).

3.4.1 Example no. 1 xenobiotics

All living creatures are composed of cells. *"Cells occupy a halfway point in the scale of biological complexity. We study them to learn, on the one hand, how they are made from molecules and, on the other, how they cooperate to make an organism as complex as a human being"* (Alberts, et al, 1989). The average cell in our bodies (of which there are an estimated 37.2 trillion in a human), synthesizes about 10,000 different proteins along a complex network of metabolic pathways despite being less than 0.1mm in diameter. A typical enzyme molecule catalyses in the order of 1000 reactions per second. It does this by moving very rapidly enabling interactions to occur when the surfaces of molecules come into contact with each other (Alberts, et al, 1989). Cells are complex chemical factories with extraordinary capabilities. It is unfortunate for us that cells have not evolved the mechanisms to cope with novel man-made chemicals.

When we purchase consumer 'stuff' we assume that it is safe, unfortunately, this is a often a false assumption as we discover that many household products contain toxic chemicals: teflon coated kitchenware if scratched releases toxins into the food. Children's clothes and furnishing textiles contain toxic fire retardants. Plastic food boxes leach chemicals into foods and so on. Phthalates found in plastics may *"risk damaging children's IQs in the womb"* (Sample, 2014). The synthetic world we have created is a poisonous one.

A letter published in the journal Science sent from 8 professional scientific societies pleaded for tighter controls of the thousands of chemicals being introduced daily because: *"The effect of environmental exposures on human health is a growing area of concern. The number of new chemicals is increasing exponentially, with approximately 12,000 new substances added daily to the American Chemical Society's registry … The need for swifter and sounder testing and review procedures cannot be overstated. Recent scientific evidence has established direct links between exposures that occur during fetal development and adult disease … most, if not virtually all Americans, are exposed to contaminants in the environment that cause serious health effects in animal models … Furthermore, there is growing evidence that some chemicals once thought to be safe and allowed into common and, in some cases, abundant commercial use may be not as benign as previously assumed"* (The American Society of Human Genetics, et al, 2011). These apparently benign chemicals once thought to be safe in high concentrations can be toxic in low concentrations. They may also unexpectedly combine with one another chemical to form un-designed chemical compounds. Furthermore, the off-gassing of chemicals (volatile organic compounds or VOCs. Such chemicals are called 'organic' because their manufacture is based on carbon chemistry and not because they are in any way natural) from synthetic building materials, adhesives, fire retardants, cosmetics and plastics etc. in buildings (*"sick building syndrome"*, **Siegle, 2014**) can be breathed into the lungs and cause various illnesses, including cancers.

The important point is that the internal environment of our body is not adapted to 'process' xenobiotics (Rappaport, Smith, 2010). (xeno- is from the Greek, meaning stranger or foreigner) which are *"a substance, typically a synthetic chemical, that is foreign to the body or to an ecological system"* (Pearsall, 1998). We should not think that all xenobiotics cause disease, however, if our bodies do not possess a physiology which has evolved to process these chemical aliens then there will always be the risk that something will go wrong with our physiology at the cellular level.

Therefore as the world adopts the western chemical-plastic-synthetic materials consumer-life-style we will not be surprised to learn that scientists have predicted that from 2002 to 2020 there will be a 95% increase in deaths from cancers in the Southeast Asia region and a more than 70% increase in North Africa, West Asia, Central and South America and the Caribbean (Gorman, 2010). More recently, a World Health Organization report concluded that *"Cancer cases worldwide are predicted to increase by 70% over the next two decades, from 14m in 2014 to 25m new cases a year"* (Boseley, 2014; Stewart & Wild, 2014).

3.4.2 Example No. 2 Plastics

In the second example of Commoner's ecological law *"that everything must go somewhere"* we shall consider the schesiology (connections and consequences) of plastics.

It is now well known that plastic debris has and is accumulating in the five oceanic gyres or circulating currents in the north and south Pacific, the north and south Atlantic and the Indian Ocean. The plastic rubbish is not always visible as it floats below the surface and breaks up into ever smaller pieces micro-plastic. Many pieces resemble small organisms and marine plankton and are 'preyed' upon by many different species including: sea birds, fishes, whales and dolphins. The smallest plastic particles are consumed by filter feeders such as mussels (Thompson, 2009) or eaten by marine organisms in the seabed such as worms which are then preyed upon and so these plastic particles or micro-plastics enter the food chains.

> "*As plastic breaks down into smaller pieces, it is more likely to infiltrate food webs. In laboratory and field studies, fish, invertebrates and microorganisms ingest micrometer-sized particles, which also come from synthetic (polyester or acrylic) clothing and cleaning products containing plastics … studies in humans and mussels have found that ingested and inhaled micro-plastic gets into cells and tissues where it can cause harm*" (Rochman, et al, 2013).

The grey water from washing machines frequently ends up in the oceans along with a cargo of micro-plastic particles from man-made textiles. A single garment washed in a washing-machine can produce more than 1,900 microscopic pieces of plastic and it appears that these particles have now found their way to shorelines all around the globe (Browne, et al 2011).

Although plastics are usually thought to be chemically inert, unfortunately the chemical ingredients *"of more than 50% of plastics are hazardous"*. Some of the additives which are used in PVC can leach out of medical packaging and have even been found to accumulate in human blood. Furthermore, the *"ingredients of PVC, polystyrene, polyurethane and polycarbonate can be carcinogenic and can affect organisms in a similar way to the hormone oestrogen"* (Rochman & Browne, 2013). Even BPA-free plastics, for example the styrofoam (or polystyrene foam) used in coffee-to-go cups and food packaging off-gas hormone mimicking chemicals or endocrine disruptors (Blake, 2014).

Ironically, the plastic used for carrier bags, polyethylene, a monomer, is thought to be benign. However, it *"can still become toxic by picking up other pollutants"* (Rochman & Browne, 2013) and chemicals from the environment such as insecticides, and other chemicals which disrupt essential physiological processes. Indeed, polyethylene accumulates more organic contaminants than other plastics such as polypropylene and PVC (Teuten, et al, 2009). Consequently, sea birds can become poisoned, not from the plastic they have consumed, mistaken as food, but from the toxins absorbed by the plastic from the environment! (Rochman & Browne, 2013).

The schesiological picture which emerges with plastic pollution resembles a roundabout with chemicals jumping on and off plastic waste. Toxic chemicals from the environment and/or which leach out of some plastics can be absorbed by other plastics, particularly polyethylene. In the oceans these toxin laden plastics break up into smaller pieces and depending on their size can be consumed by filter feeders (mussels, oysters, etc.) and benthic organisms. Polychlorinated biphenyls (PCBs) are absorbed into sea floor sediments inhabited by many creatures and from the sediment they have been found absorbed into the bodies of crabs and shrimps (Nimmo, et al 1971). Larger pieces of plastic are eaten by birds and fishes and so enter the food chain, bio-accumulating in the species at the top of the food chain, some species being consumed by ourselves.

Perhaps one of the most unexpected encounters with plastic pollution is in beer! Research commissioned by the consumer rights magazine program Markt (NDR North German Radio) reveals that some of Germany's biggest selling beer brands all contain microscopic plastic fibers. Jever Pilsner contained 78.8 particles per liter and Munich's Paulaner wheat beer contains 70 particles per liter. Some mineral waters were also investigated and found to be contaminated although less so than the beers.

The lead researcher of the investigation, Professor Gerd Liebezeit of MarChemConsult said that *"We have identified this synthetic material in a wide range of areas, not just in food and drink but also in the air."* Professor Stephan Pflugmacher, an ecological toxicologist from the Institute for Ecology at Berlin's Technical University, told Markt that *"Micro-plastic will sooner or later represent a danger to us"* (Anon, 2014).

Meanwhile, in December 2014, Marcus Eriksen and his colleagues reported that an estimated *"minimum of 5.25 trillion particles weighing 268,940 tons …"* is floating in the world's oceans *"The impact of plastic* *pollution through ingestion and entanglement of marine fauna, ranging from zoo-plankton to cetaceans, seabirds and marine reptiles, are well documented. Adsorption of persistent organic pollutants* [often referred to as POPs] *onto plastic and their transfer into the tissues and organs through ingestion is impacting marine mega-fauna as well as lower trophic-level organisms, and their predators. These impacts are further exacerbated by the persistence of floating plastics, ranging from resin pellets to large derelict nets, docks and boats that float across oceans and transport microbial communities, algae, invertebrates, and fish to non-native regions, providing further rationale to monitor (and take steps to mitigate) the global distribution and abundance of plastic pollution … Plastics Europe, a trade organization representing plastic producers and manufactures, reported that 288 million tons of plastic were produced worldwide in 2012. Our estimate of the global weight of plastic pollution on the sea surface, from all size classes combined, is only 0.1% of the world annual production."* The mystery which remains is where is the missing plastic? (Eriksen, et al, 2014).

"Everything must go somewhere," and mankind's toxins boomerang back to us in the food chain, gathered up from the environment by plastics which are fed on by fish! Ecology's justice – it all has to go somewhere. Sustainable design ethically prescribes avoiding the use of all synthetic materials for the safety of consumers. Unless of course, you know that they are absolutely safe?

3.5 Nature knows best

Commoner writes that *"Stated baldly, the third law of ecology holds that any man-made change in a natural system is likely to be detrimental to that system."* Commoner (1972) admits that this may seem rather an *"extreme claim"*. However, he makes the analogy that if we were to open the back of our watch and close our eyes whilst poking the mechanism with a pencil we would scarcely be likely to improve its performance. Although, there is a very remote chance that this could happen, we are much more likely to damage the watch. The watch's movement, as the mechanism is called, is the collective result of hundreds of years of research, invention and development or as technologists call it "R&D." (See Glossary. Kogi People).

On a geological time scale of millions of years both organisms and ecosystems have also undergone an extensive period of "research and development" which biologists call evolution. In contrast to mankind's synthetic chemicals, the chemicals produced by Natures' organisms, magically, somewhere have their natural counterpart, an enzyme, which can break it down so that it can be re-utilized by another life-form. In Commoner's second ecological law we have already seen that some of the tens of thousands of mostly untested chemicals (Grossman, 2015) which we are putting out into our environment, many embedded in all kinds of products, have eventually to go somewhere.

Consequently, consistent with Commoner's first law of the world's interconnectivity a number find their way into our bodies. However, these 'new' man-made xenobionts are incompatible with a cell's physiology which has evolved over 3.5 billion years. Therefore we learn from Nature that when we create any synthetic chemical compound we must also create the method or 'enzyme' which will break it down. Failing this, then, ethically, we should only work with Nature's compounds because they are biodegradable and not with polluting man-made compounds.

A similar complexity of interactions exists not only inside our cells but also beyond our bodies, in the Earth's ecosystems. We have already referred to 'keystone' species and the examples of the oak tree and the elephant. Cut down the oak and an ecosystem disappears along with the ecosystem services it provided. What about the vast agricultural mono-cultures which have replaced so many ecosystems?

Industrialized agriculture is already appearing to be a dead-end. The large fields enables economical cultivation, and the efficient use of fuel and easy application of fertilizers and pesticides. However, these fields are becoming ecological deserts supporting the monoculture crop to be harvested. This is not what would evolve naturally because *"Nature knows best"* and creates biodiversity and a complex web of interactions. The continued application of chemicals is not a long term strategy for mass food production because:

› the source of fossil oil used to manufacture agricultural chemicals (fertilizers and pesticides) are now stranded assets because their use will increase CO_2 emissions.
› the chemicals applied to the crops and soil kill off many of the organisms on which the soil's

natural fertility depends. Consequently, (like drug addiction) the agro-industry has created a dependency on the artificial maintenance of a synthetic soil fertility requiring increasing quantities of fertilizer.

- many insects and plants become resistant to pesticides such as glyphosate (a weed-killer) and so other weed-killers are used in combination with glyphosate. A weed called waterhemp had developed a resistance such that 89% of populations survived being sprayed with two or more herbicides! Further chemicals are developed to deal with this problem further damaging the environment.
- The cost of applying herbicides to a hectare of cotton has increased from $50-75 a few years ago to $370 in 2013 (Service, 2013).

However, industrialized agriculture does not have to depend on the heavy application of chemicals because Leontino Balbo, the CEO of Native Organic Products, has abandoned industrialized sugar cane growing (Balbo, 2012). Mr Balbo is employing a strategy he calls *Ecosystem revitalizing agriculture* applying natural principles to grow sugar cane and achieving a lot more with a lot less. He initially experimented with 16,000 hectares of the family plantation and farming it organically for several years his results were much better than conventional sugar cane farming. "*According to Balbo, modern agriculture damages soil in three ways. Farm machinery compresses it, making it less able to hold water; fertilizers upset its natural chemical balance; and mono-crops reduce its biodiversity, which he sees as essential for healthy plants. "So much soil used for agriculture is dead," he says. "We need to revitalize it, to restore the energy of its ecosystem*"" (Baker, 2013). The key to Balbo's success is his deep respect for the soil which he considers is not merely a container for water and nutrients but an ecosystem which supports biodiversity. Since adopting his strategy which includes returning the sugar cane trash to the ground to mulch down instead of burning there has been a substantial increase in the plantation's biodiversity. The mulch both fertilizes the soil, inhibits weeds and helps to maintain the soils moisture and supports biodiversity which inhibits pests.

Native Organic Products is one of the most successful organic-sugar producers in the world supplying a third of the world's market and producing annually 75,000 tonnes of organic sugar.

We can understand from this example that there are alternatives to the conventionally accepted commercial agro-industry practices which have become increasingly divorced from Nature's sustainable ways of "doing".

Sustainable agriculture is showing that it can produce food in quantities similar to the agro-industry and conventional farming. Techniques such as no-till farming replace the fertility of soils, increase biodiversity so that there are less pests and results in a variety of ecosystem services (Pretty, 2003; Pretty, 2007). Meanwhile, the recent floods in the UK washed away valuable top-soils of regions industrially farmed reducing fertility (Monbiot, 2014).

3.6 There is no such thing as a free lunch (Trashing our life support system is profitable, ... for now)

Unfortunately, we should not think that the terms 'old-' and 'new design paradigms' indicate that the old design paradigm is somehow disappearing, far from it, although we have something much better to replace it. This is because the old design paradigm operates within the prevailing economic system of (falsely perceived) infinite resources and maximum profits. The London agency Trucost calculated that just for the year 2008, the 3000 largest publicly quoted companies caused $2.2 trillion worth of damage and destruction to the environment and ecosystems, as well as causing *"the disastrous impact of pollution and the rapid loss of freshwater, fisheries and fertile soils"* (Jowit, J., 2010).

If these companies had to pay the $2.2 tn for the damage they had caused it would wipe out more than one third of their profits. In other words, trashing the environment is very profitable. The companies assessed are active in the fields of consumer goods and services ($354.7 billion of environmental damage), utilities ($420bn damage), basic materials ($312bn damage), industrials ($201bn damage) and oil and gas ($175bn damage), technology ($20.3bn damage), healthcare ($15.5bn damage). The greatest environmental damages were greenhouse gas emissions valued at $608bn; other damages included water abstraction, acid rain, smog, dust and particles, nutrients and organic pollutants, These costs are known as 'externalities' which are costs borne by third parties not involved in the economic activities themselves (Jowit, J., 2010).

3.7 Everything is finite

The majority of economists and politicians are unable to accept the finiteness of the Earth's resources as they blindly urge their nations to achieve ever more growth. However, as far back as 1948, an American ecologist, ornithologist, and conservationist, William Vogt, described the relationships between population, resources, conservation, soils and food supply. He wrote *"And as the number of human beings increases, the relative amount of productive earth decreases by that amount."* His visionary book proclaimed for the first time the intimate interdependence between the growing populations and the Earth's ecosystems and resources.

In the same year that Vogt's book appeared the famous British astrophycisist, Sir Fred Hoyle, proclaimed that: *"Once a photograph of the Earth, taken from outside, is available, we shall, in an emotional sense, acquire an additional dimension … once let the sheer isolation of the Earth become plain to every man, whatever his nationality or creed, and a new idea as powerful as any in history will be let loose"* (Hoyle, 1950). On the 24 December, 1968, the crew of the Apollo 8 mission, photographed the Earth whilst in orbit around the moon creating the now iconic image Earthrise. Subsequently, Hoyle was to observe that: *"Well, we now have such a photograph … Has any new idea been let loose? It certainly has. You will have noticed how quite suddenly everybody has become seriously concerned to protect the natural environment. Where has this idea come from? You could say from biologists, conservationists, and ecologists. But they have been saying the same things as they're saying now for many years. Previously they never got on base. Something new has happened to create a world-wide awareness of our planet as a unique and precious place. It seems to me more than a coincidence that this awareness should have happened at exactly the moment man took his first step into space"* (Clayton, 1975).

The Earthrise image confirms that our planet is finite as no amount of words could convince. How long will the majority of economists and politicians continue to pursue economic growth on our finite globe?

Herman Daly, the American ecological economist, worked as a senior economist at the World Bank in the early nineties and *"realized that economists have not grasped a simple fact that to scientists is obvious: the size of the Earth as a whole is fixed. Neither the surface nor the mass of the planet is growing or shrinking. The same is true for energy budgets: the amount absorbed by the Earth is equal to the amount it radiates. The overall size of the system – the amount of water, land, air, minerals and other resources present on the planet we live on – is fixed."* (Daly, 2008) Furthermore, in their book For the Common Good, Herman Daly and John Cobb (1989) observed that *"… it has been the ecologists especially … who have turned on the economy as the great villain. They see that the growth of the economy has meant the exponential increase of raw material inputs from the environment and waste outputs into the environment, and they see that little attention has been paid by economists either to the exhaustion of resources or to pollution. They complain that economists have not only ignored the source of inputs and the disposition of outputs, but also have encouraged the maximization of both, whereas living lightly in the world requires that throughput should be kept to a minimum sufficient to meet human needs."* Will Steffens et al. (2015) refer to this "maximization" as the "Great Acceleration" (see below).

Design is a cogwheel in an economic machine with bigger gear wheels driving it. These bigger gear wheels include: the commissioners of design – largely the manufacturing and media industries, the corporations; their shareholders; the advertisers, governments who might provide subsidies and the banks who provide the credit to finance consumer consumption, and the consumers (Packard, 1963).

In this economic mechanism the biggest cogwheel is the corporations because as Pavan Suhkdev (2012) makes clear *"it is corporations, not consumers, in the drivers seat, and they are driving us in the wrong direction. Corporate advertising converts our insecurities into a chain of wants, needs and excessive demands, which have made our ecological footprint exceed the planet's ability to produce resources and absorb emissions – by more than 50%."* The typical corporation is focused on financial return with no or little social concern as it operates in today's 'brown' economy (see Glossary), *"delivering private gains at the expense of public losses by increasing environmental risks and ecological scarcities"* (Suhkdev, 2012).

Governments or rather politicians are lobbied by corporations to promote corporate interests, for benefits and subsidies. The UK government has even taken the measure of "buddying-up" cabinet ministers with industrial moguls and the CEOs of large representative corporations enabling companies to directly influence government policies without having to lobby (Ball & Taylor, 2013). James Hansen, a renown climate modeller with NASA participated in protests against E.ON (a power and gas multinational corporation) building a new coal fired power station in the UK. Hansen clarified the problem to a journalist saying that, *"The democratic process is supposed to be one person one vote, but it turns out that money is talking louder than votes. So I'm not surprised that people are getting frustrated. I think that peaceful demonstration is not out of order, because we're running out of time."* (Adam, 2009) Hansen's final comment about time referred to mitigating global warming.

Governments provide corporations with about $1 trillion in subsidies (i.e. from taxes) supporting the brown economy (defined as the economy excessively based on fossil fuels, exhaustive use of limited resources regardless of environmental degradation and pollution (qv Glossary)) including fossil fuels and unsustainable agriculture and fisheries. The subsidies enjoyed by many big corporations deliver *"private gains at the expense of public losses by increasing environmental risks and ecological scarcities"* (Sukhdev, 2012).

All of these 'gear wheels' have received the intellectual blessing of the economists with their fallacy of infinite growth. Considered altogether, they provide a colossal illustration of *"Es gibt kein richtiges Leben im falschen"* which may be translated as: *"There is no correct life [that can be lived] within a false one."* by the German philosopher, Theodor Adorno (2005).

3.8 The deadly pursuit of growth

Why is sustainability such an urgent challenge?

Three factors make the pursuit of growth very dangerous and achieving the challenge of global sustainability essential. The first is the character of growth itself, namely: 'exponential growth', the second is 'overshoot' and the third are 'tipping points' which make the challenges we face especially dangerous if we continue on a course of "business as usual". Lets consider each of these three factors in turn so we can understand how dangerous they are.

Exponential growth

Exponential growth occurs where a quantity grows by being multiplied by the same value at regular intervals. When represented graphically growth is expressed as an exponential (geometrical) or 'hockey-stick' curve. (In contrast, linear growth which occurs where a quantity grows by having the same value added to the sum at regular intervals). We can understand how serious exponential growth can be by the French riddle adapted from Meadows and colleagues (1974). Supposing your friend owns a pond for which he buys a prolific species of water-lily. The water lily doubles in size every day. Your friend explains that were he to let the lily grow without any maintenance that it will quickly cover and choke the pond in 30 days. In the beginning the lily seems small and an unlikely threat but he tells you that he will cut it back when it has covered half the pond. On which day will the lily cover half the pond? The answer is on day 29. Your friend has one day to save his pond. (Meadows et al.,1974). The lesson that this simple riddle illustrates for us is the danger of apparently endless supply to increasing numbers of consumers accelerates the arrival of resource exhaustion and simultaneously exponentially diminishes the time for adaptation.

Steffens and colleagues (2007, 2015) describe 12 socio-economic and 12 Earth system trends in our exploitation of the Earth as *"The Great Acceleration"* in which our consumption of resources and energy, emissions and pollution is marked by exponential growth. The same growth curve describes population, total real GDP, foreign direct investment, damming of rivers, water use, fertilizer consumption, urban population, paper consumption, McDonald's restaurants, motor vehicles, telephones and international tourism. Much of this growth has occurred since 1950. Obviously, it will not be able to continue.

Overshoot

We can understand the second factor: 'overshoot' with the analogy of driving a car towards a road junction with traffic lights. Normally, we are able to see well ahead to the junction and take the appropriate action of slowing down before reaching the lights so that when they are red we can bring the car to a halt at the line. However, Meadows and colleagues (1974) suggest, suppose one were blindfolded and had to drive by following instructions given by a passenger. Naturally, there would be a delay in our reactions and we would need to drive more slowly. However, suppose we drove at the normal speed which, together with our delayed response, would probably mean we would 'overshoot' the line and enter the junction and the dangers of the cross traffic.

The overshoot principle translates into systems, such as the biosphere, which has a finite carrying capacity for our species due to its finite resources. Add to the system an exponentially growing population and at some point it will cross (the junction lights) the line of the system's carrying capacity (if it does not slow down before hand at the lights). If the population continues to grow and continues beyond the system's capacity to sustain the population then disaster will follow. This does not mean disaster is inevitable since appropriate action can be taken, however, if the 'business as usual' model is followed then collapse will occur.

The key to survival is to recognize the limit of the biosphere's carrying capacity (the red lights) and slowing down and stopping on reaching the crossing. So far we were not able to do this for the cod and other fisheries whose populations have collapsed. This would not have happened had they been managed sustainably. However, we were able to save the ozone layer although the hole will take a long time to repair.

Tipping points

The third factor are "tipping points" when a system flips from one state to another. A simple example of a tipping point occurs when water freezes to ice at 0°C. However, in geophysical systems tipping points are more complicated and reinforced by feedback mechanisms. Some scientists consider that the Arctic ice cap passed a tipping point due to the melting of the ice cap beyond a certain area caused by global warming. Unfortunately, the exposed sea surface brings an additional force into play. The increasing surface area of the dark sea additionally absorbs the sun's energy and, acting as a positive feedback mechanism, the sea now warms accelerating the meltdown of the ice cap. The Arctic ice cap apparently passed a tipping point in 2007 due to combination of global warming and the positive feedback of the warming sea. However, the crossing of a tipping point causes the system to enter a new regime unlike the old one. The North Pole ice cap existed throughout the year rhythmically contracting and expanding with the seasons. Now scientists think that by about 2030 the Arctic ocean will be completely ice free in summer and only be covered with a thin sheet of ice during the winter.

The sea-floor methane hydrates appear now to be destabilizing, methane hydrates are a frozen mash of ice bearing methane lying below the surface of the seabed. Normally, due to the pressure of the water and the icy cold temperatures the methane hydrates are stable. However, global warming has warmed the waters of the Atlantic and the Gulf Stream so that the methane hydrates "*… are currently destabilizing beneath a sea-floor area of ~10,000 km² off the US eastern seaboard*" along the Carolina Ridge (Phrampus & Hornbach, 2012; Skarke, et al, 2014). The methane entering the seas will add to ocean acidification, atmospheric methane and de-oxygenation.

Tipping points also occur in biological systems but are difficult to anticipate due to our lack of experience and knowledge and could "*transform Earth rapidly and irreversibly into a state unknown to human experience*" (Barnosky, et al, 2012) possibly within a few generations. What we know is that incremental human activities and demands on biological systems can apparently have no effect whilst they may be gradually destabilizing, furthermore, the threshold value of the tipping point is generally unknown.

A biological system can quickly change when a tipping point is reached shifting from its initial state to a very different state and possess a variable range off characteristics beyond those of the initial state. Furthermore, it is nearly impossible to return to the initial state. Our greatest danger is that we might trigger a global state shift. Previous examples of such state shifts occurred over millions of years during 4 of the 5 earlier mass extinctions (Barnosky, et al, 2012). However, we are concerned with shifts occurring over a couple of generations; a time-span within which, scientists now recognize, we are already causing the current 6th mass extinction.

The "*Amazonian forests have a substantial influence on regional and global climates. Hence their removal by deforestation can itself be a driver of climate change …*" (Mahli, et al, 2008) and could be a dangerous tipping point.

In 2001 the Amazonian rainforest had been reduced to 5.4 million km² or about 87% of its original extent (Mahli, et al, 2008) due to the clearance of 837,000 km². Although there has been a slowdown of deforestation there is still ample potential for deforestation due to a range of demands for more roads, timber, and agricultural land for soya beans, sugar-cane, bio-fuels and free range beef.

If, for example, deforestation were to reduce the rainforest down to 3.2 million km^2 (53%) of its original size scientists believe that this would most probably overstep the tipping point for the current system's rainfall maintenance and cause the emission of 32 ± 8 Pg of carbon (1 Petagram = 1,000,000,000 tonnes) into the atmosphere. The fear is that deforestation will cause some of the sub-regions to 'tip' *"into a permanently drier climate regime and greatly weaken the resilience of the entire region to large scale drought driven by SST [sea surface temperatures] changes."* (Mahli, et al, 2008). It will be crucial to limit deforestation to between 30 - 40% clearance of the original Amazon rainforest's extent if climate changing tipping points are to be avoided. The danger is that without a pan-Amazon rainforest management strategy coordinated between all the member nations the tipping point could be reached as a *"tragedy of the commons"* phenomenon (Hardin, 1968). The current record breaking droughts occurring simultaneously in both Brazil and the south west USA may be the result of Amazonian deforestation.

A lethal combination

The exponential growth of our population, hauling along with it the exponential curves of all our demands on resources and production of wastes, including: GDP, paper consumption, average surface temperature, de-forestation, motor vehicles production, CO_2 emissions, ozone depletion, species extinctions, exploitation of fisheries, habitat transformation, destruction & fragmentation, water use and foreign investment etc. (New Scientist 2008) are leading us towards overshoot situations and tipping point changes and an unknown world. As a species we seem unable to curb our needs while danger stares us in the face! This was dramatically published by Will Steffen and his colleagues firstly, in 2007 and again most recently 2015 in a paper entitled: *The trajectory of the Anthropocene: The Great Acceleration in The Anthropocene Review and in the journal Science, entitled Planetary boundaries: Guiding human development on a changing planet.* The news is not good because Steffen and his team write in *Science* that: *"The human enterprise has grown so dramatically since the mid-20th century that the relatively stable, 11,700-year long Holocene epoch, the only state of the planet that we know for certain can support contemporary human societies, is now being destabilized"* (Steffen, et al., 2015). *"Therefore, the plausibility of a future planetary state shift seems high, even though considerable uncertainty remains about whether it is inevitable and, if so, how far in the future it may be"* (Barnosky, et al, 2012).

3.9 Conclusion

We can understand that completing the paradigm shift to the new sustainable design paradigm will not be easy. Indeed, it will be an exciting and enormous challenge to change, develop, design and adapt our social infrastructures for a sustainable future and in the process to discover greater satisfaction than consumerism could ever provide.

This enormous task is not made easier by a number of politicians and industrialists who do not want the economic system to change for fear of reducing their personal wealth and profits or loosing their political influence etc. Prof Brulle (2013) has revealed that in the US a 118 climate denial organizations have been funded, for example, by such donors as Koch Affiliated Foundations and ExxonMobil and many anonymous donors. The funding, which amounts to about $900 million per year (at least from 2003 to 2010) in support of the climate counter-change movement (CCCM) and used to create climate denial literature and conferences (e.g. The Heartland Institute) and other mis-information to confuse the public and delay appropriate political action to stop global warming.

In a letter to Nature 3 scientists were concerned to distinguish skeptics from deniers. Open minded skepticism makes a productive contribution to a debate. However, *"Denialism is motivated by conviction rather than evidence. It has been applied to a wide range of issues, including evolution and the link between HIV and AIDS. Deniers use strategies that invoke conspiracies, quote fake experts, denigrate genuine experts, deploy evidence selectively and create impossible expectations of what research can deliver. They rely on misrepresentation and flawed logic (P. Diethelm and M. McKee Eur. J. Public Health 19, 2–4; 2009)"* (Kemp, Milne & Reay, 2010).

The one-time English Chancellor, Nigel Lawson, is a denier who has neither a scientific education nor published a single scientific paper on climate change (accessed 5.3.2014: http://www.desmogblog.com/nigel-lawson). Yet, he promotes his unsubstantiated opinions denying climate change through his organization the Global Warming Policy Foundation (GWPF). The Foundation masquerades as an 'educational' charity working against UK government policies to mitigate global warming.

On the one hand the Internet has made information readily available, on the other hand, there is now not only a wealth of information available but also misleading information, some of it intentionally misleading and designed to deceive. This means that education now has an additional responsibility to teach students to distinguish between charlatanism and authentic knowledge. This charlatanism has reached new heights with the industrially promulgated deceitful misinformation denying climate change financed with billions of dollars throughout the first decade of the 21st century (Brulle, 2013). There is no doubt that the deniers of climate change have substantially hindered political action to limit global warming by a decade (Monbiot, 2006). Indeed, many scientists now consider that limiting average global warming to 2°C is now unlikely and the projection has been extended to embrace a temperature range of somewhere between 1.5 - 4.5°C by the end of the century (IPCC, 2013).

Noreena Hertz (2014) draws attention to the problem of false information on the internet. For example, one estimate is that one third of online consumer reviews are fake and furthermore "astroturfing," (fake grass) as it is called, is now big business with, for example, specialist companies paid by hotels to write fake reviews. Hertz advises researching and verifying who is the source the information? how are they funded? how do they get their information? where are they located? what is the source saying – opinion or fact? is there another source which could verify the information? etc. In view of the gravity of the revelations by Brulle (2013) knowledge authentification now needs to become a component of the educational curriculum.

In spite of the confusion, design and design education are one of the best equipped fields to meet the challenge for creating the changes needed to achieve a sustainable future. Its enormous potential lies with bottom up grass-roots innovation, strongly motivated and driven by young people, but they must be sure to identify the facts so that they can create design and communicate information which is accurate and which will bring us closer to a sustainable future.

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Oaks: http://www.rcdsmm.org/oak-trees
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Johan Rockström

4 Let the environment guide our development: The Planetary Boundaries of our finite Earth

"'To survive', says Lovelock, 'we must also take care of the Earth." Jules Pretty, 2007

This script is from the TED Talk given by Prof Rockström 31.8.2010 which can be found at: http://www.ted.com/talks/johan_rockstrom_let_the_environment_guide_our_development?language=en

4.1 Abstract

We live on a human-dominated planet and we are putting unprecedented pressures on the Earth's systems. This is bad news, but although surprising, it is also part of the good news too. Thanks to science, we are the first generation to be informed that we may be undermining the stability of the Earth and its ability to support human development as we know it. It's also good news, because the planetary risks we are facing are so large, that business as usual is not an option. In fact, we are in a phase where transformative change is essential, and this opens the window for innovation, for new ideas and new paradigms. This paper is a scientific journey on the challenges facing humanity in the global phase of sustainability.

On this journey, I would like a friend to join us, a good friend and a stakeholder, but one who is always absent when we are negotiating environmental issues. It is a stakeholder who refuses to compromise – planet Earth! She is a witness of our remarkable journey over the past 100,000 years and humbly reminds us of the period of grace we have had over the past 10,000 years. Lets consider the living conditions on the planet during the last 100,000 years. It's a very important period and for roughly half that period we have been fully modern humans on the planet when we have had roughly the same abilities that enabled us to develop civilizations as we know them.

These are the environmental conditions on the planet. I refer to temperature variability over the past 100,000 years. 80,000 years ago during a climate crisis our ancestors left Africa. Then 60,000 years ago they colonized Australia in another crisis. 40,000 years ago in response to yet another crisis they left Asia for Europe. Then we enter the remarkably stable Holocene period which has been the only period in the whole history of the planet that we know of that can support human development. A thousand years into this period we abandoned our hunting and gathering behaviour patterns and from a couple of million people we grew to the 7 billion that we are today. The Mesopotamian culture invented agriculture and the domestication of animals and plants. The Romans and Greeks followed and the rest of the story is as you know it. The Holocene has been the only period that could have supported humanity's progress.

The trouble now is that we are putting a quadruple squeeze on this poor planet. The first squeeze is population growth. We are already 7 billion people committed to 9 billion but the fact is this is not merely about numbers because its also an issue of equity as well. The majority of the environmental impacts on the planet have been caused by the rich minority, that is the 20 per cent that jumped onto the industrial bandwagon in the mid-18 century. The majority of the planet are justifiably aspiring to having the right to development and are on the whole aspiring to an unsustainable lifestyle which will create a momentous pressure.

The second squeeze on the planet is the climate agenda – the big issue – where the policy interpretation of science is that it would be enough if we were to stabilize greenhouse gases at 450 parts per million (ppm) to avoid average temperatures exceeding a rise of two degrees. This would avoid the risk that we may destabilize the West Antarctic Ice Sheet and cause the sea level to rise by 6 meters and also the Greenland Ice Sheet which would add another 7 meters to sea levels! One would have wished for the climate squeeze to hit a stronger and more resilient planet because the third squeeze is the ecosystem decline. Never have we seen before as

we have during the past 50 years such a sharp decline of ecosystem functions and services on the planet. One of the services that ecosystems such as our forests, land and biodiversity provide is the long term ability to regulate climate.

The fourth squeeze is surprise. We need to abandon our old paradigm and the notion and evidence that ecosystems behave linearly, that is predictably and controllably but in fact they are non-linear and reach tipping points. Systems can tip over very rapidly creating universal surprise as they abruptly adopt a new and often irreversible state. This poses a human pressure on the planet of a momentous scale. We may, in fact, have entered a new geological era – the Anthropocene, where humans are the predominant driver of change at the planetary level.

Now what is the scientific evidence for this? Unfortunately, it's ample. It's not only the carbon dioxide that has this hockey stick pattern of accelerated change. You can take virtually any parameter that matters for human well-being: nitrous oxide emissions, methane emissions, the rate of deforestation, over-fishing, land degradation, loss of species, etc. – because they all show the same pattern over the last 200 years. Simultaneously, they start to climb exponentially in the mid-50s, 10 years after the Second World War, showing very clearly that the great acceleration of the human enterprise starts in the mid-50s. For the first time, one sees an imprint on a global level. Now I can confirm that when you examine the disciplinary research in each of these areas, you will come to a remarkably important conclusion. It is that we have entered the most challenging and exciting decade in the history of humanity on the planet because we must now bend these ascending curves back.

Unfortunately, it is not enough to just bend the curves back because simultaneously there are also accelerating pressures on the planet's resources. We also have to recognize the fact that systems do have multiple stable states, separated by thresholds. We can illustrate this in a diagram of a ball in a cup, where the cup's depth is the resilience of the system. Now under pressure from climate change, erosion, biodiversity loss, etc. a system may gradually loose the depth of the cup so that it becomes shallower, however, the resilience still appears to be healthy. Then suddenly, the decreasing resilience, the decreasing depth of the cup levels out to the cup's lip so that the ball reaches the tipping point and the ball tips out and the system enters another state. The system changes its state and literally ends up in an undesired situation where a new biophysical logic takes over, new species take over and the system gets locked into a new regime.

Do we have evidence of this? Yes, coral reef systems. These systems are bio-diverse, low nutrient, hard-coral systems which are experiencing the multiple pressures of over-fishing, unsustainable tourism and climate change. Consequently, they are loosing their resilience so that the system tips over, soft corals then take over, and we get undesired systems that cannot support economic and social development.

The Arctic, also a beautiful system, is another example of a regulating biome at the planetary level which has taken knock after knock of climate change whilst still appearing to be in a good state. No scientist could have predicted that in 2007 it could suddenly have been crossing a threshold. The system suddenly and very surprisingly looses 30 to 40 percent of its summer ice cover. The drama is that when the system does this the logic may change. It may get locked into an undesired state because it changes colour. Previously, its whiteness reflected the sun's energy, but now with less ice cover the ocean absorbs more energy contributing to the further melting of the ice cap through a positive feedback. It is my opinion that this is the largest red flag warning for humanity that we are now in a precarious situation. Incidentally, you may also know that the only red flag that popped up there was from a submarine from an unnamed country that planted a red flag at the bottom of the Arctic so as to be able to control the oil resources.

We now have the evidence that the wetlands, forests, coral reefs, the monsoon system, the rainforests etc. all behave in this non-linear way. Consequently, a team of about 30 scientists from around the world gathered and asked the question for the first time: are we threatening this extraordinarily stable Holocene state of the Earth? Are we in fact putting ourselves in a situation where we are coming too close to thresholds that could lead to deleterious and very undesired catastrophic change for human development? It is as though we are now standing on the slippery stones at the edge of a giant waterfall. Normally, there is a safety fence well away from the edge indicating the danger zone. This is the new paradigm, we are in the danger zone between the fence and the waterfall's edge. Consequently, two

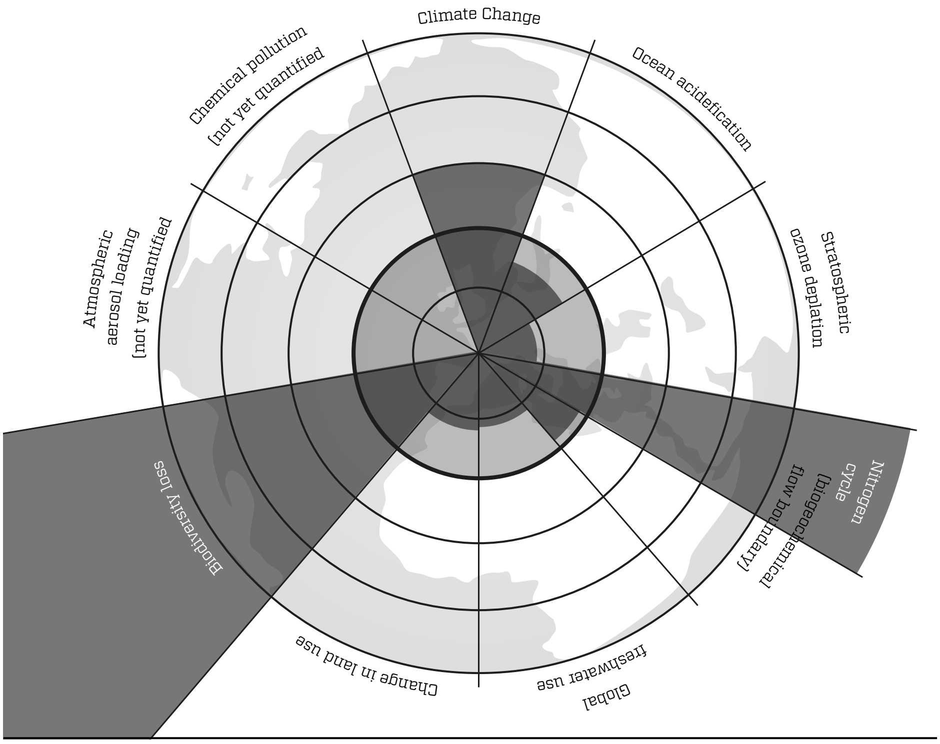

Figure 1: Planetary Boundaries Framework (Diagram with permission of the Stockholm Resilience Centre). The light grey tone enclosed in the thick circle equates to the "green circle" in the text and within which is the safe operating space. The dark grey tones extending beyond the thick circle indicate the extent to which three boundaries have been transgressed, namely: biodiversity loss, nitrogen cycle and climate change.

or three years ago we recognized that our old paradigm of just analyzing, predicting and pushing parameters into the future, aimed at minimalizing environmental impacts is in the past.

Now we have to ask ourselves: which are the large environmental processes that we have to be stewards of to keep ourselves safe in the Holocene? And could we even, thanks to major advancements in Earth systems science, identify the thresholds, the tipping points where we may expect non-linear change? And could we even define a planetary boundary, a fence, within which we then have a safe operating space for humanity? This work, which was published in "Nature," late 2009, after a number of years of research and analysis, led to the final proposition that we can only find nine planetary boundaries with which, under active stewardship, would allow ourselves to have a safe operating space. These include, of course, the climate and it may surprise you that its not just climate. This is because we are interconnected with many systems on the planet including three big systems which are: climate change, stratospheric ozone depletion and ocean acidification and there is scientific evidence of large-scale thresholds in the paleo-record of the planet's history for these three systems.

In addition to climate change, we also include boundaries which we call the slow variables; the systems that regulate and buffer the capacity of the planet's resilience and which include:

- the interference of the big nitrogen and phosphorus cycles
- land use change
- rate of biodiversity loss
- freshwater use
- functions which regulate biomass on the planet
- carbon sequestration
- Finally, we have two parameters which we were important to quantify:
- air pollution, including warming gases and air polluting sulfates and nitrates
- chemical pollution

Together, these form an integrated whole for guiding human development in the Anthropocene and for understanding that the planet is a complex self-regulating system. In fact, most evidence indicates that these nine may behave as the three Musketeers, "One for all. All for one." If forests are degraded beyond their boundary then it could undermine the ability of the climate system to remain stable. The drama here is in the fact that it may show that the climate challenge is the easy one when considering the whole challenge of sustainable development.

This is the Big Bang equivalent for human development which should remain within the safe operating space of the planetary boundaries.

In the diagram you can see the nine boundaries that have already been described radiating around the globe. The green circle in the middle indicates the safe operating space. The centre is the starting point, the pre-industrial point where we are very safely within the safe operating space. In the '50s we start progressing towards the edge of the green boundary. In the '60s already, through the green revolution and the Haber-Bosch process of nitrogen fixation from the atmosphere we cross the safe boundary. Today, humans take out more nitrogen from the atmosphere than the entire biosphere takes out naturally as a whole. We transgress the climate boundary during the '90s right after the Rio '92 conference. We are now in the situation today where we estimate that we have transgressed three boundaries:

› the rate of biodiversity loss. Scientists call this the sixth extinction because we are loosing so many species and at a rate between 100 to a 1000 times more than occurs naturally [Now reliably reported to be at 1000 times the natural rate by Pimm et al (2014)]. The fifth extinction occurred with the demise of the dinosaurs.
› nitrogen pollution
› climate change

We still have some degrees of freedom on the others but we are fast approaching the limits on land, water, phosphorus and the oceans. However, this gives us a new paradigm to guide humanity and focus on our, so far overpowered, industrial vehicle which operates as if we were only on a dark, straight highway with unlimited resources.

Now the question then is: how gloomy is this? Is sustainable development a utopia? There is no science to suggest this. In fact there is ample science to indicate that we can make this transformation, that we have the ability to now move into a new innovative gear, a transformative gear across different scales. The drama is that 200 countries on this planet have to start simultaneously moving in the same direction.

This changes fundamentally our governance and management paradigm from the current linear, command and control thinking, looking at efficiencies and optimization towards a much more flexible and much more adaptive approach where we recognize that redundancy both in social and environmental systems is a key to dealing with a turbulent era of global change. We have to invest in persistence, in the ability of social systems and ecological systems to withstand shocks and still remain in that desired cup. We have to invest in a transformations capability, moving from crisis into innovation and the ability to rise above crisis, and of course to adapt to unavoidable change. This is the new paradigm. Currently we are not doing this at any level of governance.

But is it happening anywhere? Do we have any examples of success of this mind shift being applied at the local level? Indeed we do, and the list is starting to become longer and longer. There is good news for example, from Latin America, where the -50s and -60s plough-based farming systems led farming to basically a dead-end, resulting in ever lower yields, degrading the soil's organic matter and resulting in fundamental problems for livelihoods in Paraguay, Uruguay and a number of other countries including Brazil. However, this led to innovation and entrepreneurship among farmers who, in partnership with scientists created an agricultural revolution of zero tillage systems combined with mulch farming and locally adapted technologies. Today, in some countries, this has led to a tremendous increase in the area under mulch, zero tillage farming, which not only produces more food but also sequesters carbon.

The Australian Great Barrier Reef is another success story.

It was collectively realized by tourist operators, fisherman, the Australian Great Barrier Reef Authority and scientists that the Great Barrier Reef is doomed under the current governance regime. Global change, over-fishing and unsustainable tourism were forcing this system into a state of crisis. However, the window of opportunity occurred when innovation and a new mindset has today led to a completely new governance strategy to build resilience, acknowledge redundancy and invest in the whole system as an integrated whole, and to create much more redundancy in the system.

Sweden, the country where I come from, provides another example. The wetlands in southern Sweden, as in many other countries, were regarded as a flood-prone nuisance in the peri-urban regions. But again the crisis resulted in new partnerships and new solutions with local actors transforming these regions into a key component of sustainable urban planning. So that crisis lead to new opportunities for innovative solutions.

Now, what about the future? Well, the future presents us with one massive challenge, which is to feed a world of nine billion people. We need nothing less than a new green revolution, but the planetary boundaries show that agriculture has to stop emitting greenhouse gases and start sequestering them. Furthermore, it has to do this on currently used land. We cannot expand anymore because it erodes the planetary boundaries. We cannot continue consuming water as we do today, when 25 percent of the world's rivers do not even reach the ocean. We need a transformation. Interestingly, and based on my work and that of others in Africa, for example, we have shown that even the most vulnerable small-scale rainfall farming systems, with innovations and supplementary irrigation to bridge dry spells and droughts, sustainable sanitation systems to close the loop on nutrients from toilets back to farmers' fields, and innovations in tillage systems can together triple and quadruple yield levels on currently farmed land.

The late Elinor Ostrom, Nobel laureate for economics in 2009, has clearly shown that across the world we can govern the commons if we invest in trust, local action-based partnerships and cross-scale institutional innovations with local actors, all working together can deal with the global commons on a large scale. But even for the hard policy areas we have innovations. We know that we have to move from our fossil fuel dependency very quickly into a low-carbon economy in record time. So what shall we do? Everybody talks about carbon taxes for emission schemes, but unfortunately, they won't work. One exception, however, is the policy measure of feed-in tariffs on the energy system which is already being applied for example, in China where it is used with offshore wind systems and in the U.S. where the guaranteed price for investment for renewable energy is given, but the electricity for poor people can be subsidized. Thereby you can raise people out of poverty. Furthermore, the climate issue is solved with regards to the energy sector whilst simultaneously stimulating innovation. These are examples of what could be done and scaled-up or extrapolated to the planetary level.

So doubtless there is ample opportunity here because we can list many, many examples of transformative opportunities for innovations all around the planet. However, the key to all of these, is the shift in the mindset and moving away from a situation where we are simply pushing ourselves towards a dark future. Instead, we need to backtrack to our future and ask "What is the size of the playing field on the planet? What are the planetary boundaries within which we can safely operate?" and then backtrack with innovations to within the boundaries. Clearly, the dramatic realization is that incremental change and growth is not an option. The scientific evidence confirms the harsh news that we are facing the largest transformative development since industrialization. In fact, what we have to do over the next 40 years is much more dramatic and more exciting than what we did when we moved into the situation that we're in today. Furthermore, science shows us that, yes, we can achieve a prosperous future within the safe operating space if we all move simultaneously, collaborating on a global scale in transformative options which will build resilience on a finite planet.

4.2 References and further reading

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Peter Stebbing

5 What Nature does for us: the value of Ecosystems and Biodiversity

> *"What is essential is invisible to the eyes."* Antoine Saint-Exupéry, The Little Prince

> *"Biodiversity is declining sharply, while our demands on nature are unsustainable and increasing. Species' populations worldwide have declined 52 per cent since 1970. We need 1.5 Earths to meet the demands we currently make on nature. This means we are eating into our natural capital, making it more difficult to sustain the needs of future generations."* WWF, 2014

> *"Human persistence depends on many natural processes, termed ecosystem services, which are usually not accounted for in market valuations. The global degradation of such services can undermine the ability of agriculture to meet the demands of the growing, increasingly affluent, human population."* Garibaldi, et al. 2013

> *"In nature's economy the currency is not money – it is life."* Vandana Shiva

5.1 Introduction

The individualism of the western consumer-style culture is one in which the individual is primarily and materialistically self-sufficient and independent. Care for others, strangers, even elderly relatives is usually provided by professionalized services: hospitals, schools, old peoples' homes, kindergarten, etc. Care for those unknown to us is not a part of the western consumer-style culture which is a culture of the self, selfishness and living alone or in a small family group. If we add to this the insulation from nature provided by the urban environment, then consideration for nature, let alone caring for nature is something which barely impinges on the concerns of most people.

Our world of supermarkets and shopping malls has alienated us from our ecosystems by providing a false and artificial buffer. If one were to trace the schesiological linkages of our dependency beyond the supermarket then it will lead us inevitably to nature's freely provided ecosystem services. They are powered by the sun's energy driving complex cycles and flows of water, carbon, nitrogen. The cycles, operating on different time scales, and of enormous complexity and scale are impossible for humans to replicate. Furthermore, they are not entirely inanimate but composed of an integrated and complex web of interacting organisms from the billions of soil microbes and mycorrhizal fungi inhabiting root systems to birds migrating thousands of miles. Consequently, we must understand how our continued existence on the Earth depends on the survival of all the other organisms and their ecosystems with whom we share the planet. The greatest danger we face is that a loss of species will cause not only our own ill health but cause ecosystems to collapse depriving us of the ecosystem services on which we depend.

The problems for our own welfare due to biodiversity loss appear already to be occurring so that *"For example, approximately 40% of children in the United Kingdom are now affected by allergic (Gupta et al., 2004) maladies as are similar numbers in the United States (Lynch et al., 2014)"* (Sandifer et al., 2015). It appears that allergies *"may result from a lack of exposure to microbes, especially in early childhood, which results in the human microbial community getting "poor training" which leads to hyper-responsiveness to bioparticles (allergy)."* A hypothesis has been developed called the "biodiversity" hypothesis (Hanski et al. 2012) that the increasing loss of "*macrodiversity (habitat and species richness of mac-*

roorganisms and their associated microbial biodiversity, which in turn may affect the human microbiota in ways that result in a wide variety of inflammatory based illnesses ... These disorders include allergies and asthma, inflammatory bowel disease, cardiovascular disease, some cancers,, potentially some neurodegenerative diseases, type 2 diabetes, inflammatory-associated depression, and some presentations of obesity (Rook 2013, 2010)" (Sandifer et al., 2015). When we experience good exposure to nature and biodiversity it is health enhancing with significant *"positive effects on mental/psychological health, healing, heart rate, concentration, levels of stress, blood pressure, behavior, and other health factors"* (Sandifer et al., 2015).

Maybe, due to the western style of thinking and its blindness to connectivity it is hardly surprising that "*... damage to the diversity of life on which our species critically depends has until recently escaped the attention it should have received. Here we remain ignorant of our own ignorance. Yet in this area human destructiveness has been most evident over the last 10,000 years. Current rates of extinction could in the long run be the most important of all these factors for human welfare and the future of our species. All are interlinked, and all represent pressure on the natural environment"* (Tickell, 2012).

The establishment of the Intergovernmental Panel for Climate Change (IPCC) was established in 1988. Sir Crispin Tickell's observation on the lack of recognition of our dependence on nature was confirmed by the founding of an organization for biodiversity and ecosystems, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, 2014) only as recently as April 2012. The IPBES, like its sister organization, the IPCC, is concerned with providing scientifically accurate and unbiased information to governments and policy makers about the state of biodiversity and ecosystems which are declining at an unprecedented rate.

In October 2010 at a summit meeting of the Convention on Biological Diversity (CBD) attended by 193 parties in Japan, at which the executive secretary of the CBD, Dr Ahmed Djoghlaf admitted that the CBD had failed because countries were not meeting their commitments to reduce species loss. The International Union for the Conservation of Nature (ICUN) estimates that *"some 30% of amphibians, 21% of birds and 25% of mammal species are at risk of extinction."* The director of IUCN, Dr Cyriaque Sendashonga in commenting on the lack of international progress on preserving global biodiversity stated that *"the political will is just not there."* Furthermore, *"In large part because public awareness is limited, politicians have not felt compelled to address the issue, she says, and, as a result, "biodiversity does not feature prominently at Rio""* (Tollefson, 2012).

The western urban consumer life-style is one which may appear entirely emancipated from Nature. Shopping malls and supermarkets sustain all the urbanite's needs; hermetically packaged foods are available from all over the world, regardless of the season. Rubbish is collected weekly from wheelie bins and the street's trees are 'coiffeured' each spring by the town council (Worthy, 2013). We might identify this as the consumer's ideal frame of reference (Neitzel & Welzer, 2012) enabling them to live their lives without being bothered about how nature works. The detachment of more than half the world's population from Nature is complete in this mythical urban life-style. Marketing, advertising, consumerism, working, and begging now occur in a largely concrete environment blocking out the experience and consciousness of Nature. Meanwhile, beyond the urban concrete Nature's resources are mined, sprayed, harvested, fished, piped, processed, manufactured, packaged and transported to shopping malls and supermarkets around the world. Nature is not a component of the urban-consumer's frame of reference. Our psychological dissociation and alienation from Nature is complete (Humes, 2013). Consequently, as Dr Sendashonga observed "In large part ... public awareness is limited." It is therefore profoundly regrettable that, *"Biodiversity does not feature prominently at Rio."* i.e. the Rio +20 conference (Tollefson, 2012) nor unduly bother a critical mass of the urban population.

So far about 1.23 million species of plants and animals have been catalogued of an estimated 8.7m - 9m species (Sweetlove, 2011; Cardinale, et al, 2012) with whom we share the planet (this estimate does not include the prokaryotes – the lowest forms like bacteria). Lord May of Oxford, a renown zoologist at the University of Oxford, UK, confirms that. *"Knowing how many plants and animals there are on the planet is absolutely fundamental,"* because *"Without this knowledge, we cannot even begin to answer questions such as how much diversity we can lose while still maintaining the ecosystem services that humanity depends upon"* (Sweetlove, 2011).

There are human societies which exist without money but there are none which can exist without either the plants and animals which constitute ecosystems nor the ecosystem services which they provide.

Past societies who either ignored or mismanaged their ecosystems have collapsed (Diamond, 2005). Today we are in the same danger because the current rate of species extinctions is about 1000 times the natural background rate (Pimm et al, 2014) and set to increase. Consequently, one of the most important reasons for us to design sustainably is to cause neither the destruction of ecosystems nor the extinction of species. Unfortunately, the fact is that economic growth and socio-economic productivity *"is almost always accompanied by the loss of natural habitat and species"* (Midgley, 2012).

This chapter is organized into two major parts: what nature does for us and what we do to nature. We begin by considering Nature's freely provided ecosystem services which fall into four major categories. Then we will consider what we are doing to Nature. The first major action concerning biodiversity was the environmental benchmarking project, the Millennium Ecosystem Assessment published in 2005. Trucost revealed the financial value of the extent of the damage that we have been doing to the environment. In this connection we will also briefly consider Pavan Sukhdev's work on The Economics of Ecosystems and Biodiversity (TEEB) revealing the pressures we are putting on Nature. The TEEB work, like Trucost, translates ecosystems and organisms into fiscal terms: money – an universally understood form of value. Finally, we consider the human driven 6th extinction and a summary of E.O. Wilson's extinction drivers with some examples.

It may seem unusual for a book on design to contain so much about ecosystems, plants and animals. This is deliberate because it is essential to have some understanding of ecosystems and design's impact on the environment, ecosystems and the species inhabiting them. International supply chains provide a global choice of resources, components, products etc. encouraging international trade which "… *is the underlying cause of 30% of threatened animal species extinctions*" (Hertwich, 2012) together with the demise of ecosystems and their ability to provide ecosystem services. The pioneering study by Lenzen and colleagues (2012) identifies for example, that German imports and consumption threaten 18 species around the world while Malaysian exports and foreign consumption threaten 70 of its own indigenous species. Meanwhile, imports into the USA from around the world threaten over 900 species (Lenzen et al, 2012). The international corporate advisory firm, Ernst and Young (2014), calculate that by 2030 the 'middle class' of consumers will reach 5 billion worldwide, notably in Asia. We can be sure that by 2030 design choices will be competing (if they do not already do so?) strongly against human needs for not only resources but ecosystems and the services they provide. An understanding of ecological-literacy can enable us to understand the problems catalyzed by the old design paradigm and help us move towards the new paradigm and a sustainable future.

5.2 What Nature does for us (why plants, animals and ecosystems are essential)

So what is it that all the millions of organisms give us, not merely as designers, but as fellow species on spaceship Earth? The plants, animals, and microscopic life, living in diverse communities and interacting in complex networks are the Earth's ecosystems. The ecosystems, considered albeit selfishly and anthropocentrically, provide us with ecosystem services which are free and are not merely benefits for our enjoyment but essential for continuing our survival. As Ehrlich & Ehrlich (1970) make clear: *"An understanding of the flow of energy and cycling of materials in ecosystems is essential to our perception of what is perhaps the most subtle and dangerous threat to man's existence. This threat is the potential destruction, by man's own activities, of those ecological systems upon which the very existence of the human species depends"* – ecosystem services. The term and idea of "environmental services" was developed by Ehrlich & Ehrlich in their book *Extinction: The Causes and Consequences of the Disappearance of Species. (1981)* when they named these benefits for the first time "ecosystem services."

5.3 Ecosystem Services

Ecosystem services are now classified into four major groups which are essential for our existence. Space does not permit here an exhaustive account of the services within each group rather, several examples are briefly described to illustrate each service.

The four groups are:

› **Provisioning Services:** which provide food, freshwater, wood for building and fuel, fibers and medicines etc.

- **Regulating Services:** which contribute to the stabilization and regulation of the environment, including: climate regulation, purifying water, air, disease regulation, mitigating floods, infiltration of water replenishing aquifers, controlling soil erosion, detoxifying soils and modifying climate.
- **Cultural Services:** which include the non-material and psychological benefits such as intellectual stimulation, aesthetics, spiritual values, recreation, education, and a sense of place.
- **Supporting Services:** the supporting services which are the essential foundation supporting the production and maintenance of all the above ecosystem services and include: soil formation, photosynthesis & the production of the net primary productivity (NPP), nutrient cycling and pollination.

5.3.1 Provisioning Services

Water

Life would be impossible without the circulation of water through the biosphere and its redistribution as rain. This is an ecosystem service powered by solar energy, with the aid of plants, especially trees, and the oceans. Typically water molecules circulate through the biosphere every 10 to 15 days (King, 1989). Water evaporates from the seas by the sun's energy forming clouds, which when blown inland deposit rain on the land. Plants also contribute to the water cycle by drawing water up from the soil through their roots and on reaching the leaves evapotranspires into the air (green water; see Glossary). The runoff water (blue water; see Glossary) from the land enters lakes, streams, rivers eventually rejoining the sea. Some (blue) water will soak (infiltrate) into the ground where it collects in aquifers.

There is a very small amount of freshwater on the Earth because 97% is salt water and of the remaining 3% about 2.2% is ice and the remaining 0.8% is available as freshwater (Ashby, 2009). If a bucket filled with water represents all the water that we have on the Earth then a drop on the finger represents the amount of available freshwater. Our use of water is prodigious: about 80% of all water consumption is used for growing food (Allan, 2011). It is calculated that the total water cost (virtual water) of producing a kilogram of beef is approximately 15,500 liters including water for the grass to grow to feed the cow (Allan, 2011). Meanwhile, the manufacture of a car requires an estimated 378,500 liters of (100,000 US gallons; Ehrlich & Ehrlich, 1970) virtual water. In the western US it has been estimated that since 2011 the fracking of nearly 40,000 oil and gas wells has used about 367,185,000,000 liters of water (97bn gallons; Goldenberg, 2014) contributing to the depletion of water in America's driest areas. Humans now appropriate half of all renewable and accessible freshwater flows which is leading to ecological disruptions because we have surpassed 'peak ecological water' (Gleick, 2009). If the water needs of ecosystems are curtailed then it will limit ecosystem services.

Food, Forests, Fibers and Medicines

Archeology confirms that for thousands of years Nature's generosity has fed, clothed, warmed and housed mankind. The provision of food, timber and fibers and medicines are ecosystem services. Agriculture covers about 38% of the Earth's terrestrial surface of which 12% is devoted to growing crops and the other 26% is pasture (Foley, et al. 2011) supporting animals which provide, beef, milk, leather and wool. Forests provide not only timber for building, products, paper and fuel but also a range of foods including nuts, fruits, fungi, and honey amongst others. Fuel from plant sources and trees constitutes 15% of the world's total energy consumption, but in developing countries it is 40%. Meanwhile, forests also provide a miscellaneous range of other resources such as oils, dyes, resins and insecticides (Chivian & Berstein, 2008).

Marine ecosystems are already overexploited and industrial *"Fisheries remove more than a third of the primary production of the ocean's coastal waters"* (Kolbert, 2014; Crutzen, 2002) confirming our dependence on a resource that has been tragically over-exploited. The film. End of the Line (Glover, 2009), confirms our worst fears. 'By catch', species caught but unwanted and not sold and *"some 7 million tonnes of caught fish are thrown back into the sea each year – has arisen because fishermen simply do not want the species they have caught. But wasteful discarding is more often the consequence of a fisheries policy that is designed to prevent fishermen targeting juveniles and species outside of their allotted quota."* Due to *"the culprits of the fisheries crisis – slippery politicians, greedy fisherman, thoughtless consumers and big business"* (Heffernan, 2009). Fisheries worldwide are in a severe crisis, but probably by 2050 the crisis will have ceased to exist as will sea food.

Plants and animals also provide a wide range of fibres for textiles, nets, cords and ropes.

Our medicine chest has been provided with many compounds which have evolved in our fellow organisms over hundreds of millions of years. Consequently, we have a range of drugs against a variety of diseases substantially contributing to both the security and the extension of the human life span. For example, chemotherapy drugs for cancer treatment have been developed from the needles of the European Yew. The willow (*Salix* spp) provides us with the essential ingredient of aspirin-salicyclic acid, which was even used by the Egyptians (Aspree, 2010).

The biodiversity of Australia is of special interest to bio-prospectors searching for new compounds for drugs. The Great Barrier Reef and Australia's northern coastline provide the habitat for cone shells which *"are veritable factories for producing pharmacologically diverse venom peptides"* with the potential for controlling nerve cells *"for treating intractable back pain, urinary incontinence, stroke, epilepsy, anxiety and high blood pressure."* Meanwhile, a rainforest tree from Sarawak of the *Aglia* genus has a bark with an apparently unique compound: CBL 316, with an unusual molecular structure (Blake, 2004). Research on *"CBL316 has shown inhibitory activity against 57 of 60 human cancer cell lines used by the National Cancer Institute, and selectively killed cell lines from tumours of the central nervous system, breast and melanoma"* (Kingsley, 2002).

It should not be forgotten that many indigenous peoples throughout the world whose livelihoods are threatened by the encroaching demands of economic development, have specialized knowledge of the medicinal properties of their endemic plants. Typical of many indigenous peoples around the world *"Australia's aboriginal people make use of many native plants as medicines – at least 70 species in central Australia alone. A few of these Aboriginal medicines, such as eucalyptus oil, tea tree oil and emu oil, are widely used, but indigenous knowledge is a largely untapped resource for bio-discovery"* Tragically, the Western Australia government's enforcement of aborigines to live in urban communities will hasten the loss of this knowledge (Blake, 2004).

5.3.2 Regulating Services

Ecosystem regulating services provide benefits by neutralizing many of the environmental disturbances caused by mankind to the environment. Although it might sound unscientific, regulating services can be thought of as ecosystem's "housecleaning and maintenance" activities. However, the reality is that the continual cycling of materials through ecosystems, creates the opportunity for continual interaction, change and the dispersion and disablement of many kinds of pollutants. Unfortunately, many of mankind's pollutants are beyond Nature's ability to break them down or are produced in such quantities that they overwhelm the environment (see Chapter 10 on pollution). However, so long as the ecosystem does not become overloaded with pollutants and particulates, it can continue to clean the environment. In cities, for example, the lead in the atmosphere produced by exhaust fumes can be taken up by the leaves of roadside trees. Chemical reactions which take place on the surfaces of moist leaves can transform many pollutants such as nitrous oxide into harmless compounds (Chivian & Berstein, 2008). Indeed, forest canopies function as amazing filter systems which help to regulate the composition of the air. Soil microbes perform similar roles and, for example, can break down methane, a potent greenhouse gas.

The movement of polluted water (the hydrological cycle) through ecosystems enables it to be purified because the soils, swamps, wetlands and marshes through which the water cycles perform a purifying role like an enormous physico-chemical-bio-filter.

Water, taken up by plants evapo-transpires into the air leaving behind its pollutants in the plants throughout which they become dispersed. Some wetland plants have been found to be highly efficient in removing toxins and their capabilities are deliberately exploited. For example, the water plant, Parrot Feather *(Myriophyllum brasiliense)*, can break down the explosive chemical TNT. In addition to actually breaking up a chemical compound some plants can detoxify soils by removing the toxin so that for example, Indian mustard and sunflowers can successfully reduce the lead content of heavily polluted soil by 43 %. Research into micro-organisms is revealing their potential to reduce toxins and manufactured chemicals into harmless compounds such as the hazardous chemical, vinyl chloride, which can be broken down by a bacterium BAV1 (Chivian & Berstein, 2008).

Climate regulation and modification is significantly influenced by vegetation and its global distribution. The Amazon rainforest for example, recycles about half its average rainfall from leaves through evapo-transpiration. In 2001 the extent of the Amazonian rainforest had been reduced to 87% of its original area. Computer models lead scientists to believe that were deforestation to continue so that a total of 30 to 40% of the Amazonian rainforest were removed then the climate would tip into a drier regime, locally weakening the entire region's resilience to large scale drought (Malhi et al, 2008). The severe 'mega-drought' affecting the region of Sao Paulo, Brazil, appears to be the combined result of deforestation, pollution and climate change (Larkin, 2015).

The loss of plant cover makes soil vulnerable to not only rain. It can also be blown away as shocked *"the people of America in 1934. In that year a vast trans-continental dust-laden windstorm, darkening the sun, broadcast the fact that large once-fertile portions of five western states – Kansas, Texas, Oklahoma. Colorado and New Mexico – had become a desolate dust bowl"* (Osborn, 1968). Plant cover and tree roots help to bind soils and also protect the soil from flooding. Root systems also help water to sink into the soil (infiltration) and replenish water tables. The extensive heavy rains during the 2013-2014 winter in the UK caused much top soil to be washed away into drains and rivers from ploughed fields which had been left bare over the winter (Monbiot, 2014). Satellite pictures of the UK after the record breaking rainfalls reveal brown streaks around the coasts of the UK caused by tons of top soil sediments which had been washed out to sea.

Pest control is a problem because industrialized agriculture creates unnatural expanses of single species crops – mono-cultures, which cause the problem. The crop pests multiply according to the availability of their food plant but are kept in control by the extensive use of pesticides (which further disrupt the ecosystem).

In China during the -50s, one of Chairman Mao's concerns during Great Leap Forward was that sparrows (any little brownish bird) were consuming large quantities of grain and were therefore "enemies" which should be eradicated. Sparrows (tree, house, dunnock, etc.) are omnivorous opportunists, however, those species with thick beaks specialize in eating seeds and those with finer beaks are insectivores. In 1958 a campaign was organized and across China citizens were mobilized to eradicate "sparrows". 800,000 birds were exterminated in Beijing alone during a coordinated killing spree which lasted several days. (Chivian & Berstein, 2008).

It was a catastrophic leap backward because it was discovered too late that "sparrows" eat not only grain but also insects, including the insect pests. The lack of the sparrows resulted in one of the biggest ecological imbalances in history. Insect pests devastated the rice crops and swarms of locusts overran the countryside. The eradication of the 'sparrow' (any small brown bird was considered a 'sparrow') undoubtedly contributed to a famine which killed 45 million Chinese. Eventually, sparrows had to be imported from Russia. The famine was exacerbated by the effects of extensive deforestation and the misuse of poisons and pesticides (Dvorsky, 2012). Today, we might consider that Chairman Mao's Great Leap Forward, which included the ignorant destruction of sparrows throughout much of China, as an event belonging to the past. However, today in Europe an estimated *"Half a billion songbirds are killed each year as they migrate between Europe and Africa. Historically, farmers across the Mediterranean captured a small number of passerines during the autumn and spring migration. Now poaching occurs on an industrial scale. Non-traditional methods such as thin "mist" nets allow individuals to capture tens of thousands of birds in a single night"* (McKenna, 2015). Many of these birds are insectivores that protect our crops for free, an ecosystem service.

The tragedy of the history of human interaction with ecosystems records that as we disturb the balance our continued actions to subsequently correct the situation make it progressively worse. Industrialized agriculture aided by the chemical industries is currently following this course. Industrial agriculture and the enlargement of fields by the removal of hedgerows has significantly contributed to the loss of biodiversity and the demise of many species which would have helped to control pests. Consequently, the increasing dependence on pesticides has also reduced the populations of many other beneficial species, notably wild bees and other pollinators. Meanwhile, the quality of the soil deteriorates due to the chemical care of industrialized agriculture. Nature, however, maintains healthier and more fertile soils for free.

5.3.3 Cultural Services

Cultural Services sustain our psychological well being in contrast to the benefits provided by the other three groups of services providing: food, warmth, shelter and a degree of environmental stability. Ecosystems have provided the initial spiritual stimulus for many religions in the World and the idea of the bountiful Earth mother can be found throughout time, worshipped in a diversity of forms and cultures. The Inuit, for example, worship the Sea mother. Animals have also provided the basis for-, or roles in many belief and spiritual systems influenced by the character of the culture: hunter, hunter-gatherer, agrarian or other criteria. There is no shortage of examples: the Athenian owl, the Christian fish, sacrificial lambs, cows and snakes in Hinduism, Ganesha the elephant God. The bear of the Finnish Sami people (Pentikäinen, 2007). The First American peoples celebrate many deities profoundly based in Nature and natural forms and elements. The tribal belief systems, although they are usually unique to each tribe or region, often embrace the principle of a Great Spirit connected to the Earth and its creation. Edward Wilson's hypothesis 'biophilia' (see Glossary), proposing our innate and emotional relationship with nature finds ubiquitous support in many cultures by the deification of animals, their symbolic representation and the use of organic motifs for decoration.

Aesthetics is deeply rooted in the character of our species and is confirmed by our propensity to decorate, first ourselves and our surroundings. For example, our ancestors decorated themselves with shell beads. Forty small pea-sized shells each bored with a hole and showing wear confirmed that they had been strung together. They were found in the Blombos cave in South Africa and are the oldest known jewellery at 75,000 years old (Pearson, 2004). In contrast to this unique find we have all unwittingly observed the ubiquitous use of botanical, especially floral motifs in the ornament of textiles, ceramics, wrought iron, wall papers and in many other forms in nearly all cultures. Nature in all its diverse forms, from individual organisms to natural scenes, is ubiquitously featured in cultures since the earliest times beginning with the cave paintings of Lascaux and the even older aboriginal paintings in Australia.

Nature and its ecosystems have provided the source for intellectual stimulation, and the ultimate challenge, enabling us to discover our own origin. The crucial step for which was the publication of *"On the origin of species by means of natural selection"* published in 1859 based on the acute observations of Charles Darwin. The study of nature has its own field of science, biology, the science and study of life, including ecology. However, has what we learnt in school served us well or does it alienate us from Nature? Do we understand how our individual lifestyles impact on the environment that supports us? More recently, school studies have adopted more integrated approaches to help students to understand the connectivity between different systems within our self-regulating planet. This latter concept, known as *Gaia theory* originally propounded by James Lovelock (1979) (see Glossary) emphasises the interconnectivity of our world.

Today we need to learn still much more about nature in order to determine whether we can have a future, but the nature we need to better understand is our own and how we are increasingly alienating ourselves from Nature. Nature has a limited capacity for our excesses and it is we who must know how to change ourselves to fit within boundaries set by our planet (See Chapter 4 by Johan Rockström).

Nature provides us with the environment for recreation and relaxation, be it a walk in the woods or the challenge of ascending a peak. Both provide the potential to discover spiritual values in the experience. Nature provides a sense of home or *"heimat"* through our experience and familiarity of the natural features of the environment in the region where we live.

5.3.4 Supporting Services

The supporting services, as their name implies, are necessary for the support and maintenance all of the: provisioning services, regulating services and the cultural services. The supporting services include: soil formation, photosynthesis & (net) primary productivity (NPP), nutrient cycling and pollination.

Soil

The dirt underfoot, the soil, care for it as little as we may is essential for our existence. *"Soil does far more that support farming and forestry. It stores carbon, filters water, transforms nutrients and sustains biodiversity"* (Banwart, 2011). Soil is not simply disintegrated rock broken down by the physico-chemical processes of weathering. It is an ecosystem composed of diverse soil organisms such as mites, nematodes, fungi, bacteria etc. creating an aggregate of decaying biomass and microbes. Genetic analyses of soil indicate that there can be anywhere between thousands to hundreds of thousands of bacteria in a gram of soil (Dance, 2008). The resulting mélange is an dynamic balance of mineral and organic nutrients which becomes accessible to plants after transformation by microbial action (Banwart, 2011).

Bardgett and Putten (2014) write in their abstract that *"Evidence is mounting that the immense diversity of microorganisms and animals that live belowground contributes significantly to shaping aboveground biodiversity and the functioning of terrestrial ecosystems. Our understanding of how this below-ground biodiversity is distributed, and how it regulates the structure and functioning of terrestrial ecosystems, is rapidly growing. Evidence also points to soil biodiversity as having a key role in determining the ecological and evolutionary responses of terrestrial ecosystems to current and future environmental change."*

Tragically, this essential natural capital: soil, is easily destroyed by industrialized agriculture which regards soil little more than a substrate to hold crop plants. The heavy winter rains of 2013-2014 in the UK which washed away so much topsoil from fields and deposited it into the seas around the British coast has already been described (Monbiot, G. (2014); as has the other soil scourge, winds which caused the 1930s US dustbowl problem. The overuse of chemicals; pesticides and fertilizers degrades and kills the soils' living component or biome. Evaporation of irrigated water causes salts to become concentrated in the soil. In some places around the world *"soil is being lost 100 times faster than it forms"* (Banwart, 2011). Furthermore, there are substantial areas where the soil is very degraded.

"One estimate valued the free services provided by the world's soils biota (organisms) at US$1.5 trillion or more each year." There is a very serious risk that if soils remain degraded and many of their inhabitants vanish we are in danger of loosing species which could increase harvests, purify the soils of toxins and provide medicines (Dance, 2008).

Photosynthesis and Net Primary Productivity (NPP)

Our existence on the Earth depends on one beautifully simple chemical reaction. Carbon dioxide and water interact with the chlorophyll molecule and powered by sunlight create the sugar glucose and oxygen. It is written like this:

$$6CO_2 + 6H_2O + \text{sunlight} > \text{(chlorophyll)} > C_6H_{12}O_6 + 6O_2$$

We can also see that six molecules of CO_2 are taken up in the photosynthesis reaction which means that the process sequesters or takes up CO_2 and so helps to mitigate global warming. Unfortunately, we are putting too much CO_2 into the atmosphere than plants are able to use in photosynthesis. Consequently, the CO_2 content of the atmosphere now stands at 400 ppm since pre-industrial times when it stood at about 280 ppm.

What is so amazing about this reaction is that we can recognize that we, along with all aerobically respiring organisms, are an integral part of this chemistry because we depend on the oxygen produced by photosynthesis and plants require the carbon dioxide we expire. Furthermore, it is free – no one has to pay to breath, at least not yet!

Net primary production is *"the net amount of solar energy converted to plant organic matter through photosynthesis"* (Imhoff et al 2004). Photosynthesis is the first step in the carbon cycle because carbon becomes fixed by plants and accumulates as quantifiable biomass. In fact *"oxygenic photosynthesis is responsible for virtually all of the biochemical production of organic matter"* (Field, et al. 1998). The marine (plankton and algae) and terrestrial (plants) are all primary producers and contribute in about equal portions to produce about 104.9 petagrams (104,900,000,000 metric tonnes) of carbon per annum (Field, et al. 1998).

Human appropriation of net primary production (known as HANPP) on land is for a range of produce including: vegetal food, meat, milk, eggs, paper, fiber, wood for fuel and construction (see above: ecosystem provisioning services). There are various estimates for the proportion of human 'appropriation' including 31-32% (with low and high estimates of 10-55%). Whatever the exact figure the proportion of appropriation is remarkable for a single species to co-opt so much of net primary production for its own use. Furthermore, our appropriation deprives other species for their needs, and changes the energy flows within food webs, the provision of ecosystem services, and also alters atmospheric composition and levels of biodiversity. A study by Imhoff and colleagues (2004) investigated the distribution of HANPP and found that there was enormous variations in the appropriation but an average of 20% ± 6% with in some regions such as western Europe and south central Asia consuming more than 70% and the lowest value in South America of about 6%. However, differences were more extreme on local levels which ranged from 0% in sparsely populated areas to over 30,000% in large urban conurbations.

Human activities can threaten net primary production in many ways. Land which used to normally support ecosystems is covered by cities, roads and other installations all reducing NPP by restricting the plant cover. For example, *"China plans to move 250 million people from farms to cities"* in a vast urbanization plan with the government goal of integrating 70 per cent of the population into cities by 2025 (Johnson, 2013). *"Some 3 million hectares of high-quality arable land and some 1 million hectares of paddy land have been built on or converted to urban use in just over a decade"* (Kong, 2014). Agriculture changes land-use from a natural ecosystem to monoculture crops providing only scant ground cover, furthermore, the land may remain fallow for significant periods of time reducing NPP yields. *"Altogether, agriculture occupies about 38% of the Earth's terrestrial surface"* (Foley et al, 2011).

Climate change may also reduce NPP. The first decade of the new millennium has been the warmest since records began. Water is essential for photosynthesis, as the formula confirms, and consequently, water stress limits terrestrial NPP. It has been calculated by Zhao & Running (2010) that over the decade 2000-2009 there was a reduction of NPP of 0.55 petagrams (550,000,000 metric tonnes) in the southern hemisphere. We can now understand that the danger of deforestation will not merely contribute to the loss of biodiversity, but that it would also increase the danger of regional droughts which would increase as the forest area further decreases. So far the Amazon rainforest has lost 13% of its original extent, if deforestation were to continue and remove as much as 30 to 40% of its original extent then the region might be pushed past its tipping point and into a drier climate regime. Increasing droughts would mean less water available for photosynthesis and NPP and the forest would no longer be a carbon sink but become a carbon emitter. Already *"There has been a drying trend in northern Amazonia since the mid-1970s …"* (Malhi, 2008).

Nutrient Cycling

"An adequate and balanced supply of elements necessary for life, provided through the ecological processes of nutrient cycling, underpins all other ecosystem services. The cycles of several key nutrients have been substantially altered by human activities …, with important positive and negative consequences for a range of other ecosystem services and for human well-being" (Millennium Ecosystem Assessment, 2005).

Solar energy powers the water cycle causing evaporation from water surfaces and also drives the winds carrying moisture inland to fall as rain. Obviously, the Sun's energy is the basis of our existence and provides about 170 Watts/m² which annually amounts to a colossal 87 Peta Watts or thereabouts (P = 1015 and so 87,000,000,000,000,000 Watts) *"This total is almost 8,000 times higher than the worldwide consumption of fossil fuels and electricity during the early 1990s"* (Smil, 1999). Amazingly, despite the sun's generous supply of energy *"A plant leaf converts, on average, just 1% [often less] of the energy it gets from sunlight into chemical bonds"* (Van Noorden, 2011). Powered by sunlight, plant photosynthesis is the point of interaction where carbon and water fluxes meet to create biomass (NPP) and the starting point for all food chains be they marine, freshwater or terrestrial (except those associated with deep sea vents). Although water and carbon are major constituents in the creation of biomass, it would not be possible without other essential elements namely, nitrogen and phosphorus. Nitrogen is in plentiful supply since almost 80% of the air consists of nitrogen, however, it cannot be so easily utilized by organisms and circulates through ecosystems in complex pathways. Nitrogen is converted by some algae and soil-living nitrogen-fixing bacteria into compounds that can be used by plants and animals. When the latter die their detritus is broken down by detrivores and bacteria and eventually becomes available to be taken up by the roots of plants.

The element phosphorus was first isolated from evaporated urine by the alchemist Hennig Brand in 1669 (Curtis, 1962). Phosphorus is essential for life because it is a key element in the composition of both the DNA and RNA, the genetic molecules. It also plays a key role in the cell's energy management. Phosphorus does not cycle so readily through the biosphere as the ubiquitous nitrogen and is found mainly in rock deposits or in sea bird excrement known as guano (Ehrlich & Ehrlich, 1970). Guano is collected along the west coast of South America, in Chile and Peru and gathered in sufficient quantities to be marketed as fertilizer. In the mid-1800s it was learned how to make fertilizer from phosphate bearing rock strata. Phosphate fertilizers have played a key role in the world's population explosion (Gray, 2009). The starting point for the phosphorus cycle might be considered its extraction for rock deposits and application to the land as a fertilizer. It cycles then between grass and plants and herbivores which return it to the ground in their waste and carcasses. When spread as fertilizer it frequently leaches off the land to eventually reach the sea. Phosphate rich oceanic upwellings may nourish marine food-chains eventually feeding the guano producing sea-birds with fish. However, on reaching the sea, phosphorus may be semi-permanently lost because the likelihood of its return to the land will depend on the tectonic upwelling of phosphate rich submarine strata during a future geological age (Ehrlich & Ehrlich, 1970).

Pollination

The decline of the honeybee (*Apis mellifera*) has been going on now for more than half a century with a loss of 50% amongst commercial colonies in the USA between 1940 and 1995 due to pesticides and parasites. Furthermore, populations of other pollinators are also "crashing" (Holden, 2004). In recent years the debate has focused on the impact of neonicotinoid (an insect nerve poison) pesticides which cause bees to become disoriented so that they are unable to find their way back to the hive or nest and so die. In parts of China bees have all but disappeared and on the border between China and Nepal in Maoxian County they are extinct so that people must pollinate flowers by hand. Apparently, it takes about 20 to 25 people to pollinate 100 apple trees. However, two hives of bees could perform the same task for free (Chivian & Berstein, 2008). We can now appreciate that it would cost a lot to pay 20-25 people to pollinate the 100 apple trees in full flower. In fact it has been calculated that in the UK insect pollinators contributed £510 million to agriculture which if done by hand would cost £1.8 billion! (King, 2012). The worldwide value of the ecosystem service of pollination carried out by bees and other insects, birds and bats has been calculated at €153bn (Gallai, et al. 2008). In food terms, 75% "*of global food crops depend at least partly on pollination by animals, usually insects.*" Furthermore, *"These crops form an increasing fraction of global food demand"* (Tylianakis, 2013).

This concludes a very brief summary of the four groups of ecosystem services and what Nature gives us. It also demonstrates the breadth of what we take for granted and confirms Nature's major contribution to human survival and culture.

In return, what do we do for Nature?

5.4 What we do to Nature

5.4.1 Millennium Ecosystem Assessment (MEA) 2005: Nature – the patient

In 2005, following six years of research by 1360 scientists an invaluable report appeared which effectively took the pulse of the health of the Earth's ecosystems (Stokstad, 2005). It is only possible with such a fundamental audit to know whether we are approaching sustainability. The question at the heart of the MEA was *"How well can ecosystems continue to provide the so-called services that people depend on but so often take for granted?"* (Stokstad, 2005). The MEA adopted diverse approaches and provided options which can help policy makers to take decisions where ecosystems and people interact. 24 kinds of ecosystem services were described and following the MEA evaluation 60% were being used unsustainably or becoming downgraded. *"Forests have essentially disappeared from 25 countries, with 9.4 million hectares being lost annually ... one third of the mangrove forests for which there is historical data have been lost, as have 20% of coral reefs, with a further 20% downgraded. Nearly 40% of the rivers of the world have been fragmented"* (Mooney, Cropper & Reid, 2005). In other words *"We're undermining our ecological capital all around the world,"* says Robert Watson, chief scientist of the World Bank and a lead author. During the assessment it became clear that ecosystems that were undergoing substantial damage could reach a tipping point and go into irreversible change. Furthermore, the pressure on ecosystems harms the poor the most, particularly in the drier regions of *"sub-Saharan Africa, central Asia, central Latin-America where a third of the world's population tries to make do with 8% of its freshwater"* (Stokstad, 2005). However, healthy ecosystems are the best way forward to alleviate poverty. We now know that there is a danger that if policymakers make the wrong decisions then ecosystems can undergo catastrophic failure. Unfortunately, the MEA was unable to indicate where those thresholds might be. Following the MEA the need for the design of *"effective policy is more quantification and dollar values of ecosystem services, says FAO's Tschirley"* (Stokstad, 2005). It was a couple of years later that this knowledge was to became known and hit the headlines *"The trillion-dollar cost of global pollution"* (Jowit, 2010).

5.4.2 Trucost (2008) & TEEB (2010)

In 2008 the London Agency Trucost received a commission from the United Nations Environmental Program (UNEP), to investigate the activities of the top 3000 largest publicly quoted companies. *"The report comes amid growing concern that no-one is made to pay for the disastrous impact of pollution and the rapid loss of freshwater, fisheries and fertile soils"* (Jowit, 2010).

The report revealed that just for the year 2008 these companies made profits in the region of $6 trillion but had caused an estimated $2.2 trillion of environmental damage and pollution. In other words about a third of their profits. *"What we are talking about is a completely a new paradigm ... markets are not fully aware of these risks, and don't know how to deal with them."* said Richard Mattison, the leader of the report and Trucost's chief operating officer (Jowit, 2010).

The economist, Pavan Sukhdev and the lead author of *The Economics of Ecosystems and Biodiversity* (TEEB) study published in 2010, is equally compelling. The report shows *"how economic concepts and tools can help equip society with the means to incorporate the values of nature into decision making at all levels."* Sukhdev points out in his WWF YouTube video (WWF, 2008, *Living Planet Report*) that industry could not support an annual capital loss of $1.5 trillion per annum yet an annual loss of $2-5 trillion of natural capital, which is equivalent to 7% of GDP *"passes below the radar because what is being destroyed are the commons, the natural public goods and services which belong to no-one but belong to everyone. Forests, fisheries and top soils are being destroyed, there is pollution of freshwater, we are losing biodiversity and reducing the gene pool and species from which we could provide new medicines."* etc. etc.

Valuing Nature: from a tree to a hectare of rainforest

How can we imagine the economic value of ecosystems and biodiversity? If we think of the value of one tree, we probably think of how much its wood, depending on the wood's qualities, can be sold for and used for building, paper or fuel etc.

Another way of valuing a tree is by its ecological benefit (see also Chapter 12 by Vandana Shiva). On the campus of the Ohio State University, the University's Chadwick Arboretum has labelled the trees with their annual ecological values so that the value of a Norway Spruce (*Picea abies*) with a crown diameter of 14 feet breaks down as:

- › Storm water mitigation $41.70
- › Reduced atmospheric carbon $2.43
- › Energy (heating/cooling) $24.14
- › Air quality value $2.82
- › Aesthetic/history $32.32

The total annual ecological benefit provided by this spruce is $103.41.

Meanwhile, the Overcup oak *(Quercus lyrata)* with a crown diameter of 39 feet provides annually ecological benefits with a total value of $504.33:

- › Storm water mitigation $173.76
- › Reduced atmospheric carbon $25.90
- › Energy (heating/cooling) $87.97
- › Air quality value $10.96
- › Aesthetic / History $205.74

If we can understand the ecological value of how one tree can benefit our existence then it is possible to understand how we can place a fiscal value on the rest of nature. The New Scientist (Pearce, 2012) published the value of some different biomes.

- › Rainforest per hectare $23,000
- › Coral reef per hectare $1,195,000
- › Mangroves per hectare $18,000
- › Savannah per hectare $31,000

In his Youtube WWF video Sukhdev referred to the 'commons'– the oceans, air and forests that do not belong to anyone but belong to us all and are being destroyed, damaged and polluted. This is the *'tragedy of the commons'* that Garrett Hardin (1968) described in his key paper in 1968. It is a concept derived from the village 'common,' a piece of land around which a village was built in medieval times. The common belonged to all the villagers and anyone could freely put their livestock out on it to feed. This freedom encouraged all the villagers to put their livestock on the common with eventually the tragedy occurring that the 'common' became so overgrazed it could not support a single cow.

This 'tragedy' is what is happening to the 'commons' of the seas and the oceans which are all being over-fished and polluted with plastic; to the atmosphere into which CO_2, smog and other pollutants are released; and of course to deforestation. Another 'commons' is the freedom to have children which is also declared as a right in Article 16 of the United Nations Declaration of Human Rights (Amnesty, 2008). Population growth is an enormous issue since it is estimated that by 2050 the World's population will have increased by another 2 billion. Hardin writes that *"It is painful to have to deny categorically the validity of this right."* We have already abandoned a number of commons, firstly, food gathering by creating enclosed farms. Subsequently, another was to use the commons for waste disposal but now restrictions are generally accepted. Relevant today as much as it was when Hardin wrote in 1968 that *"we are still struggling to close the commons to pollution by automobiles, factories, insecticide sprayers, fertilizing operations, and atomic energy installations."* So with a rapidly increasing population, *"The most important aspect of necessity that we must recognize, is the necessity of abandoning the commons in breeding. No technical solution can rescue us from the misery of overpopulation. Freedom to breed will bring ruin to all."* These are serious words but on a planet with limited resources Hardin's words touch the central problem. Already, famine has been exacerbated by the bio-fuel boom (Vidal, 2010).

In a more recent report entitled "Natural Capital at Risk – The Top 100 Externalities of Business" (2013) Trucost calculates now that the *"global top 100 environmental externalities are costing the economy world-wide around $4.7 trillion a year in terms of the economic costs of greenhouse gas emissions, loss of natural resources, loss of nature-based services such as carbon storage by forests, climate change and air pollution-related health costs."*

5.5 6th Extinction and E.O. Wilson's 'HIPPO'

The current worldwide dying out of so many species has been described by biologists as the sixth extinction, the last comparable extinction event occurred 65 million years ago when the dinosaurs met their demise. The normal rate of extinction is about 1 species per million, per year and the evolution of new species is estimated to be about the same rate (Wilson, 2011). The current rate is now 1000 times the normal background rate (Pimm, et al. 2014). Edward *"Wilson famously used the species – area relationship to estimate an annual extinction rate of 27,000 species – one species every twenty minutes. This and similar estimates have attracted criticism but recent work has shown that levels of species endangerment are rising in line with species – area predictions"* (Purvis & Hector, 2000). Wilson (2010) lists the causes for the current extinctions with the apt acronym HIPPO which stands for:

5.5.1 Habitat destruction

We might all consider that the deforestation of rainforests is probably the most serious example of habitat destruction now occurring on the planet. The rainforest is being replaced by cattle ranches (which is driving 80% of the current deforestation) and agriculture (which is driving the rest) and oil palm or soya bean plantations. In the Brazilian Amazon, the rainforest cover *"has declined to about 80% of its original area"* (Davidson, et al. 2012). The Amazon rainforest is *"the richest assemblage of plant species on Earth"* totaling about 16,000 tree species (Steege, et al, 2013). About 6000 of the tree species have populations of less than 1000 individuals. Clearly, such small populations are particularly vulnerable and extinction of a species is easily possible by deforestation. In 2010 it was reported that *"Over half of all medicinal plants in Africa face extinction"* and furthermore, worldwide *"More than 17,000 species of fauna and flora were at risk of extinction in 2009"* (Gilbert, 2010).

The fragmentation of habitats due to roads and the development of human infrastructures, such as farming, leaving islands of 'nature' causes a slow loss of biodiversity. For example a 100-hectare fragmented/isolated experimental plot in the Brazilian rainforest suffered a 50% decline in the species of birds living below the canopy over 15 years. If the fragmented plot is 1,000-fold larger then it takes 10 times longer to loose half the species (Ferraz et al, 2003). In Tanzania it is planned to build a road through part of the Serengeti National Game Park across the large mammal migration route and also bisect populations of rhinoceros and wild dogs – it is a textbook example of fragmentation (Dobson, Borner & Sinclair, 2010). Meanwhile, another great environmental concern is the planned building of a second canal through the Central American isthmus.

In Europe the overproduction of food during the 1970s and 1980s (Stewart, 2005) which lead to the accumulation of butter mountains and wine lakes together with the introduction of the European Common Agricultural Policy has caused a catastrophic 50% loss of European bird populations since 1980 from an estimated 600 million to 300 million (McKie, 2014). In the UK hedgerows, which provided habitats for many species, disappeared to enlarge fields and increase the efficiency of industrialized agriculture. Added to which the extensive use of pesticides were significant contributors to the halving of the bird population.

Another threat occurring everywhere and encroaching on ecosystems is the spread of human habitation. The emergence from the economic recession is witnessing building booms in several European countries, despite 11 million vacant homes in Europe (Neate, 2014) with more and more people living alone or in smaller numbers, small households have become an ecological threat. Research reveals that over the longer term from 1893 the average household consisted of 5 people living together but today the average number is 2.5 (Liu & Peterson, 2014). Even considering the shorter term between 1970 and 2000, the average household in developing countries dropped from 5.1 to 4.4 and the decrease in developed countries just over the same 30 years was from 3.2 to 2.5 (Kellman, 2003). Critically, it is not just that the Earth's surface is being covered, but habitation is expanding into biodiversity "hotspots" especially in countries like China, India, Brazil, Indonesia and Bangladesh. Furthermore, households influence the consumption of resources including fuel for cooking, wood for furniture etc. (Liu, Daily, Ehrlich, Luck, 2003).

5.5.2 Invasive species

Species can invade new regions by several agencies. Humans have deliberately introduced new species into regions for food and fiber, or for their ornamental value. Some species have been introduced to new regions as biological controls to eradicate pests often with unanticipated results.

In our globablized world species travel in the bilge-water of ships which is emptied into foreign waters. Currently, global warming is also a driver for species movement and invasion as new regions become more hospitable than the endemic region. Global warming has, for example, enabled the mountain pine beetle and several other species of bark beetle in North America to extend their ranges farther north and they are now destroying swathes of pine forest in British Columbia. Previously, the cold northern climate restricted their range, killing off those beetles who spread too far north. It has been calculated that from 2000 to 2020 the mountain pine beetle together with other bark beetles will cause the release of 270 mega-tonnes of carbon and kill trees over an area of 374,000 km² (Kurz, et al. 2008). Furthermore, nearly 30 billion conifers from Mexico to Alaska have been killed causing changes to watersheds and ecosystems. Human action on two counts has created the ideal situation for the beetle epidemic: extensive pine forests and global warming which has extended the beetle's range (Nikiforuk, 2011).

Mankind has deliberately introduced species to new regions to control pests ('biological control') instead of using pesticides. Unfortunately, this procedure can go tragically wrong. One failure was the introduction into Australia of the cane toad from Hawaii where the toad had reportedly eaten sugar cane pests, notably the sugar cane beetle. This highly invasive species can advance about 50 kilometres per year and now covers a range of more than a million square kilometers of north and north-east Australia (Phillips, et al. 2006). Australia has no native toads. Unfortunately, the toad has now become a pest because in addition to being a voracious predator it also has very toxic chemical defences which are deadly to predatory Australian species which are now threatened with extinction (Zielinski, 2012). It is feared that the cane toad will have a lasting impact on the unique Australian fauna.

'Domesticated' or ornamental plants are frequently introduced into new regions by gardeners. However, if they become established in the wild they can damage the endemic ecosystems. The Japanese Knotweed *Fallopia japonica*, for example, is native of the Far East but has been introduced into Europe where, growing in tall stands upto 2 meters high in the wild it can completely smother native species. The common raccoon (*Procyon lotor*) from the USA is now spreading throughout Europe after initially being imported as a pet but subsequently was released into the wild. A population has now become established which in Germany is estimated to be over a million (Schulz, 2012). The raccoon is an omnivore feeding on invertebrates, small animals including amphibians and rodents and plant foods and will undoubtedly become a threat to European biodiversity. The problem with introduced species is that the native fauna and flora have not evolved and are not adapted to compete with alien introductions.

5.5.3 Pollution

Marine dead zones are caused by fertilizer run-off or sewage pollution. The excess of nutrient causes an algal bloom which on dying and rotting down causes the body of water to become de-oxygenated and unable to support life creating a dead region. This succession of events is known as eutrophication. Dead regions due to eutrophication are also extensive where there are high concentrations of population around continental coastlines. Furthermore, *"rising levels of carbon dioxide could increase the volume of oxygen-depleted 'dead zones' in tropical oceans by as much as 50% before the end of the century – with dire consequences for the health of ecosystems in some of the world's most productive fishing grounds"* (Schiermeier, 2008). The areas in the seas which now cannot support fishes because of prohibitively low oxygen levels has increased by 4.5 million square kilometers during the past 50 years (Gewin, 2010). Oil spills such as the Torrey Canyon, the Exxon Valdez and the largest oil spill ever, the Deepwater Horizon disaster due to criminal negligence by BP, damage large areas of the marine environment for many years afterwards.

The pollution by CO_2 causing global warming has been described in Chapter 10 and the pollution of the oceans by plastic waste has been described in Chapter 3.

5.5.4 Population, i.e. human population growth

Spreading cities and towns, industrial installations, road and rail transport systems etc. covers ever more land destroying and fragmenting ecosystems and natural habitats. In 2008 the United Nations announced that one-half of the world's population was living in cities and that furthermore, the urban population is projected to increase by another 50% by 2030 to 5 billion (Glaeser, 2011). The anticipated world population by 2050 is predicted to reach about ± 9 billion. However, in 1995 about 1.1 billion people, or 20% of the world's population at that time were already living in biodiversity hotspots (areas which are particularly rich in endemic species and simultaneously threatened by humans and their activities). The area covered about 12% of the Earth's land surface (Cincotta, et al. 2000). If the urban population is going to increase by 50% what will this mean for biodiversity?

5.5.5 Over-harvesting by hunting (poaching) and fishing

The illegal trades in ivory and rhino horn are decimating the elephant and rhino populations *("five countries in central Africa lost 65% of their forest elephant population between 2002 and 2011 despite an ivory sales ban in 1989 … South Africa alone lost more than 1,000 rhinos to poachers in 2013, a 50% increase on the year before"* (Vaughan, 2014). Meanwhile the fishing of sharks for just their fins together with industrialized fishing is contributing to the collapse of commercial fish species' populations worldwide. An analysis by the ichthyologists, Myers & Worm, (2003) *"suggests that the global ocean has lost more than 90% of large predatory fishes"* compared to pre-industrial levels. Major fish stocks that have now declined and collapsed, including the: Atlantic halibut, Atlantic bluefin tuna, Atlantic swordfish, North Sea herring, Grand Banks cod, Argentinian hake, and the Australian Murray River cod (Diamond, 2005). The collapse of the populations of all these species are further examples of *"the tragedy of the commons"* (Hardin, 1968) where consumers share resources but no-one owns, cares or manages them nor is ultimately responsible.

"By-catch – the technical term for unwanted fish or marine life that get caught up in trawlers, gill nets and longlines – is dangerously depleting the ocean of fish stocks, and could jeopardize global food supply. As much as 40%, or 63 billion pounds (28bn kg), of the 160bn pounds (lbs) of fish caught globally every year are discarded. Scientists estimate as many as 650,000 whales, dolphins and seals were also killed every year by fishing vessels" (Goldenberg, 2014). The report, about which Suzanne Goldenberg writes is prepared by the conservation group Oceana (Keledjian, et al, 2014) which also reveals that *"These nine fisheries combined throw away almost half of what they catch and are responsible for more than 50 percent of all reported bycatch in the U.S., injuring and killing thousands of protected and endangered species every year"* (Oceana, 2014).

How long can a situation like this continue? It is certainly not a long term sustainable strategy, because eventually marine food chains will suffer and ecosystems collapse. The oceans may provide jobs for fishermen now but this strategy destroys their own future. Is this the message we all must understand if we are to eat fish in the future?

5.6 Conclusion: the environment is not well; what to do?

So what does all this mean for designers and design educators? Design is a commercial corner stone of developed economies and a growing activity in developing economies. Designers play an increasingly pivotal role in commerce from product design, their packaging, advertising, web sites, promotion and communications and much, much more. Tischner (2000) writes that *"More than 80% of all product-related costs and environment impacts of a product during its manufacture, use and disposal are determined during the product-planning phase."* Therefore all design decisions must always consider the ecological cost in order that design solutions have the least ecological impact possible. As we have learnt *"Despite technological developments, we are still intimately connected to our environment. Our lives depend on ecosystem goods such as food, timber, genetic resources, and medicines. Ecosystems also provide services including water purification, flood control, coastline stabilization carbon sequestration, waste treatment, biodiversity conservation, soil generation, disease regulation, maintenance of air quality and cultural benefits"* (Ayensu, et al.,1999). Meanwhile "… *socio-economic development is almost always accompanied by the loss of natural habitat and species. Short-term economic gains may thus trump longer-term benefits for human society creating vulnerabilities that could be avoided or corrected with enough knowledge about the role of biodiversity"* (Midgley, 2012). This uniquely challenging dilemma already calls for enormous innovation because designers have a colossal task of balancing design activity with an understanding of biodiversity and minimising ecological impact. However, although the population growth rate is in decline, nonetheless, the population is estimated to increase to about 9 billion by 2050. It should be clear that so far our efforts to minimise our ecological impact are inadequate due to our exponential demands on the world's resources. In the new design paradigm design innovation has to find new ways through which it can contribute to the restoration of ecosystems and the environment. Using less of Nature's bounty is not an answer for a sustainable future. We have to integrate ways into design activity which increase the planet's Natural capital. The communication of our predicament is crucial so as to enable all to understand and act. Design has enormous potential to communicate knowledge about our dependency on ecosystems and the life supporting services they provide through the visualization, communication and dissemination of information by different media to all stakeholders: the planet's inhabitants. This information must reach all from primary school children to policy makers and presidents.

Earth Stewardship or tithe-ship

Victor Papanek (1971) proposed that all designers should devote a tenth of their time to working for *"the 75 per cent of mankind in need."* However, the tithe could be for repairing and restoring our natural capital, the ecosystems on which we all depend.

There are many organisations for which one can become a volunteer, for example the charity, Trees for Life (TFL) has planted a million native trees to restore the Caledonian forest in Scotland and also to repopulate it with native animals. Invasive species are being removed and the aim is to plant another million trees (Rees, 2009). However, will voluntary action be sufficient to protect our ecosystems while large corporations drive the loss of natural capital to generate profits? We all need to personally re-engage with Nature. It could be a universal and integral component of education. It could be promoted to become a social norm.

In many countries houses are protected from fire with the attentive availability of the fire service. In many countries the police exist to protect private property from theft. How are we to protect our planet's renewable resources and their future provision for both our own future and the futures of those to come? *"Overexploitation of renewable resources today has a high cost on the welfare of future generations …"* write Hauser, et al. (2014) *"Exhausting the resource maximizes the payoff for the present generation, but leaves all future generations empty-handed. Here we show that the resource is almost always destroyed if extraction decisions are made individually. This failure to cooperate with the future is driven primarily by a minority of individuals who extract far more than what is sustainable. In contrast, when extractions are democratically decided by vote, the resource is consistently sustained. Voting is effective for two reasons. First, it allows a majority of cooperators to restrain defectors. Second, it reassures conditional cooperators that their efforts are not futile. Voting, however, only promotes sustainability if it is binding for all involved. Our results have implications for policy interventions designed to sustain intergenerational public goods"* (Hauser, et al, 2014).

The key question is: how can we design and integrate strategies into society which will increase our natural capital or at least conserve it? Have our democracies become too corrupt, so that for example, fishing continues until fish stocks collapse? Do we need new methods of monitoring democratic decisions? Could monitoring by UAVs help to ensure democratic decisions are followed. The problem of caring for "intergenerational public goods" is one requiring answers at many levels. Many of those answers could be from designers. The work of the Nobel Prize Winning economist Elinor Ostrom (see Glossary) shows that the delegation of resource management to local communities can result in the resource's sustainable management due to their direct commitment. However, those far removed from the resource, such as government bodies (and probably more concerned with jobs and profits) manage the resource badly as has been well illustrated by the European Fisheries Policy. Ostrom's (2012) work confirmed that "the tragedy of the commons" (Hardin, 1968) can be avoided.

In September 2014, The World Wildlife Fund (WWF, 2014), together with its partners Global Footprint Network and the Water Footprint Network published the *Living Planet Report 2014. "The Living Planet Report is the world's leading, science-based analysis on the health of our planet and the impact of human activity. Knowing we only have one planet, WWF believes that humanity can make better choices that translate into clear benefits for ecology, society and the economy today and in the long term … This latest edition of the Living Planet Report is not for the faint-hearted. One key point that jumps out is that the Living Planet Index (LPI), which measures more than 10,000 representative populations of mammals, birds, reptiles, amphibians and fish, has declined by 52 per cent since 1970.*
Put another way, in less than two human generations, population sizes of vertebrate species have dropped by half. These are the living forms that constitute the fabric of the ecosystems which sustain life on Earth – and the barometer of what we are doing to our own planet, our only home. We ignore their decline at our peril" (WWF, 2014).

This appalling news requires truly innovative social measures and systemic change to restore our ecosystems and the animal populations which play a key role in their maintenance. Earth-stewardship, proposed above is one strategy in which all could participate. Another is Positive Impact Design, mentioned in Chapters 2 and 15. *"What is urgently required is 'positive impact design' so that the by-product of design activity is the creation and increase of the Earth's natural capital"* and not the creation of a footprint but the removal of the footprint!

Now, for just a brief moment *"We are at a key juncture in history where biodiversity loss is occurring daily and accelerating in the face of population growth, climate change, and rampant development. Simultaneously, we are just beginning to appreciate the wealth of human health benefits that stem from experiencing nature and biodiversity"* (Sandifer, et al. 2015). Designers must communicate to all: policy makers and stakeholders, i.e. everyone, that just as there are many ways to destroy Nature there are also many ways to care for her that will increase our Natural capital.

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Peter Stebbing

6 WATER

"When the well's dry, we know the value of water." Benjamin Franklin (Tony Allan, 2011)

"… the use of the term "peak water" is flawed, the idea of maximizing both social and ecological benefits that water provides is more relevant. We propose the idea of "peak ecological water" as the point when maximum benefits to human society and the ecosystem can occur." Meena Palaniappan & Peter Gleick, 2009

"Human persistence depends on many natural processes, termed ecosystem services, which are usually not accounted for in market valuations. The global degradation of such services can undermine the ability of agriculture to meet the demands of the growing, increasingly affluent, human population." Garibaldi, et al. 2013

"Water is the basis of life, and our stewardship of it will determine not only the quality but the staying power of human societies" Sandra Postel, (1992), Founder of the Global Water Policy Project, (http://www.globalwaterpolicy.org/)

"Water scarcity = an excess of water demand over available supply." FAO, (2012)

6.1 Introduction

"July 2010, UN General Assembly Resolution A/RES/64/292

For the first time, this UN Resolution formally recognizes for the right to water and sanitation and acknowledges that clean drinking water and sanitation are essential to the realization of all human rights. The Resolution calls upon States and international organizations to provide financial resources, help capacity-building and technology transfer to help countries, in particular developing countries, to provide safe, clean, accessible and affordable drinking water and sanitation for all." Extract from The Human Right to Water and Sanitation Milestones, United Nations, (2010)

Our Earth, the Blue Planet, is mostly covered with water (an estimated total of 1,386,000,000 km^3). However, only about 2.5 % is freshwater, two thirds of which is frozen into glaciers and ice caps leaving us with about 0.77% (or about 10,665,000km^3) (Postel & Carpenter, 1997) *"held in aquifers, soil pores, lakes, swamps, rivers, plant life, and the atmosphere. Only water flowing through the solar-powered hydrological cycle is renewable. Non-replenishable ground water can be tapped, but such extraction depletes reserves in much the same way as extractions from oil wells do. The terrestrial renewable freshwater supply equals precipitation on land which then subdivides into two main segments: evapo-transpiration* [green water which evaporates from leaves] *from the land and runoff* [blue water] *to the sea"* (Postel, Daily & Ehrlich, 1996). One can easily visualize this 0.77% by imagining that if all the water in the World could be contained in a bucket, then the amount of freshwater available to us would be just a drop on our finger. *"Precipitation over* *land surfaces amounts to an average of 113,500 km³/year which is partitioned into two major flow branches"* (Falkenmark & Rockström, 2004). *"This water is made available year after year by the hydrological cycle and constitutes the total renewable freshwater supply"* (Postel & Carpenter, 1997). In the meantime this is supplemented by an annual withdrawal from aquifers and groundwater supplies of 734 (±82) km^3 a-1 for the year 2000 (Wada, et al. 2010). This figure is in the mid-range of estimates from 658 km^3 a-1 to 1000 km^3 a-1. *"Although estimates may vary there is no doubt that since the 1950s groundwater abstraction has increased almost tenfold"* (Charalambous, 2013). Water is used by us in three primary areas:

1. for drinking, hygiene and sanitation
2. for food production
3. by industries (Mauser 2007).

However, despite our increasing demand for water we must ensure that Nature has what she needs too because ecosystems require water to function and provide the ecosystem services on which we depend. We have to share water with Nature!

6.2 Water: essential for all life

Water is a weird substance due to a delicate balance of quantum forces which provide it with unique properties enabling it to support life. For example, it takes a lot of heat to warm water and it is this property which enables mammals to regulate their body temperature (Grossman, 2011). It is also a remarkable solvent for an enormous range of substances and reactions and enables the transport of many materials within organisms (Young, 1979). Water is essential for not just the physiology and metabolism of mankind but other organisms too because most are composed of about 59% water. Our bodies are composed of about 60% (± 10%) water by weight (Weininger, 2014) and daily we require two and a half liters of freshwater (Batmanghelidji, 2013) to maintain the correct water balance and a healthy metabolism. Water plays a key role in the thousands of chemical reactions on which our metabolism depends (Chaplin, 2001). We might be able to fast for a week but without water we start to suffer within hours. Tragically, thousands of people die every day because they either do not have access to the water they need or they die from illnesses caught by drinking contaminated water. Furthermore, a shortage of water traps millions of people into poverty due to the time expended each day walking miles to get a sufficient supply just to live. The development of nations with insufficient water are also handicapped.

However, the challenge of water, as vital as we know it to be for our personal health, is of equal concern for the whole of the globe and humanity. The maintenance of the equilibrium of the Earth's benign climate depends on the water cycle and the key role played by vegetation in maintaining the water cycle (described briefly below).

6.3 Our Problem

One cannot be a designer and not know about water; this is because, apart from the needs of humans and for all the other organisms on the planet, water is also essential for agricultural, industrial purposes and manufacturing. It is probably no surprise to learn that 10 liters of water are required to manufacture a sheet of A4 paper (Allen, 2011). A computer, depending on the type, can require 158,000 liters (42,000 gallons) of water throughput for its manufacture. Then to drive all our technology we need energy for which water is essential. *"Energy requires enormous sums of water. Fifty percent of the water in the U.S. is actually used to create electricity"* (Cook & Kostigen, 2005). Worldwide the *"energy sector already accounts for 15% of the world's total water use. Its needs are set to grow, making water an increasingly important criterion for assessing the viability of energy projects"* (IEA, 2012). Furthermore, the combined information and communication (ICT) technologies together with the Internet infrastructure now accounts for more than 6% of the global electricity consumption (Somavat & Namboodiri, 2011).

Never before has there been such an urgent need to think globally and act locally as with water. *"In the rich North, flush toilets are the largest single drain on domestic water supplies"* (Nature, 2003). Five years later another editorial in Nature (2008) stated that *"Our planet is facing a water crisis in public health: more than a billion people in developing nations lack access to safe drinking water, and more than 2 billion lack proper sanitation. And in the near future, water shortages are likely to spread into other key sectors – notably agriculture and energy."* In 2000 the Global Water Partnership estimated that by

2025 two-thirds of the world's population will be water stressed (Mauser, 2007).

Prior to our global awareness, countries lucky enough to have a natural abundance of water, not surprisingly, had an historically developed perception of freshwater and that it is an infinite resource available for unrestricted use without an awareness of a global limitation. However, today with our global awareness we must all use water sparingly as competition for this priceless resource now develops. We have a limited quantity of 35,000,000 km³ of freshwater (Gleick, 2009). At the beginning of the 3rd millennium the total global amount of water being used was estimated at 3,700 km³ per annum. In 2009 human demand was calculated by McKinsey & Co as 4,500 cubic kilometers per annum and they have estimated that by 2030 demand will increase to be 6,900 km³ (McKinsey, 2009). Another projection is that by 2050 the world's growing population may require some 12,000 km³ per annum (Nature, 2008). How is this to be achieved?

In the early years of this millennium three groups of experts were independently asked to assess the world's need for water. One group was composed of 700 scientists from agricultural research centers. Meanwhile, the United Nations asked a second group of 1,500 experts to assess the social impact of water scarcity in developing countries and a third group was composed of business executives from the world's largest water, oil and chemical companies. The independent assessments of the three groups were unanimous and alarming (Vidal, 2006).

The agricultural experts reported that a third of the world already has a short supply of water and that over the next 40 years demand will double. The UN's World Water Development Report drew attention to people changing to growing cash crops which needed more water to grow. For example, Peru is the largest exporter of asparagus in the world, a luxury food flown by plane to Europe and the USA. *"The United States remains the leading importer of Peruvian fresh asparagus, accounting for 50% of total exports"* (Nolte, 2013). Peru's asparagus production in 2012 was 385,645 metric tonnes. Furthermore, the asparagus has an air-miles footprint. More than that however, asparagus is a very thirsty crop and grown in the desert of the Ica valley. In order to provide constant irrigation water is extracted from the local water table which has dropped in some areas by 8 metres per year causing the wells of small farmers and families living in the Ica valley to dry up (Lawrence, 2010).

Beef demand and production is creating another problem as more people, especially in economically successful countries such as India and China, are including more beef in their diet. *("It takes some 15,500 liters of water to produce a kilogram of industrial beef, ten times as much as is needed to produce a kilogram of wheat"* (Editorial Nature, 2008). The environmental impact of beef production was revealed recently in a study by Eshel and colleagues (2014) whose key conclusion was *"– that beef production demands about 1 order of magnitude more resources than alternative livestock categories – is robust under existing uncertainties. The study thus elucidates the multiple environmental benefits of potential, easy-to implement dietary changes, and highlights the uniquely high resource demands of beef."*

Finally, the industrialists' group reported that if water supplies were unable to keep up with development then economies could collapse resulting in both eco-refugees and conflict. In addition, reports revealed that many countries know little about how fast water is being used (Vidal, 2006). Many countries with insufficient blue water (i.e. water freely available running off the land into streams and rivers after rainfall) are drawing water from their aquifers which are becoming exhausted. This is because the water in many aquifers has accumulated over thousands of years and the aquifer is replenished much more slowly than the water is extracted.

In the future *"The water shortage that threatens humanity will have wide-ranging consequences for agriculture and energy production, requiring significant shifts in the way this precious resource is managed."* So began an editorial in a special issue of the journal Nature (2008) devoted to the problem of water. The severe drought in the Sao Paulo state, Brazil which *"is experiencing a third consecutive year with soaring temperatures and rainfall patterns well below historic records"* has reduced reserves so that *"water could run out before the next rainy season starts in November"* (Whately & Lerer, 2015). The strong political development policies have ignored *"More and more scientific studies* [which] *show the link between deforestation in the north and the reduction of rainfall in the southeast, presenting further evidence of how the effects of climate change are already upon us."* Meanwhile, *"Today more than 13 million inhabitants of Sao Paulo state find themselves on the edge of an unprecedented public calam-*

ity" (Whately & Lerer, 2015). The state appears to have reacted with too little too late. Is this unfolding scenario prophetic in that politicians too often ignore scientific advice in order to achieve their short term political aims?

Water is primarily a problem because ...

1. of the bad attitude we generally possess about water. In reviewing two publications on water, Catley-Carlson (2014) writes that the authors *"Sedlak and Barlow agree that our worldwide failure to value water is at the heart of the problem." Furthermore, "most political leaders ... create policy decisions as if there were no end to water supply"*. That is the problem in a nutshell "and currently demonstrated in Sao Paulo.
2. we are not merely too many people, we are too many consumers: over 7 billion and our demand for water is growing for not merely potable water but also for industrial processes and production. It is estimated that agriculture uses 95% (Falkenmark & Rockström, 2004) of the available freshwater.
3. like all resources freshwater is unevenly distributed. So an Icelander has 671,940m^3, an Hollander 680m3 and a Kuwaiti has 0m^3 (Buckley, ed., 1994).
4. we are polluting our own supplies with agricultural fertilizers and pesticides or taking it out of the hydrological cycle. China for example, now reports that half of its ground water is polluted due to its over ambitious growth-at-all-costs economic strategy (Kalman, 2014) and *"only 3% of the country's urban groundwater can be classified as "clean"*." Consequently, the state plans to build a desalination plant to provide Beijing with one third of its tap-water by 2019.
   Furthermore, consumption of water by the fracking industry has become critical in areas already suffering water shortages notably in the south west of the USA. In Texas, for example ground water supplies have been reduced and so depleted *"leaving cattle dead, farms bone-dry and people thirsty"* (Goldenberg, 2013). In addition, we cannot know whether fracking will endanger groundwater supplies in the future. This is because no geologist can a guarantee as to where the toxic cocktail of fracking chemicals may seep to in the long term or what may happen 2 km deep underground (Ingraffea, 2011).
5. *"80 per cent of all water consumption goes into food production"* (Allan, 2011) but agricultural production must double in the years ahead to feed the anticipated extra ~2 billion people by 2050. However, if food security could be greatly improved then we could save the 30-50% of the currently wasted food (Inst. Mech. Eng., 2012). In other words we already grow enough food but we need new logistical infrastructures. Could designers help? In the UK it has been calculated that *"The water used to produce food thrown away by households in the UK amounts to about 6.2bn cubic meters a year"* (Harvey, 2011).
6. In 1996 scientists estimated that humanity was already using about half of the available freshwater. The global demand for freshwater tripled in the period from 1950 up to 1990. One estimate suggests that by 2030 the demand for water will exceed availability (Ball, 2000). However, in a report for UNESCO Mekonnen and Hoekstra (2010) write that *"Global freshwater withdrawal has increased nearly seven-fold in the past century (Gleick, 2000) ... Currently, the agricultural sector accounts for about 85% of global freshwater consumption (Shiklomanov, 2000; Hoekstra & Chapagain, 2007)"*. Meanwhile, another estimate calculates that by 2030 water demand will increase by 40% if we continue "business as usual" without introducing any efficiency measures. That is a volume increase from 4,500 billion m^3 to 6,900 billion m^3 (Addams, et al, 2009).
7. *"... nearly 80% of the world's population is exposed to high levels of threat to water security. Massive investment in water technology enables rich nations to offset high stressor levels without remedying their underlying causes, whereas less wealthy nations remain vulnerable."* (Vörösmarty, et al, 2010). The water crisis will be exacerbated by climate change which will extend the extremes of our normal weather patterns beyond the normal envelope or stationarity (Milly, et al. 2008). Consequently,

countries with a reputation of having a wet climate such as the British Isles can have droughts such as occurred in 2011 which had *"Britain's second-driest spring in 100 years and the warmest since 1659 has left soils in parts of East Anglia and south-east England concrete hard, with many rivers shrunk to trickles and crops withering at critical times in their growth ... The government's Centre for Hydrology and Ecology reported soils in many areas were at their driest for 50 years. "The exceptional aridity of the early spring, following a relatively dry 2010, has resulted in agricultural and hydrological drought conditions affecting large parts of southern Britain." it said"* (Vidal, 2011) Meanwhile, 2013 was marked in the UK by extensive floods and droughts. Currently, (Feb, 2015) the south west USA and Brazil are suffering from record breaking droughts.

8. It is a matter of regret that it was only relatively recently that we began to fully understand our use of water and the water economy when the concept of *virtual water*, was proposed in 1993 by the scientist Tony Allan (2011). Although originally proposed as 'embedded water,' Allan's concept of 'virtual water' has enabled us to begin to understand the quantities of water used to produce a product or service. *Virtual water* is the water required to produce a product or service which is *embedded* within it; so for example, it takes about 1000 liters of water to grow a kilogram of wheat (Chartres & Varma, 2011).
9. Everyone has a water footprint. Is water the problem because we have the problem of being unaware of our water footprint? We have an idea about how much we eat and what we eat, but are we unaware of how much water we use? A lack of awareness exacerbates such problems and prescribes the necessity of information (Water Footprint Network Glossary, 2014).

6.4 Peak water

There are two major types of water scarcity. The first is due to a lack of financial investment to create the necessary infrastructure to provide water security. Secondly, the physical scarcity where demand for water exceeds supply. There is already great concern that during the present century water provision will 'peak' and demand will eclipse supply.

This awareness has arisen because another resource, oil, has 'peaked,' (Heinberg, 2007) which, once exhausted, will be gone for ever, although we may be able to substitute it. There is no substitute for water, which happily for us, cycles in the biosphere so that each year we can reckon on perhaps about 113,500 km³ of rainfall (Falkenmark & Rockström, 2004) and so theoretically at least, we cannot run out of water. Therefore the concept of water 'peaking' is more complicated and is best described by three concepts:

1. *"Peak renewable water applies where flow constraints limit total water availability over time.*
2. *Peak non-renewable water is observable in groundwater systems where production rates substantially exceed natural recharge rates and where over-pumping or contamination leads to peak production followed by a decline, similar to more traditional peak-oil curves.*
3. *Peak 'ecological' water is defined as the point beyond which the total costs of ecological disruptions and damages exceed the total value provided by human use of that water"* (Palaniappan & Gleick, 2009). This means that if we should take out of the water cycle for our own use so much water that ecosystems start to collapse and are unable to provide the ecosystem services on which we depend; then we shall have reached peak 'ecological' water. *"Defined this way, many regions of the world have already surpassed "peak ecological water" – humans use more water than the ecosystems can sustain without significant deterioration and degradation"* (Palaniappan & Gleick, 2009). Significant examples where peak ecological water has been exceeded, for example in China in the Xishuangbanna prefecture, Yunnan (Qiu, 2010) and in the Three Gorges Project. Meanwhile, the difficulty we have is how will we be able to recognize when we will have reached 'peak ecological water' before damage is done? Unfortunately, the ecological metrics do not exist until we can visibly see that an ecosystem has died – then its too late.

"The environment then becomes another competing consumer of water "The environment is a resource, but it is also a user," says Vladimir Smakhtin, a principle hydrologist at the International Water Management Institute in Colombo, Sri Lanka. "It deserves a fair share of water"" (Marris, 2008).

The characteristic western attitude and approach to Nature is one of competition and conquering. However, this is destructive and unsustainable because we are now compelled to cooperate, understand and satiate Nature's thirst because she provides a diversity of services without which we cannot survive. *"Balancing the water needs of humans and nature requires knowledge of the actual water requirements necessary to sustain goods and services in society and in ecosystems. The biggest threat to secure availability of water for ecosystems is the pressure exercised by humans on finite freshwater. We need to understand the compelling forces that alter that availability. These powerful forces are linked to human water demand and to water-dependent land use in agriculture"* (Falkenmark & Rockström, 2007).

6.5 The Water Cycle – a summary of the big picture

The amount of water on the earth is finite, however, the wonderful thing about water is that it cycles through the environment, a phenomenon known as the hydrological cycle. *"Life on Earth is dependent upon an intact water cycle and that this dependency creates vital goods and services"* (Mauser, 2007). One of these ecosystem services is the 'cleaning' and purification of the water as it cycles through the biosphere and its ecosystems.

Once rainwater has fallen it follows one of two major pathways enabling life to exist on the planet. One pathway is as runoff into lakes, streams and rivers so that the water eventually reaches the ocean. The other pathway is into the ground where it is taken up by the roots of plants and evaporates from their leaves and so returns to the atmosphere as water vapour. There is also an intimate interaction, like mighty cogwheels, between the hydrological cycle, the carbon cycle, and the planet's vegetation. The teeth of these cogwheels meet and turn on the process of photosynthesis. The climate equilibrium which the Earth enjoys depends on the delicate balance of the green house gases being maintained by the vegetation which interact with both the carbon and water cycles (see Glossary, Gaia Theory). Terrestrial vegetation, marine plankton and algae create the primary biomass or Net Primary Production (NPP) by photosynthesis, taking up CO_2 from the atmosphere and creating the simple carbohydrate-glucose by solar power! Vegetation influences the atmospheric water vapour by controlling the evaporation of water from plants' leaves. Plant leaves have pores, called stomata, which open and close enabling water to evaporate from leaves-evapo-transpiration. Once in the atmosphere, the water at some point falls again as rain, continuing the cycle. Up to three times more water can evaporate from leaves from an area of vegetation as the same area of bare soil (Mauser, 2007). However, the role of soil is incompletely understood in the water cycle but *"A feedback loop appears to be at work: as heat dries up the soil, the dry soil amplifies the heat." Therefore, a computer model simulating the hydrological cycle is difficult to create because of "the complex interactions between rainfall, evaporation, carbon dioxide concentration, plant growth and soil moisture are not easily computerized"* (Schiermeier, 2008).

Photosynthesis also produces oxygen on which other organisms depend and which also facilitates the break down of vegetation releasing CO_2 so that it again becomes available for plant use. Alternatively, when vegetation dies the carbon may be transferred to reservoirs in the earth or deep ocean (creating oil deposits as happened millions of years ago during the Carboniferous period). The cog wheels of vegetation and photosynthesis, the cycling of carbon, oxygen and water interact like clockwork. A clockwork we are disturbing by removing vegetation, releasing masses of CO_2 and other greenhouse gases into the atmosphere, and redistributing and withholding water from the hydrocycle. Unknowingly, we could tip the system into another equilibrium unable to support life (Mauser, 2007).

A crucial factor in water supply is the speed of water circulation of freshwater and this is determined by the climate system and *"climate change is expected to accelerate the global hydrological cycles, and precipitation will increase on average. Evapo-transpiration will not increase as much as precipitation globally because elevated CO_2 concentration induces stomata closure and reduces transpiration and river discharge will increase on a global scale because of the increased precipitation and the reduced transpiration … Furthermore, precipitation will become more intense and intermittent, and the risks of floods* *and droughts will increase, sometimes in the same region of the world"* (Oki & Kanae, 2006).

Water can circulate in the hydrological cycle at a slow or a fast rate. For example, water might remain 'resident' for a long time in the vast oceans or frozen into an ice cap. However, in the fast cycle water evaporates either by evapo-transpiration from the leaves of plants on the land, or from the sea's surface to join the water vapour already in the atmosphere and then to fall and as rain to evaporate again. It is estimated that about 500,000 km^3 of water circulates through the fast cycle (Pearce, 2006).

6.6 The water economy by colour

Water has been given a colour coding according to the course it takes in the hydrological cycle so that it is easier to understand the Earth's water economy. The terms 'green' and 'blue' water were coined by the hydrologist Malin Falkenmark at the Stockholm International Water Institute in the early 1990s. Globally, there is about 110,000 km^3 (Postel & Carpenter, 1997) of rainfall per annum of which 39% is 'blue water' running off into rivers, lakes and groundwater. *"The rest is 'green water' and is crucial to forests, biodiversity and rainfed agriculture. Among human activities, agriculture is the biggest user of both blue and green water"* (Schiermeier, 2008). *"Of particular concern is that some 70% of global freshwater with-drawals (80-90% of consumptive uses) are devoted to irrigation. Furthermore, rain-fed agriculture is the world's largest user of water"* (Foley, 2011).

6.6.1 Green water

Rain falling onto the Earth's surface seeps to a shallow depth, where *"soils store rainfall in the root zone of plants"* (Schiermeier, 2008) and it is available for uptake by a plant's roots and so is known as 'green water'. *"Green water is hidden inside trees, shrubs an other plants and biota. There is significantly more green water than blue: the ratio is 61.2 to 38.8 per cent"* (Allan, 2011).

Water enters a plant through the hairs on its roots and is transported to the xylem, a network of cellular tubes leading up through the stem which further transports water to the leaves. Water is pulled up by evapo-transpiration from the leaves (Alberts, et al, 1989). The hydrogen bonds of the water molecules also play a key role in enabling the water to ascend in the xylem as they interact with the xylem cell walls and the water is pulled up the cellular tubes. Should the water column break, cavitation occurs, when air bubbles enter the xylem stopping the water from ascending the xylem tubes and stimulating the plant to grow replacements. Tremendous forces are required to raise water up to the leaves and trees reach the limits of their growth when cavitation occurs and air breaks the water's upward movement (Woodward, 1989).

The water and carbon cycles intimately interact once the water reaches the leaves and plays its crucial key role in the biochemistry of photosynthesis on which virtually all life depends:

$6CO_2$	+	$6H_2O$	+	sunlight > (chlorophyll)	>	$C_6H_{12}O_6$	+	$6O_2$
carbon dioxide	+	water	+	light enables photosynthesis to create	>	sugars	+	oxygen

The leaves' rate of transpiration, i.e. water evaporating into the air is controlled by pores on the leaves' surfaces. When evaporation takes place from the surface of a leaf it is called evapo-transpiration which also cools a plant and is an important reason, along with shade provision, for planting trees in the urban environment. Once the water has evapo-transpired it joins the water vapour in the atmosphere, forming clouds from which the water eventually falls again as rain. *""Green water is the key to water and food security in drought-prone regions," says Falkenmark"* (Schiermeier, 2008).

6.6.2 Blue water

In contrast to 'green water,' 'blue' water runs off the ground's surface into lakes and rivers or seeps or infiltrates into the earth where it becomes groundwater or collects in aquifers. The greater the run-off then the more 'blue' water is potentially available for human use. Eventually the water reaches a river's estuary and joins the oceans where evaporation from the sea's surface and formation into clouds enables the water's cycle to continue and fall again as rain. *"In the commonly used terminology, water 'withdrawal' refers to the direct human extraction of blue water flow for societal use in irrigated agriculture, industry and municipal use"* (Falkenmark & Rockström, 2007). However, true water 'use' is always somewhat less than the water 'withdrawal.' For example, when irrigating crops the water 'consumed' by the plants becomes part of the green water flow and evaporates from their leaves. However, some of the water percolates into the soil and rejoins the groundwater.

"Green water flow from vegetation is by far the largest 'consumptive' use of water … Consumptive water use refers to water withdrawn from a source and made unsuitable for reuse in the same basin," also "When use results in contamination of water it then has to be considered as consumed water" (Falkenmark & Rockström, 2007).

6.6.3 Brown water

Brown water is the blue water that is contaminated by human use and then returned to the surface water system.

6.6.4 Grey water and Blackwater

Greywater or "used" water might be said to get its name from its colour derived from relatively limited domestic use in the kitchen, and for personal hygiene, washing and laundry, in other words it contains soaps, detergents and other residues and is relatively clean. Therefore it can be reused without treatment, for example for irrigation and for flushing lavatories. It does not contain industrial chemicals or hazardous wastes or human sewage (Pedersen, Woelfe-Erskine, & Hill-Hart1, 2007). Finally, blackwater is water containing human faecal material or sewage.

6.7 Water economy: the Water footprint

The concept of the water footprint as a way to understand the water economy is a recent strategy reflecting our previously lax attitude to water and its apparent abundance. However, with demand for water increasing in the world a new perception of water management is essential. *"Hoekstra and Chapagain (2008) have shown that visualizing the hidden water use behind products can help in understanding the global character of fresh water and in quantifying the effects of consumption and trade on water resources use. The improved understanding can form a basis for better management of the globe's freshwater resources"* (Hoekstra, A. et al, 2011). One can consider the water footprint of a process, a product, along supply chains, a consumer, a group of consumers, a business, a community, a geographical region, a nation or even humanity as a whole (Hoekstra, A. et al, 2011). *"For instance, in the UK about 75% of the water footprint of the UK consumers lies abroad"* (Hoekstra, 2014).

"The water footprint of a product is the volume of freshwater used to produce the product over the full supply chain. It is a multidimensional indicator, showing water consumption volumes by source and polluted volumes by type of pollution; all components of a total water footprint are specified geographically and temporally" (Hoekstra, A. et al, 2011).

The blue water footprint refers to consumption of blue water resources (surface and groundwater) along the supply chain of a product. 'Consumption' refers to loss of water from the available ground-surface water body in a catchment area.

The green water footprint refers to consumption of green water resources (rainwater, insofar as it does not become run-off) *"stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, this part of precipitation evaporates or transpires through plants"* (Hoekstra, A. et al, 2011).

The grey water footprint refers to freshwater pollution and "… is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards" (Hoekstra, A. et al, 2011).

6.8. Water economy: Virtual or 'embedded' water

Tony Allan was working on his idea of 'embedded' water in 1988, but the term did not create any resonance until he renamed his concept after a chance remark at a workshop in 1992 and 'virtual water' was coined (Allan, 2011). Simply defined it is the total water required to grow or produce a product be it asparagus, a handbag or a motorcar (it is also a component of the 'ecological rucksack,' see Glossary). It has been calculated for example that to produce a kilogram of beef requires about 15,500 liters of water (Marris, 2008) and it takes 11,400 liters of water to produce 1 liter of bio-diesel (Water Foot Print Network product gallery, 2014). The concept of virtual water enables us to understand how the economies of water and waste are closely connected. It has been found that *"… people in the UK each waste on average 243 liters a day in the food they throw away – over one and a half times what they use in their homes."* This amounts to 6% of all the water wasted in the UK (Upfront, 2011). Several months later the Food and Agricultural Organization released a report that each year one third of the world's food goes to waste (Provost, C., 2011) while the Institute of Mechanical Engineers (2012) estimated the wasted food may be as much as 50%! Recall that 80% of all freshwater is used for irrigation for food production.

"The weight of traded goods is normally just a small fraction, such as 1/100 to 1/1000 of the weight of the water required to produce that goods, so transporting goods is considerably easier than transporting the water itself. Total international "virtual water trade" is estimated to be about 1000 km³/yr, although only a part of that "virtual water trade" is done to compensate for water shortage" (Oki & Kanae, 2006). Meanwhile, other trade, which may bring short term cash into a country, is creating longer term water problems. This tragedy is occurring in some poorer countries with limited water resources such as Peru flying asparagus to Europe (Lawrence, 2010) and the US and Kenya flying roses to Europe (Lawrence, 2011).

In February, 2014, the worst drought on record was being reported from the Central Valley, California, USA. People in cities were being told to conserve water due to warnings of a record drought. Simultaneously, (Leithead, 2014) water from the Colorado River supplied by the All American Canal is used to irrigate the lush Imperial Valley, formerly a desert, and where now alfalfa is grown in such quantities that it is plastic wrapped and exported to China, Asia and the Middle East. *"A hundred billion gallons of water per year is being exported in the form of alfalfa from California,"* argues Professor Robert Glennon from Arizona College of Law.

"It's a huge amount. It's enough for a year's supply for a million families – it's a lot of water, particularly when you're looking at the dreadful drought throughout the south-west" (Leithead, 2014). This extraordinary case of a record breaking drought in the Central Valley where further south in the very same state of California in the Imperial Valley the desert is watered to produce cattle feed for export to Asia illustrates the environmentally destructive anomalies of globalization and profits because *"It's now cheaper to send alfalfa from LA to Beijing than it is to send it from the Imperial Valley to the Central Valley"* (Leithead, 2014)! This example clearly illustrates the old paradigm of short term profit regardless of environmental damage.

Meanwhile, at the time of writing (21 August 2014) the drought continues and California governor Jerry Brown *"put the state under an official emergency declaration last week, … warned his state is 'facing perhaps the worst drought California has ever seen since records began being kept 100 years ago'. Wildfire dangers are increased, and some cities are close to running out of water"* (McCann, 2014).

These problems are driven by neo-liberal capitalism, climate change and globalization and the drive for profit at the cost of ecological destruction and they will be further exacerbated by climate change.

6.9 How we are disturbing the water cycle

> *"Today, the volume of water removed from rivers, lakes, and aquifers for human activities worldwide totals some 4,430 km³."*
> (Postel & Capenter, 1997)

The magnitude of human activity now significantly affects the water cycle in the biosphere and is another reason why scientists say we are now living in the Anthropocene.

If we go back 10,000 years and more when humans lived as hunter-gatherers the world's freshwater was fully utilized by Nature. It is estimated that 60% of the rain was 'green water' evapotranspired by plants and the remaining 40% was 'blue' run-off water (Mauser, 2007). Today, agriculture has extensively modified these flows and 60% of the world's green water flows are controlled by humans since instead of the water going to forests and wetlands it is now directed to crops and pastures. In a moist temperate climate, grazing pasture transpires half the water that would have evaporated from a forest (Mauser, 2007). As a consequence more blue water flows from the land taking with it vital plant nutrients. The conclusion is that today *"humans have acquired control over the water flow on the continents of Earth. They not only regulate the division of the precipitation at the relevant points on the surface and in the soil differently from the way nature does, they have also learned to store water and to utilize it at times that nature never would have …"* (Mauser, 2007).

6.9.1 Deforestation

Deforestation has already played a key role in the demise of a number of cultures (Diamond, 2005) including those of Easter Island, the Anasazi, and the Maya. If we forget history then we are doomed to repeat it, or so goes the saying. What happened to the forests throughout much of the Roman Empire 2,000 yrs ago and contributed to its downfall is now occurring in Brazil (Whately & Lerer, 2015; Watts, a. 2014; Watts, b. 2014; Malhi et al, 2008), India (Vandan Shiva, see Chapter 12) and China (Qiu, 2010; see below) and elsewhere. It is therefore unfortunate that politicians do not appear to heed the repeated message of history which confirms and teaches us that the destruction of forests profoundly affects the water supply. The extensive deforestation and the unsustainable style of agriculture carried out by the Romans were contributary factors in the Empire's decline and to the changes to the Mediterranean climate and topography that now characterize the region for us today. *"The removal of a large proportion of the Mediterranean forests was the most devastating effect of human activity. Ancient economies were affected by shortages and rising prices of wood, partly owing to difficulty of transport, but the most damaging result was erosion on millions of acres of denuded slopes exposed to rains. The extent of deforestation was amplified by pasturing herd animals everywhere ... They overgrazed, destroying some native plant species and preventing regeneration of trees and shrubs. After the soil was removed by torrential rain, in some places down to bare rocks, neither forests nor farms could flourish"* (Hughes, 2014). Computer climate simulation models provide further evidence that the *"deforestation around the Mediterranean during the last 2000 years contributed to the dryness of the region"* (Reale & Shukla, 2000).

In South America *"Evaporation and condensation over Amazonia are engines of the global atmospheric circulation, having downstream effects on precipitation across South America and further afield across the Northern Hemisphere. Amazonian forests have been an important and continuous part of Earth system functioning since the Cretaceous"* (Malhi et al, 2008). However, by 2001 the extent of the Amazonian rainforest had been reduced to 87% of its original area with the clearance of "about 837,000 km² of Amazonian forests ..." The Amazon rainforest recycles about half its average rainfall from leaves through evapo-transpiration. "The extraction of soil water by tree roots up to 10 m deep, and its return to the atmosphere (a "transpiration service"), is perhaps the most important regional ecosystem service" (Malhi et al, 2008). Despite this invaluable ecosystem service, the end of 2014 was marked by an increase in deforestation with *"a 190% surge in land clearance in August and September compared with the same period last year as loggers and farmers exploit loopholes in regulations that are designed to protect the world's largest forest."* In September more than 400 square kilometres was cleared (Watts, b. 2014). Computer models lead scientists to believe that were deforestation to continue so that a total of 30 to 40% of the Amazonian rainforest were removed then the climate would tip into a drier regime, locally weakening the entire region's resilience to large scale drought (Malhi et al, 2008) and accelerate further drying of the region. However, this may now be happening because the region of Sao Paulo, including Brazil's southeast and central regions is, at the time of writing (January, 2015) experiencing its driest six months since records began 84 years ago. Water in Brazil is normally abundant but *"the rain fronts that are normally carried south from the humid Amazon have largely failed to materialise and temperatures have been higher than usual, prompting the authorities to scrabble to tap new sources and reduce demand. "It has been a terrible year. The last rainy season was drier than the dry season," Mauro Arce, São Paulo's water resources secretary, told the Guardian"* (Watts, a. 2014). The drought is bringing a cascade of economic problems since hydroelectric power is seriously affected, not to mention water for consumption and sanitation. Furthermore, water is required for many factory processes. Water is seldom recognized for the colossal role it plays in our technological societies but maybe that is because it comes too easily out of a tap. Forests all over the world ensure its seasonal supply, so long as they continue to exist ...

However, the new Brazilian president, Dilma Rousseff has appointed a new minister for agriculture, Kátia Abreu, (who has the nickname, the "chainsaw queen"), "*a controversial advocate of agribusiness and weaker forest conservation ... Abreu is a leading figure in the "ruralista" lobby, which prompted the government to weaken Brazil's forest code. In congressional debates and in her feisty newspaper column, she has called for more roads through the Amazon, congressional control over demarcation of indigenous reserves, more efficient mono-cultures, and the approval of genetically modified "terminator seeds""* (Watts, c. 2014). In addition President Rousseff has appointed a climate change sceptic as her new minister for science and technology, Aldo Rebelo. Currently, the Amazon rainforest is not in good hands.

Trees and forests play an essential role in the Earth's hydrological system. In addition to drawing up water from 10 meters below the surface and thereby enabling it to become rain by evapotranspiration from leaves, it can also do the opposite by recharging groundwater. Research in the UK reveals that *"Water infiltration rates were up to 60 times higher in areas planted with young trees than in adjacent grazed pastures" (Carroll, et al, 2006). "The roots of the trees provide channels down which the water flows, deep into the ground. The soil there becomes a sponge, a reservoir which sucks up water and then releases it slowly"* (Monbiot, 2014). Can we learn from the Romans not what to do?

6.9.2 Rivers and Dams

> *"All life – terrestrial and aquatic, ranging from microbes to vertebrates – depends on and is shaped by water and watershed dynamics"* (Palmer, 2010).

> *"Today some 70% of all the water abstracted from rivers and underground reserves is being spread onto 270 million hectares of irrigated land that grows a third of the world's food. This massive global undertaking has kept the world's granaries full, but it has emptied the rivers"* (Pearce, 2006).

Terrestrial plants became established during the Palaeozoic period (542 -251 million years ago (Crick, 2014)) and their evolutionary development led to them spreading all over the world, fundamentally changing the environment for ever. One major effect that trees and vegetation had was to cause the development of meandering channels in rivers and the stabilization of flood plains. The diversity of rooting assemblages in the alluvial flood plains, the deposition of woody debris, and *"the expansion of tree habitats led to the crossing of a threshold in vegetative control of floodplain and river morphology during the Carboniferous"* (Davies & Gibling, 2011).

Streams, rivers, and their adjacent ecological zones, which include the river banks and floodplains collectively perform two essential functions for our species: the ecosystem service – water purification and providing a rich biodiversity (which in turn provide other ecosystem services). The study of these river zones and their role in maintaining water quality is known as *riparian ecology* (Nature, 2014).

Healthy riparian environments provide a lot of capacity for groundwater storage, absorbing a lot of water and acting as a buffer to sudden deluges of rainfall. Furthermore, the roots of trees and other vegetation makes the soils of the riparian ecosystem very permeable. In the event of flooding riparian vegetation can evapo-transpire tens of thousands of liters of water per day per hectare (Hoorman & McCutcheon, n.d.).

Although, the benefits provided by streams, rivers and lakes may be well recognized – *"including water for drinking, irrigation, and manufacturing; goods such as fish and waterfowl; and a host of non-extractive benefits, including recreation, transportation, flood control, bird and wildlife habitat, and the dilution of pollutants ... Much additional research is needed to establish the intricate connections between human activities and the loss of freshwater ecosystem services"* (Postel & Carpenter, 1997). However, many of these benefits are difficult to measure and consequently their value is not fully recognized, and even taken for granted. The earliest civilizations established their towns and cities near rivers dependent on the ready supply of potable freshwater. Subsequently, dams were built to control and divert the water flow, raising the water level for power (water wheels and today hydro-electricity), navigation or recreation, storing water for irrigation or for flood and erosion control. During the first half of the 20th century governments throughout the world began investing public funds extensively in large multi-purpose dams. A trend which has continued up to the present day with the world's largest hydroelectric-power project, the Three Gorges dam in China. A project which China's government has admitted *"is plagued by pollution, silt accumulation and ecological deterioration nearby, and has affected irrigation, water supply and shipping in downstream regions"* (Anon., 2012). The last great unexploited region for hydro-electric dams is the Amazon basin for which Brazil has extensive plans. The world's third largest dam is planned at Belo Monte across the Xingu River, a tributary of the Amazon. Indeed, in the developing world hydropower projects are booming. *"The world has a lot of dams – 45,000 large ones, according to the World Energy Council, and many more at small scales ... and they currently supply almost one fifth of the electricity consumed worldwide"* (Schiermeier, 2008) and about 18% of the world's land area drains into a dam (Tollefson, 2011). During the period from 1950 up-to the mid 1980s and average of 885 dams at least > 15m high were built and upto the mid 1990s about 500 large dams were being completed per year (Postel, Daily & Ehrlich, 1996).

The benefits of dams

The 'hard path' approach of centrally organized massive infrastructures for power supply and water security requiring the building of dams, aqueducts, pipelines and treatment plants have brought many benefits to millions of people. The benefits include hydro-electric power, water security during times of drought, water for irrigation, the reduction of water borne diseases and the mitigation of flooding, etc. (Gleick, 2003).

The massive demand for energy is also crucial for economic development and industrialization. Hydro-electric power, a renewable energy source, produces energy which is carbon-free, cheap and sustainable so long as it is well engineered and the rains keep falling to maintain generating turbines.

The dangers of dams

Dams have reshaped the world's rivers and altered 48% of the riverflow worldwide. This proportion will nearly double if, within the next few decades, all the planned dams are built. The biggest effects will be created by those dams planned for the Amazon basin (Grill, et al. 2015).

Dams have also come at a cost to millions of people especially to those who have been relocated. For example, the Three Gorges dam required the resettlement of over a million people (Gleick, 2003). Another problem has been that when water is stored in the Three Gorges reservoir to drive the dam's turbines through the winter the flow of the Yangtze falls causing the water level to drop in China's largest lake, the Poyang Lake. Normally, the lake covers an area of 3,500 km² but during December 2011 and the following January it only extended for 200 km² due to the combined impact of a severe drought and the Three Gorges dam. Consequently, the fisheries collapsed and the ecological and economic impacts have been disastrous and even freighters have to be empty so that they can move at all (Thibault, 2012)!

A similar problem is illustrated by the Colorado River. *"Since 1905, flows in the Colorado River have decreased markedly because seven states and Mexico withdraw the river's entire flow for agricultural and urban uses. In most years no runoff reaches the river's delta in the Sea of Cortez"* (Gleick, 2003). Unfortunately, the problem is not unusual. Peter Gleick, the world renown hydrologist at the Pacific Institute for Studies in Development, Environment and Security in California writes that *"Adequate flows no longer reach the deltas of many rivers in average years, including the Nile, Huang He (Yellow), Amu Darya and Syr Darya, and Colorado, leading to nutrient depletion, loss of habitat for native fisheries, plummeting populations of birds, shoreline erosion, and adverse effects on local communities"* (Gleick, 2003).

Global warming has now changed weather patterns so that weather extremes, which seldom occurred in the previous envelope of benign conditions – stationarity (Milly, et al. 2008), are now more frequent. Dams are built to help control floods and droughts. Consequently, those managing a dam will try to ensure that the reservoir it holds has sufficient water for generating electricity, irrigation or other services. However, a reservoir which is near its water carrying capacity is not well prepared for a deluge so that *"a dam's capacity to capture water becomes a menace ... The risks are greatest when natural sponges on river catchments like forests and wetlands are being destroyed; when dams are designed with poor knowledge about the history of floods on the rivers they block; and when climate change is making all hydrological statistics useless anyway."* (Pearce, 2006). Many countries have several dams on the same river and the dilemma of a full reservoir with little capacity for a flood has been a cause for a number of tragedies. The worst occurred in Henan Province, China in 1975 when a typhoon unleashed floods causing the River Ru to swell causing a dam to burst releasing a 120 million m³ of water downstream to the 120m high Banqiao dam which also burst. The 6 meter high wall of water was twelve kilometers wide traveling at about 50 kilometers an hour and killed between 80,000 to 200,000 people (Pearce, 2006).

Another danger of creating dams and large reservoirs is that the enormous weight of water can trigger earthquakes and this appears to have been the case with the new Zipingpu dam in China, which *"may have triggered the failure of the nearby fault, a failure that went on to rupture almost 300 kilometers of fault and kill some 80,000 people"* (Kerr & Stone, 2009). Prior to the Wenchuan quake occurring, the dam's reservoir was successively filled to near capacity and partially emptied could have provided the stresses to have triggered smaller quakes which subsequently resulted in the major quake (Xiao, 2012).

Disruption of natural systems

The tragedy of the Amazonian dams is that, unlike the Three Gorges dam in China, many of the Amazonian dams have been planned in terrains with shallow flood valleys. Consequently, the waters behind the dams cover land far greater than recommended by the economics and have a colossal environmental impact. The example of the Balbina dam is a tragic illustration since the rising flood waters caused by the dam covered 240,000 hectares (Monbiot, 1992) and might eventually cover 400,000 hectares. Many dams are planned for the Amazon basin and dam construction will lead to more roads being constructed, an invasion of workers and many new settlements which in turn leads to deforestation and ecological destruction. The building of the Belo Monte dam in Brazil was stopped by the legal opposition of environmental campaigners and by indigenous peoples who will loose the forest where they live and which they know. The Belo Monte dam is just one of a series planned on the Xingu River, a tributary of the Amazon.

The great danger in the Amazon is that deforestation and climate change could cause a tipping point to be reached so that the weather pattern changes into a drier regime resulting in the dams becoming obsolete (Tollefson, 2011). In addition, the environmental damage and loss of habitat, the drowned vegetation will emit methane as it rots. In North America more than a quarter of all freshwater fauna populations are in danger of extinction due to the development of dams (Gleick, 2003).

In 2010 China experienced an unusually severe drought providing the world with invaluable environmental lessons. *"Scientists in China say that the crisis marks one of the strongest case studies so far of how climate change and poor environmental practices can combine to create a disaster"* (Qiu, 2010). It is thought that the extensive deforestation in the mountainous regions of Yunnan is a probable cause since *"Natural forests are a key regulator of climate and hydrological processes" says Xu, who is China's representative at the World Agro-forestry Centre, ... The forest's thick litter layer of organic material can absorb up to seven times its own weight in water"* (Qiu, 2010). Meanwhile, in the Xishuangbanna prefecture, Yunnan, 96% of the tropical rainforest was cleared between 1976 and 2003 and 20% or the prefecture has been planted with rubber trees. In the north of the prefecture, eucalyptus trees have been extensively planted for the paper industry; both rubber and eucalyptus trees are renown for their water requirement. Elsewhere in Yunnan logging, quarrying, mining and urban building have severely reduced the forest causing an increase in, *"soil erosion, landslides and flash floods ... "Such large-scale deforestation removes the valuable ecological services natural forests provide,""* says Liu, an ecologist at the Xishuangbanna Tropical Botanical Gardens.

The region has adopted "hard" (Gleick, 2003) strategies by building huge reservoirs and hydropower stations because of the prestige that these projects have for administrators rather than focusing on local *"small-scale infrastructure – ponds, small reservoirs and canals – to distribute clean water to the hardest hit areas." Xu says "There is an urgent need to develop an effective hydrological network in the province"* (Qiu, 2010).

A "mega" engineering project being carried out in China is *"China's South-North Water Diversion Project, initially a vision of Mao's, will take water from the south of the country to the arid northern region, including the capital Beijing, which suffers from water shortages"* (Duggan, 2013). It will enable nearly 45 billion m^3 of water a year from the Yangtze river and its basin to be pumped to the north. What ever else it may achieve, it is an environmental experiment which will have unknown results as was opined by *"Ma Jun, the director of the Institute of Public and Environmental Affairs and one of China's well-known environmentalists ... "Though the water diversion will enrich the water supply in the north, its impact on the ecosystem is irreversible""* (Duggan, 2013).

A solution for the Colorado River

The Colorado River has not flowed regularly to the sea since the 1960s and currently almost the entire river bed is bone dry. A new agreement between the USA and Mexico allowed the Morelos Dam floodgates to open on 23 March 2014 to release 130 billion liters of water over an eight week period. Scientists are watching very carefully to observe what happens to the riparian environment along its banks. This experiment will also help to remove the accumulated salts from the soil and to recharge the water table (Stokstad, 2014; Upfront, a. 2014).

6.9.3 Groundwater and Aquifers: underground water

> *"Groundwater is a life-sustaining resource that supplies water to billions of people, plays a central part in irrigated agriculture and influences the health of many ecosystems ... We estimate that the size of the global groundwater footprint is currently about 3.5 times the actual area of aquifers and that about 1.7 billion people live in areas where groundwater resources and/or groundwater-dependent ecosystems are under threat"* (Gleeson et al, 2012).

Aquifers are deposits of water fed by rainwater seeping (infiltrating) beyond the root zone and then deep into the ground where it is trapped by geological strata forming an underground basin or catchment. The rate at which water accumulates, and the aquifers are recharged, varies from more than 150mm per year to no recharge at all. The Nubian Sandstone aquifer which provides water to four nations: Chad, Egypt, Libya and the Sudan contains water about 1,000,000 years old and isotope studies confirm that it is not being recharged at all (Wald, 2012) due, perhaps to changing weather patterns over this period. Consequently, oases and a lake are drying up in Libya because the aquifer is being rapidly emptied. Egypt extracts water to supply its cities located far from the Nile; however, the Nubian Sandstone Aquifer is Libya's only fresh source apart from the salty Mediterranean. Other aquifers vary in age from relatively young to 50,000 years old. As the impact of global warming increases and weather patterns change so will the recharging of aquifers change too. Currently, *"we are depleting everyone of the world's major mid-latitude aquifers ... the main culprit is agriculture, which uses massive amounts of water ..."* (Wald, 2012).

NASA satellites reveal the serious depletion of aquifers and groundwater by measuring changes in the Earth's gravity caused by the underground water masses (Cook-Anderson, 2009). In India the extraction of groundwater is very a very serious problem. NASA scientists, Rodell et al, report that *"During our study period of August 2002 to October 2008, groundwater depletion was equivalent to a net loss of 109 km^3 of water, which is double the capacity of India's largest surface-water reservoir."* They warn that *"If measures are not taken soon to ensure sustainable groundwater usage, the consequences for the 114,000,000 residents of the region may include a reduction of agricultural output and shortages of potable water, leading to extensive socio-economic stresses"* (Rodell, Velicogna, & Famiglietti, 2009).

The extraction of 'fossil' groundwater (ground water thousands of years old) from aquifers are causing them to shrink at an ever increasing rate. In 2010, it was estimated that the *"annual depletion more than doubled from 126 km^3 in 1960 to 283 km^3 in 2000"* (Research Highlights, 2010). The highest depletion rates were in major agricultural areas such as north-west India, the central USA and northeast China. Total global groundwater withdrawal from aquifers and groundwater supplies is estimated to be 734 (±82) km^3 a-1 for the year 2000 (Wada, et al. 2010). However, groundwater and aquifers are recharged by rainfall and so *"Abstractions in excess of recharge provide an estimate of the amount of groundwater depletion ... total global groundwater depletion is quite substantial, totalling an estimated 39 (±10)% of the global yearly groundwater abstraction, 2 (±0.6)% of the global yearly groundwater recharge, 0.8 (±0.1)% of the global yearly continental runoff and 0.4 (±0.06)% of the global yearly evaporation. This makes groundwater over abstraction a term of the global water balance that cannot be neglected"* (Wada, et al. 2010).

An unanticipated consequence of the use of groundwater is that after it had evaporated and fallen as rain over the oceans it was contributing about 25% of the annual sea-level rise. In other words about *"the same order of magnitude as the contribution from glaciers and ice caps (without Greenland and Antarctica)"* (Wada, et al, 2010).

In Germany 70% of the drinking water comes from aquifers but 36% of German aquifers are in a bad condition and 27% of the 36% are polluted with nitrates from agricultural fertilizers (Schrum & von Aster, 2015). Less fertilizer needs to be used by the agro-industry. However, instead of the chemical industry maximising its profits what is needed is a systemic approach with a limited use of fertilizer so that there is no or minimal run-off to pollute the groundwater. Unfortunately, all stakeholders involved are trying to maximise their profits and so we see an example of a fundamental problem of neo-liberal capitalism. The competitive drive for profit by each stakeholder is not the way to run a natural system that provides our water and food.

Dependence on groundwater supplies is obviously not a sustainable strategy, nonetheless, more and more countries are resorting to the use of their groundwater. *"Forthcoming projections for global water stress in 2020, 2030 and 2040 by WRI's Aqueduct project indicate that the global water picture is likely going to get worse over the next few decades. Larger populations and growing economies demand more water and in some places climate change will likely reduce available water supply. While our vulnerability to drought grows, the incidence of extreme weather events, including drought, will grow as well, according to most climate change experts"* (Iceland, 2015).

6.9.4 Agricultural Needs

> *"Global water scarcity is primarily an issue of hunger, not thirst."* (Schiermeier, 2008).

> *"Recent studies suggest that the world will need 70 to 100% more food by 2050"* (Godfray, et al 2010).

> *"It is estimated that 30–50% (or 1.2-2 billion tonnes) of all food produced on the planet is lost before reaching a human stomach,"* Dr Tim Fox, CEng FImechE, Head of Energy & Environment, ImechE (Inst. of Mechanical Engineers, 2013).

"Feeding future populations requires an unprecedented increase in agricultural productivity – unprecedented both in magnitude and in scope. The challenge is to generate more food for vulnerable societies and do it in balance with ecological functions in vulnerable ecosystems." The most cited figure for agriculture's water needs is 70% but this is based on *"the annual withdrawal of blue water for irrigation"* (Falkenmark & Rockström, 2004).

"Of the estimated 1.4 billion hectares of crop land worldwide, around 80 per cent is rain-fed and accounts for about 60 per cent of global agricultural output … Some 20 per cent of the world's cropped area is irrigated, and produces around 40 per cent of total agricultural output." (FAO, 2013)

Although the overall picture is therefore complicated due to regional differences in rainfall, climate and styles of agricultural production *"Water for food accounts for up to 95 per cent of the direct per capita fresh water needs"* (Falkenmark & Rockström, 2004).

There is no single answer to the challenge of more water to grow more food for those currently undernourished and the extra 2 billion by 2050. The problem of food requires a systematically coordinated range of answers so that, for example, the current substantial 30–50% wastage of food (Institute of Mechanical Engineers, 2013) means that improved food storage and logistics could make a significant contribution to the problem of more water. However, we are experiencing an intersection of several challenges which include climate change, more people consuming meat, and food producers are all competing with other sectors for land, energy and water. Water is also of primary concern because as has already been described peak ecological water means that we have to ensure that nature has the water it requires to maintain the ecosystems and provide ecosystem services on which our survival also depends.

The FAO (2012) states that *"It is expected that by 2050 an additional billion tonnes of cereals and 200 million tonnes of meat will need to be produced annually to satisfy growing food demand … In broad terms, agriculture has three options for managing overall water demand within the water domain:*

› *reduce water losses*
› *increase water productivity; and*
› *water re-allocation"*

In contrast to agro-industrial production *"smallholder farmers carry out 60 per cent of global agriculture. The smallholder sector as a whole is responsible for 80 per cent of agricultural production in developing countries,"* (Falkenmark & Rockström, 2004). The vast majority of these farmers are found in the developing tropical countries. Developments have shown simple strategies can return degraded lands to productivity. For example, in the Illela district in Niger, more than 300,000 hectares were rehabilitated by a variety of water harvesting techniques such as contour stone bunds, and half moon stone bunding. Furthermore, planting in small pits/basins (zai") stabilized the region and increased tree cover (Godfray, 2010).

In the Himalayas, the ancient kingdom of Ladakh is suffering from global warming which is causing the disappearance of the glaciers which normally provide a seasonal supply of water for farming. Chewang Norphel, an engineer-hydrologist, uses a different kind of water harvesting by creating artifical glaciers. Although the idea was initially ridiculed he successfully diverted the lost winter melt waters into shady depressions where the water slows and again freezes to create an artificial glacier. Then when the sun's orbit rises higher in the spring it melted the ice providing water for the sowing season. His first artificial glacier above the village of Phuktse supplies water for crops sustaining 1500 inhabitants. Norphel has now built 10 artificial glaciers by creating holding walls in appropriate shaded locations to which waters can be diverted (Vince, 2009).

6.9.5 Industry's Needs

"Water is the most essential component for the life of all beings. Hardly any economic activity can be sustained without water" (Haddadin, 2001). Water plays a key role in energy generation just as energy plays a key role in industry. *"Water is essential to the production of energy, and the energy sector already accounts for 15% of the world's total water use. Its needs are set to grow, making water an increasingly important criterion for assessing the viability of energy projects"* (IEA, 2012). In 2012 the long heat wave in the USA impacted on energy production because power plants *"… are completely dependent on water for cooling and make up about half the water usage in the US. That makes them vulnerable in a heat wave. If water levels in the rivers that cool them drop too low, the power plant – already overworked from the heat – won't be able to draw in enough water. In addition, if the cooling water discharged from a plant raises already-hot river temperatures above certain thresholds, environmental regulations require the plant to shut down"* (Reardon, 2012). Nuclear power plants require the most water and so for example, a plant that generates about *"12.2 million megawatt hours of electricity"* requires 2,725 liters of water per megawatt hour for cooling while on average coal and natural gas plants need only 1,890 and 719 liters respectively of water per megawatt hour for cooling. Meanwhile according to the Dutch water expert, Arjen Hoekstra, bio-fuel also suffers during droughts because *"… According to his "water footprint calculator", bio-fuels require orders of magnitude more water than any other energy source"* (Reardon, 2012).

Industry is the second biggest user of blue water after irrigation for agriculture. Water plays a key role in industry and manufacturing and would be unable to function without water because it fulfills many requirements. *"Industrial use is very unevenly distributed over the world, with only 10 m³ / person / year used in sub-Saharan African countries while 140 m³ / person / year used in European countries. Certain industrial sectors require large volumes of water, such as the wood pulp and paper industry. One tonne of cellulose pulp normally requires 400-500 m³ of water. Ferrous metallurgy uses some 40-50 m³ per 1 tonne of cast iron, and it takes up to 500 m³ to produce 1 tonne of copper. Synthetic rubbers, fibers and plastics require large volumes of water in the range of 2000-5000 m³/ tonne (Shiklomanov, 2000)"* (Falkenmark & Rockström, 2004).

Coal washing improves the quality of the coal and helps to reduce emissions, however, it requires both water and energy. *"In China, for instance, washing contributes to the 18% of total national water use that goes to coal, the second-largest source of water consumption after agriculture"* (Alvarez, 2014).

About 16% of the world's energy is provided by hydro-electric power (Wagner, 2008). Water is also used to refine agricultural products and crude oil, cool industrial processes, clean products, remove industrial waste and for all these processes industry primarily uses blue water (Mauser, 2007). A fracking well may require any amount of water ranging from 22,000 liters to 2.2 million liters in the initial stages and during its entire lifespan between 7.5 - 15 million liters of water (Prud'homme, 2014). In America's driest areas fracking is depleting the water supplies from Texas to California. In recent years aquifer levels in the Eagle Ford formation have dropped over 90 meters (300 feet). There is now fierce competition for water for local and domestic use and the fracking industry (Goldenberg, 2014). The use of the enormous quantities of water in fracking is very questionable because many chemicals are added to the water for the fracking process and then pumped deep underground so that it can no longer participate in the water cycle. The water that does return to the surface is heavily polluted.

The current severe droughts of central and western USA are causing people to use groundwater supplies extensively resulting in wells drying up. Satellite metrics now reveal *"California's devastating loss of freshwater since 2002. In each of the past 3 years, epic drought has drained the region of more than 15 cubic kilometers of freshwater."* Furthermore, the satellites also show that the water withdrawals have lightened crustal loading causing the Earth's surface to rise an average of 5 mm and a maximum of 15mm. The scientists estimate that the total water *"deficit to be ~240 gigatons, equivalent to a 10-cm layer of water cover over the entire region, or the annual mass loss from the Greenland ice sheet"* (Borsa, Agnew & Cayan, 2014).

Following its use in the industrial process water is either warmer or chemically polluted, perhaps with acids or other toxins. However, enormous strides have been made by many industries to re-use their water and thereby cut their costs. So for example in Germany *"the Audi factory in Ingolstadt, over 98% of the water used in car production is re-used"* (Mauser, 2007). This trend has now become significant so that for example the oil and coal industries in 1954 were re-using 3.3% of their water but by 2000 this had increased to 32.7%. The paper industry in 1954 was re-using only 2.4%, but by 2000 it was 11.8%. Other industries such as the chemical, processing and heavy industries have also increased their re-use of water within this band width (Mauser, 2007).

The recycling of water by the European industries has resulted in a drop of consumption. However, another factor which has contributed to the decreasing water consumption in Europe is due to industries relocating their factories from Europe to countries with emerging economies such as Brazil, India, China and South Africa (Mauser, 2007). Yet Brazil, India, China and South Africa are all seriously water stressed.

6.9.6 Domestic and Urban Needs; water stewardship

The domestic use of water per capita varies enormously around the world; so that in the USA domestic water use is estimated at 366 m^3 per person per year. European consumption is 232 m^3 per person per year and in Africa it is 25 m^3 per person per year (Falkenmark & Rockström, 2007).

Separate from our consumption of water in food and products, is the provision of the water as a utility "on tap" for domestic use. This domestic use includes, in order of priority, water for: drinking, cooking, sanitation, laundry, and other uses (Savenije & van der Zaag, 2002). Obviously, it is not efficient to use drinking quality water for flushing lavatories.

The first place where we can all start thinking about the problem of water conservation and practicing water stewardship is in the home (Purvis, 2014). It is also an area which offers designers many opportunities for innovative design:

- **Dishwasher versus Washing by hand:** Dishwashers use about 14 liters of water plus electricity and that is not counting the rinsing of crockery with water so they can be washed in the dishwasher. Meanwhile, a washing-up bowl requires only 4 to 5 liters of water.
- **Lavatories:** An editorial from the journal Nature states the problem: *"The world's difficulties with sanitation might be eased if we abandon the idea of disposing of our waste with a flush. In the rich North, flush toilets are the largest single drain on domestic water supplies. But there is no need for the developing countries that currently lack adequate sanitation to imitate this wasteful practice, which would require substantial investment in sewage-treatment infrastructure. Ventilated, composting toilets can now safely turn human waste into an odourless, soil-like residue. Further development may be needed to reduce the cost of the technology. But as demands for water grow, this has to be a better solution than a system that involves the contamination and subsequent treatment of precious water supplies"* (Nature editorial, 2003). There are many potential developments for saving domestic water use by lavatories and the quantity of water used for flushing reduced.
- **Washing:** Showering as opposed to taking a bath is now a well established alternative for saving water, however, there are shower heads for conserving water which halve the quantity of water without a perceptible difference. Much water is wasted when showering since liters of cold water are run before the warm water reaches the shower head. In Costa Rica water heaters are integrated into shower heads saving the waste of cold water.
- **Grey water:** 95% of the water delivered to a household leaves down the drain and so a grey water system could make a substantial saving.
- **The garden:** A water butt collecting water from the roof can provide rainwater for watering the garden rather than using drinking quality water from the tap.
- Water meters which display a householder's use of water are proving very effective and have helped to reduce consumption by about 10%. Water is an essential requirement

for food production and consequently, the proportions and choice of the foods we eat has an environmental impact. A kilo of beef requires 15,500 liters (Marris, 2008) of water whereas a kilo of maize requires 900 liters of water (Allan, 2011). These metrics are of increasing concern as prosperity across some of the developing countries is enabling people to increase their meat consumption. The study cited above by Eshel et al (2014) and their calculations basically reveal that *"Livestock-based food production is an important and pervasive way humans impact the environment. It causes about one-fifth of global greenhouse gas emissions, and is the key land user and source of water pollution by nutrient overabundance. It also competes with biodiversity, and promotes species extinctions. Empowering consumers to make choices that mitigate some of these impacts through devising and disseminating numerically sound information is thus a key socio-environmental priority."* More specifically their calculations show *"that the environmental costs per consumed calorie of dairy, poultry, pork, and eggs are mutually comparable (to within a factor of 2), but strikingly lower than the impacts of beef. Beef production requires 28, 11, 5, and 6 times more land, irrigation water, GHG, and Nr [reactive Nitrogen], respectively, than the average of the other livestock categories. Preliminary analysis of three staple plant foods shows two- to sixfold lower land, GHG, and Nr requirements than those of the non-beef animal-derived calories, whereas irrigation requirements are comparable"* (Eshel et al., 2014).

Those of us who are lucky enough to choose what we eat can act to reduce our ecological footprint through our diet. However, there are many strategies for reducing water consumption and enhancing its productivity; furthermore, we can be sure that there are innovations, as yet unknown, that designers will develop for contributing to our water security.

6.10 Achieving Water security: new 'soft' path strategies to supplement 'hard' path strategies

The issue of water security is now receiving considerable attention and confirmed by the publication of 200 papers in just the last 6 years. Water security can be defined as *"an acceptable level of water-related risks to humans and ecosystems, coupled with the availability of water of sufficient quantity and quality to support livelihoods, national security, human health, and ecosystem services"* (Bakker, 2010).

The old 'hard path' strategy

In many nations the centralized water provision systems are in need of renovation and modernization. One cause of the problem of water supply is the historical 'hard path' perception of water engineers to provide water by depending on more large dams, boreholes, water pipelines, and centralized infrastructures needed to supply all stakeholders. However, this old fashioned approach, predominant up to the 1960s, is too inefficient and costly. Worse than its inefficiency, 'hard path' strategies are destructive and disruptive of natural ecosystems (Gleick, 2003). Up to 1900 there were only 40 reservoirs which had been built capable of holding more than 25 billion gallons of water but by 2001 there were 3,000 reservoirs with this capacity or more and covering 120 million acres. The Aral sea has largely disappeared due to dams on the rivers which once fed it and which were built to irrigate cotton farming. However, with the destruction of ecosystems and the riparian environments around streams, rivers and lakes gone, people have become aware of the environmental consequences and begun to protest against further major dam projects. Consequently, dams in some countries, for example France, have been demolished restoring the fisheries and in the USA 500 dams have been demolished (Gleick, 2005).

Furthermore, many ageing hydro-infrastructures are in poor condition and need replacing. However, the costs of restoration beg the question of viable alternative strategies. What is really required is a major systemic increase in our efficiency of how we use water, more 'crop per drop', and not just in agriculture. Much water is lost through leaking pipelines; it is calculated that the cities of Boston and London loose about one third of their water through leaking pipes, whilst Singapore looses less than 5%. Indeed, Singapore has a water policy which aims to recycle 50% of its water by the time its water link with Malaysia is cut in 2061 (Pearce, 2010).

The new 'soft path' decentralized strategies

The existing centralized water supply needs now to be supported by a parallel water supply system of distributed, local and interconnected infrastructures (Qiu, 2010). There is ample room for design innovation to create localized water provision and enhance water security. Peter Gleick (2003), an internationally renown expert on water, advocates the '*soft path*' strategy approach to complement the centralized infrastructure, with "*small-scale decentralized facilities*" aimed at improving the productivity of water which delivers water according to a user's needs rather than merely quantities of water. This '*soft path*' approach, originally proposed by Amory Lovins (1977) for energy is already happening with power generation so that now many householders and companies have solar panels on their roofs. Roofs are conventionally regarded as providing shelter when they should also be seen as resource harvesters because every roof has the potential to not only collect solar energy but also to function as a water catchment. In this way the houses in each street could feed their runoff into local mini-reservoirs. In addition, without constricting the flow of rivers, many rivers could have low (micro) dams to hold back some water enabling more water to seep into the ground and recharge aquifers. Furthermore, micro-dams could contain micro-turbines to provide energy locally (Deveney, 2012; Vidal, 2015). Shallow rivers could be widened to increase the surface area of the ground over which they move to help feed the aquifers by water infiltration. In addition, increasing the water area could encourage wildlife and biodiversity.

Off-the-water-grid Home

The concept of a self-sufficient home able to be 'off-the-water-grid' becomes possible if appropriately modified and equipped with items such as a vacuum lavatory, anaerobic digestor producing methane (for heating the water), greywater micro-filter supplying water to a wetland for irrigation (Sedlak, 2014). New legislation could be implemented so that housing and other buildings with roofs draining rainwater away into gutters to reach urban sewers could drain into inhouse water storage systems for sanitation use or for holding in local ponds. If the concept of the 'off-the-water-grid' house were combined with Rifkin's concept for transforming the housing stock into energy generators the potential need for innovative design becomes an incredibly exciting challenge.

Australia is well known for its droughts but the Millennium Drought, *"The severe drought that afflicted South Eastern Australia from 1997–2009 'Big Dry' is likely to have been the worst since first European settlement according to a new study by climate scientists at the University of Melbourne"* (Cockfield, 2011). The lead author of the report, published in the US journal Climatic Change, Dr Joelle Gergis, states that: *"Our study shows that while rainfall has varied naturally over time, the recent drought may have been exacerbated by the 1°C increase in maximum temperatures observed in the south-eastern Australian region over the past 50 years."* The Millennium Drought substantially changed the way water was used and new municipal aims were publicized and regulations were implemented to promote greater efficiency in water use. In South East Queensland (SEQ) some of these measures included:

"Target 200: maintaining average consumption at or below 200 liters per person per day.

Local water supplies: Off-Grid supplies, such as rainwater tanks, must now be installed for all new houses and most new industrial and commercial buildings. This water will be used for appropriate internal purposes, as well as for outdoor watering. The Strategy supports the adoption of stormwater harvesting and recycling where efficient and effective.

…

- *Power stations will be required to use recycled water rather than other supplies when using water from the SEQ Water Grid.*
- *All building development applications lodged for the construction of new homes in SEQ must meet mandatory water savings targets. Internally plumbed rainwater tanks are one option to achieve the water savings target.*
- *Rainwater tanks and stormwater harvesting in new developments are forecast to reduce demand on bulk water supplies by about 7 per cent by 2056"* (Sharma, 2012).

Local developments for de-centralized wastewater and communal rainwater tank systems (Sharma, 2012) have already been built and are successfully functioning at the Ecovillage at Currumbin (110 houses) and at Capo di Monte (46 houses) and provide examples of

"off-grid" community water management. The conclusions were that:
"... cluster scale rainwater systems, with some top-up supply source, can provide a reliable water source.
However, there is an energy penalty. This could be addressed by smaller pump sizing, which would meet flow and head requirements, but improve energy efficiency."

Furthermore, rather than leaving the management of rainwater harvesting to individual householders, it could be more effectively managed collectively, in a cluster or community by a local corporation. A cluster system is more easily implemented where housing is not highly concentrated so as to provide space for the associated facilities such as a decentralized wastewater plant, biofilters, septic tanks etc. It was found that over a *"30 month monitoring period, more than 80% of the demand for potable water (35 kL/household/year) could be met from the harvested roof runoff"* (Sharma, 2010).

The South East Queensland challenge is to reduce the total water consumption per person from the 450 liters per day in 2004–05 to a conservative maximum of 375 liters per person per day while aiming for an average of 200 liters. The overall aim is to maintain demand of water to 24% below levels prior to the Millenium drought saving an estimated 241,000 megaliters per year with medium population growth (Sharma, 2010).

Consequently, strategies developed in Australia for water management could be more widely adopted around the world as climate change increases the likelihood of droughts and water stress in other regions. The move towards 'soft' (Lovins, 1977) strategies for localized water management and water farming etc. offers an enormous potential for innovative design to make a significant contribution towards a sustainable future and securing water security. However, such strategies may already be too late for some regions such as the south west of North America.

In August 2014, *Nature* reported that *"More than 20% of California shifted from extreme to exceptional drought – the most severe category – in the week up to 29 July. An update from the US Drought Monitor shows that exceptional drought now affects more than half* [58%] *of the state ..., with more than 80% classified as under extreme drought or worse. California is short of more than a year's worth of reservoir water"* (Trendwatch, 2014). The language now being used by climate scientists is of 'mega-droughts.' Furthermore, computer models based on past climate and collected observations for the Southwest and Central Plains of Western North America robustly indicate that *"drought in the late 21st century over the Central Plains and Southwest will likely exceed even the most severe megadrought periods of the Medieval era in both high and moderate future emissions scenarios, representing an unprecedented fundamental climate shift with respect to the last millennium. Notably, the drying in our assessment is robust across models and moisture balance metrics ... Combined with the likelihood of a much drier future and increased demand, the loss of groundwater and higher temperatures will likely exacerbate the impacts of future droughts, presenting a major adaptation challenge for managing ecological and anthropogenic water needs"* (Cook, et al., 2015).

6.11 Conclusion: Design could make an invaluable contribution

As Earth stewards (Chapter 14) we are automatically water stewards, designers have a responsibility to understand the implications of water not only in their personal lives but very importantly in their work and the water required for the manufacture of their designs and the choices they make in other areas of design.

We have to change how we perceive and use water. The good news is that as a resource water keeps cycling. However, our historical perception of water based on our past experience and 'business as usual' are not a recipe for the future. The American Southwest is a warning we must all take seriously. There is good news, for example, although during the first three quarters of the twentieth century water use in the USA increased per capita ten times, since 1980 water consumption per person has dropped due to the introduction of a range of new technologies and legislation. For example, the US legislation that flush lavatories reduce water per flush by 70% from 6 gallons to 1.7 gallons. We have to use water more productively and design can play a key role.

Firstly, the additional 2 billion people by 2050 will cause increasing demands of:

› water for agriculture
› water for energy
› water for industry
› water for domestic and urban use

all the while we must ensure that adequate water must be available for ecosystems and biodiversity so that ecosystem services can function.

Secondly, solving the water problem for any one of these areas will, as likely as not, create a problem in one of the other areas. However, another strategy consists of embracing a systemic approach concerned with several or all areas together because of:

- the overall increasing demand for water. (In 2009 a McKinsey report noted that the contemporary water requirement was 4,500 km^3 and if no efficiency measures adopted by 2030 then the global water requirement would increase to 6,900 km^3. (McKinsey, 2009))
- climate change
- the increasing cost of centralized infrastructures, both their repair and modernization.
- the development of 'soft path' strategies.

We are all water stewards now

The problem we have is to ensure enough water to grow enough food for everyone. Therefore, what range of strategies and innovations need to be developed? Although water supply is usually regarded as a hydrologists problem, designers have the potential to provide many innovative solutions, by applying and transferring principles from other areas to solving water problems (Carswell, 2009; Gabel, 2014; Smith, 2007) and creating design solutions for:

- 'soft' decentralized water strategies.
- increasing the groundwater by soil infiltration & percolation aids.
- re-establishment of riparian ecologies for better water management and security, mitigating flooding, enhancing biodiversity, landscape aesthetics. The good news is that many dams are being dismantled due to obsolescence and deterioration. In the USA about 1,150 dams have been removed, and ecosystems are reviving and fish species and other fauna and flora are returning (Lovatt, 2014).
- urban rainwater harvesting, every roof is a potential water catchment.
- rainwater harvesting.
- more crop per drop.
- digital monitoring of soil moisture with sensors implanted into the soil is providing the basis for a new kind of farming – precision farming (Hodson, 2014; Gebbers & Adamchuk, 2010).
- micro-dams providing power for local communities.
- distributed small reservoirs and ponds (Qiu, 2010) which also enhance biodiversity.
- etc.

Climate change will make it increasingly necessary for us to revise how we consider water. We need a new Water stewardship. A change of attitude towards water is crucial. The western style consumer culture expects drinkable water at the turn of a tap for any domestic use but this is not realistic because we can no longer be profligate with water? Today the use of drinking water to wash-down a vehicle is ethically questionable with 2 billion people without enough water for sanitation. How can we all learn to deeply value water since circulating as vapour in our atmosphere water belongs to everyone and is a 'commons' which may fall as rain anywhere.

When we use water we borrow it from the hydrocycle.

Communication essential

Design has a key role to play; on the one hand in communicating a new perception of the value of water and creating an awareness of the water problem. On the other hand design can contribute innovative products, services and social innovations for achieving a sustainable use of water. There is much scope for design in the development of 'soft strategies' (Lovins, 1977) such as local water harvesting and for the bioregional and local organization of water security. This will help to provide resilience against global warming which is already changing weather patterns. These new weather patterns require adaptive design for innovative water management. Sandra Postel, director of the Global Water Policy Project in Massachusetts, USA says *"The challenge now is to put as much human ingenuity into learning to live in balance with water as we have into controlling and manipulating it"* (Ball, 2000).

Soft strategies & systematic innovations to replace "siloed" thinking with integrated utilities

We need systemic answers for our sustainable future. Traditionally, utilities such as sewage removal, waste disposal, energy provision and water supply are organized by separate departments or outsourced to competing corporations providing specific services. This fragmentation of utilities driven by neo-liberal capitalism and competing 'outsourcers' is unsustainable and well illustrates that the market will not provide what is needed or best (a dominant political mindset). What is required is an integrated systemic response to housing and the utilities housing requires so that the whole functions like an organism. Two separate utilities become one when sewage provides energy. Water instead of draining off roofs to join sewers can be recycled etc.

Furthermore, the concept of a house changes from a people container providing protection from the elements to providing a symbiosis with its inhabitants. Simultaneously, existing with its own 'physiological' cycling of integrated utilities. The concept of the "off-the-grid" house (Rosen, 2010) is one which is primarily independent of a central municipal supply of utilities but might remain connected in order to share its resources when in surfeit or when needing a "top-up" (Sharma, 2012). The sustainable house could be modified or built to contain an integrated system: its own rain-water harvesting system, water filters, solar panels, solar thermal collector, wind-turbine, methane gas generator, dry lavatory, ground source heat-pump, etc. (Vince, 2008). Alternatively, a cluster or community of houses can be organized and provisioned to be "off-grid" and self sustaining or nearly so (Sharma, 2012). In 2008 (Vince, 2008) it was estimated that there were approximately 200,000 households living "off-grid" in the US, however, only a couple of years later another author (Lydersen, 2010), estimated that there are about 750,000 US households with numbers increasing by about 10% per year.

In this chapter we have primarily been concerned with understanding water so that we can achieve a sustainable future. However, for over 2 billion people water is and remains a problem since they have insufficient provisions for sanitation and drinking. Furthermore, we need to consider how we will cope with the additional 2, possibly 3 billion people by 2050. Water security is not only a problem which severely affects people in India or in the Sahel across Africa, it also affects citizens in the richest country of the world – the USA where, for example, in the city of Detroit, Michigan, over 15,000 homes had their water supply cut off. The Detroit Water and Sewerage Department took the decision because of unpaid water bills, an action condemned by the United Nations as a violation of human rights (Upfront, b. 2014; Agence France-Presse, 2014). Is water a commodity to be privatized, speculated on and marketed for shareholders' dividends or is it a right for life? If our lives depend on a daily consumption of 2.5 liters of water and if it is a right for life then how can design contribute to ensuring that it remains so?

6.12 Peak Ecological Water reached?

The McKinsey (2009) report *Charting our Water Future* states that by 2030 our demand for water will increase by 40%. The estimates for the proportion of the world's water used for growing food ranges from 70 - 95% (Falkenmark & Rockström, 2004) depending on the source. Meanwhile, Peter Gleick (2009) states that we are loosing freshwater species faster than either terrestrial or marine organisms due to our excessive demand for- and reorganization of water. Furthermore, it is estimated we already appropriate almost 50% of freshwater flows (Postel et al. 1996; Gleick, 2009). So what is left for nature? I believe that we have reached what Palaniappan and Gleick (2010) call *'peak ecological water'* (you will recall that *"Peak 'ecological' water"* was *"defined as the point beyond which the total costs of ecological disruptions and damages exceed the total value provided by human use of that water."*) and which demands that we share the world's water with Nature and the biosphere. We need to re-educate ourselves very profoundly about water because for those of us able to turn on a tap gives us the illusion of it being plentiful – it's not. Already, our use of it is damaging ecosystems, the same ecosystems which both purify the water and help it to flow through the Earth system enabling us to re-use it again and again and …?

The good news is that technologies are being developed to recycle water from least likely sources. At the beginning of 2015 Bill Gates showcased the technology for distilling water from human faeces (BBC, 2015).

"The developer of the Omniprocessor system, Peter Janicki, says the raw "sewer sludge" is first boiled, during which process the water vapour is separated from the solids … Those solids are then put into a fire, producing steam that drives an engine producing electricity for the system's processor and for the local community. The water is put through a cleaning system to produce drinking water. "Why would anyone want to turn waste into drinking water and electricity?" Gates asked. The answer, he wrote, was because "diseases caused by poor sanitation kill some

700,000 children every year, and they prevent many more from fully developing mentally and physically". He added: "If we can develop safe, affordable ways to get rid of human waste, we can prevent many of those deaths and help more children grow up healthy." (BBC, 2015).

Now that this is possible then the challenge remains from what other polluted sources can water be distilled and re-used? Communication, media and product design have key roles to play in changing our attitudes about water and designing and promoting every means possible for saving and ensuring the re-use of our water.

6.13 References and further reading

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Detlef Virchow

7 Food and Nutrition Security – a challenge for all

"It is estimated that 30-50% (or 1.2 - 2 billion tonnes) of all food produced on the planet is lost before reaching a human stomach." Dr. Tim Fox, Head of Energy & Environment, Institution of Mechanical Engineers 2013

"The world population is predicted to grow from 6.9 billion in 2010 to 8.3 billion in 2030 and to 9.1 billion in 2050. By 2030, food demand is predicted to increase by 50% (70% by 2050). The main challenge facing the agricultural sector is not so much growing 70% more food in 40 years, but making 70% more food available on the plate." United Nations Department of Economic and Social Affairs, (accessed at: http://www.un.org/waterforlifedecade/food_security.shtml)

7.1 Introduction

Food security is easy to achieve at individual but also national and global level – at least it seems to be an easy task. And so it is not surprising that for the average consumer in the high-income-countries food security is not on the top of the agenda and an increasing number of urban population even do not know the basics of food production, processing and utilization. However, a closer look discloses the complexity of the challenge to have a global population food secured. Getting involved in the complexity shows then as well, how multidimensional the impacts of food insecurity are on an individual but as well on the society as a whole. Furthermore, it unveils the influence of action in totally other areas of society on food production, trading, processing and utilization. Even activities in the urban-dominated service sector are impacting on the availability of and on access to food as well as its proper utilization. And so even slight changes in the work of designers may have – indirect – impact on the food security at local but as well at global level. And this influence is more than the "flap of a butterfly's wings in Brazil setting off a tornado in Texas" as Lorenz (1972) predicted or the well-known snowball effect. Agriculture as the dominant part of the primary sector of most economies is most dependent on the natural resources of land, water, biodiversity and climate and the long-term maintenance of these resources. But other sectors are increasingly influencing the demand for natural resources. Hence, the impact other activities have on the environment will affect agriculture and with it food security. But due to the complexity of agriculture and food security, it is not only the stability of the natural environment which counts, but also the stability of the social and economic environment, which has significant impact on the food production and food security of individuals as well as nations and the world in large.

Before analyzing the impact of external factors on food security, food security will be defined, the concept of food security and the various forms of malnutrition presented, the major challenges to food security summarized and a political and a human-rights approach introduced.

7.2 The concept of food and nutrition security

According to a survey in 1999, there existed at that time approximately 200 definitions of and 450 indicators for food security (Hoddinott, 1999), which shows the diversity of understanding and approaching food security (Pangaribowo, Gerber & Torero, 2013). Although not accepted by all, the most favorable definition at present is recommended by the Committee on World Food Security at Food and Agriculture Organization of the United Nations (FAO), which is increasingly accepted and is a good starting point to the topic: *Food and* *nutrition security exists when all people, at all times, have physical, social and economic access to food, which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences; and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life* (CFS, 2012). This definition includes all four major aspects of food security, which are depicted in Figure 1 and elaborated by the following authors (Weingärtner & Trentmann, 2010; Negin, Remans, Karuti & Fanzo, 2009; Gross, Schoeneberger, Pfeifer & Preuss, 2000):

Food availability is the precondition to all other aspects of food security. If not enough food is produced in the first place, people will suffer of food deficiency. So to maintain the quantity but also the quality of food it is essential to produce food as well as to keep food available through storing, transporting, trading and processing agricultural produce (i.e., from plant as well as animal and aquatic production) adequately.

But even with sufficient food produced at global, regional, national, local and household level, the access to food remains another crucial determinant of food security at the various levels. At present there is enough food produced world-wide, but still there are more than 800 million people undernourished (FAO, IFAD & WFP, 2013) – a clear indicator that, although food is available globally, not all people have the same access to the available food. On the one hand, it is "just" a problem of physical access that the food cannot be transported to the people in need or the people in need do not have the means to access the markets, due to missing or inadequate infrastructure. However, access to food is also determined by socio-economic causes, of which the entitlement failures (Sen, 1981) are the most significant ones. Besides those, who do not have the access to land and the other natural resources to produce their own food or do not have the financial means to buy food on the market, there are others, who are excluded or restricted to access to food through specific institutional, cultural, religious or other reasons. These failures are relevant at all levels affecting different groups. At intra-household level mainly women and children are affected, with severe long-term effects for the persons but also for the productivity of the household (Beuchelt & Badstue, 2013).

Food and Nutrition Security			
	↑	↑	↑
	Food availability →	**Food access** →	**Food utilization**
Food stability	Production	Markets	Preparation
	Storage	Income	Knowledge, Culture & Gender
	Processing	Intra-household distribution	Health/hygiene & Child care
	Transport		Access to: Clean water, Energy

Table X: Determinants of Food and Nutrition Security; Source: adopted from Negin et al. (2009)

The third determinant of food and nutrition security is the ability and competence of food utilization mainly on household level, but also including food processing. Depending on external and internal factors, qualitative sufficient food can be prepared in such a manner that all household members benefit of a well-balanced, nutritious meal and diet. However, external factors like biotic or abiotic polluted water and limited energy resources for food preparation may turn the qualitative sufficient food to health-hazards. Furthermore, traditional and other factors in addition to hygienic and child care aspects and the over-all health status of each household member may determine a sub-optimal food preparation, utilization and nutrient up-take. Over the past years it has been strongly argued that food security is not only or mainly a challenge of taking up enough food energy as calories and protein, but it is as important to have a sufficient uptake of micronutrients like vitamin A, iron, iodine and zinc (Biesalski, 2013). To stress this fact the term "food security" is broadened to "food and nutrition security" – FNS – (CFS, 2012), which will be used in the following as well.

Eventually, at all levels, the food and nutrition availability, access and proper utilization has to be sustained so that a regular, qualitative sufficient and well-balanced diet can be available for all and the food stability can be ensured year round. This stability can be threatened at the global to intra-household level by all different categories of challenges discussed in the next section, especially from natural conditions, economic development and political instability. How much the stability is threatened depends in general on the vulnerability of the system and its resilience, i.e., the ability to cope and recover from a shock (Pieters, Guariso & Vandeplas, 2013).

Besides the factors influencing directly the four major aspects of food and nutrition security (FNS), other external factors play a significant cross-cutting role in influencing FNS. Among others these are: Education, gender equality as well as empowerment, knowledge, culture, socio-economic status, health environment and others. Despite the fact that in most cultures and social settings, women play a dominant role within the food system, a social and economic discrimination against women is experienced and documented in many countries (FAO, 2011). In general and in the majority of countries, women have limited access to education, low levels of employment, restricted access to land, credit, information, technology and decision making bodies (FAO, 2011; Cramer & Wandira, 2010). Wherever this exclusion exists in total or partially, more than 50% of the population is excluded or restricted in participating in the social and economic development in general and in the improvement of FNS in specific. Besides women as productive power in agriculture and in the economic in general, it has been shown that the main factors contributing to reduce child malnutrition are – in order of importance – women's education, food availability, health environment, women's status in the society and economy (Smith & Haddad, 2000). In this group of determinants, the education of women is contributing more than 40%.

7.3 Various forms of malnutrition

To achieve FNS at individual level but also globally, one has to understand the different types of malnutrition: The lack of food energy and protein is the classical undernourishment and is synonymic to "hunger" and its impact is quite obvious in form of stunting (low height by age), wasting (low weight by height) and underweight in children and low Body Mass Index in adults. Micronutrient deficiency is a lack of sufficient amounts of one or more essential micronutrients such as vitamins and/or minerals and due to its different and often non-visible symptoms called 'hidden hunger'. But the lack of nutrients leads not only to undernourishment. When an individual has an oversupply mainly of energy and protein (calories) over a longer period of time, overweight and after all obesity are the consequences. Very often, overweight and obesity go hand in hand with an undersupply of micronutrients. Finally, secondary malnutrition exists, when an individual has a condition or illness (e.g., diarrhea or HIV/AIDS) that prevents him/her from properly absorbing or digesting food even though good quality food is available to this person (EC - FAO, 2008).

Even though the mortality rates caused directly by malnutrition (starving to death) are relatively low, the indirect effects of early childhood malnutrition are severe, leading to death or life-long reduction of potential, mainly impacting on adult education and productivity (Hoddinott, Maluccio, Behrman, Flores & Martorell, 2008). This is especially a threat to children under 5 years, who, undernourished, will die due to secondary illnesses like influenza and pneumonia, malaria, diarrheal diseases and anemia. This holds true also for adults, however, they experience additional risks of malnourishment: Through overweight additional diseases are causing increased threat of death, like diabetes mellitus, high blood pressure, heart attack, and stroke. But also micronutrient deficiency has severe consequences for adults regarding general health, well-being and productivity.

Important to note is that malnourishment is not only an individual calamity, but has consequences for the next generation(s) (Biesalski, 2013): Undernourished or micronutrient-deficient women give significantly more often birth to babies with low birth weight and in the majority of these cases, the child grows up suffering under this weakness life-long and, being a female, has higher risk of delivering a child with low birth weight as well. This example shows in a striking way, how important a well-balanced nutritious diet is throughout the whole life-cycle (ACC/SCN, 2000).

Although the absolute numbers of (energy and protein) undernourished people is declining globally from approximately one billion people in 1990/92 to 842 million in 2011/13 (FAO et al., 2013), the absolute numbers of people suffering under micronutrient deficiency as well as under overweight are on the rise, even if there are only rough estimates existing. It is estimated that there are around two billion people suffering under micronutrient deficiencies and over one billion under overweight and obesity. For Asia, for instance, obesity is evolving to a major public health problem, mainly for the urban rich as well as for urban poor, who in addition have the added predisposing factors associated with low birth weight (Popkin, Horton & Kim, 2001). On the other hand, the biggest success of reducing the number of (food-energy) undernourished people has taken place in Asia, although still today the most undernourished people live in Asia (FAO et al., 2013). A very worrisome issue is the situation in India, which understands itself as regional power and pioneer in development. Despite India's success in many areas, 43.5% of the children under the age of five in India are undernourished, which is the highest prevalence rate of underweight globally (Index Mundi, 2014).

Furthermore – and irritatingly, the majority of undernourished people are living in rural areas and are food producers themselves (UN-HRC, 2010): Approximately 50% of the undernourished are farmers, 20% rural landless, 10% fisherfolk, pastoralists and forest dwellers, while 20% of the over-all undernourished live in urban areas (UN Millennium Project, 2005). These figures show that any policy and action to improve FNS has to take into account all four aspects of food security, including the production of food in small-scale farming environments.

7.4 Major challenges of food and nutrition security

Based on the definition of FNS and the technical concept behind, it is obvious that FNS is not only a question of producing enough food globally. It has been shown that FNS is challenged by far more than agricultural production. Very different challenges from numerous areas are affecting the direction and speed of the development into a food and nutrition secured world, in which not only enough food is available globally, but all have enough good quality food available in their daily diets.

Major challenges from the demand side are linked to the demographic trends, including the continuously growing population and the general structural development as well as the change in demand patterns of an increasing portion of the global population. A growing population from now approximately seven billion to approximately nine billion in 2015 (UN-DESA, 2013) will add more demand for the amount of food globally and – based on the general projections – there will be more or less three billion more people demanding sufficient food in 2050 (around two billion "new" people plus around one billion undernourished people of today). Besides this increase in pure quantitative demand, there is already a change in demand patterns going on leading to an increased demand of higher qualitative agricultural produce (Schmidhuber, 2004; Kearney, 2010). This shift in food demand from less staple crops to more high value produce like meat and other animal products leads to an exponential increase of demand for primary agricultural products (grain crops, oil seed crops and forages) due to the fact that the production of one kg of animal product needs – depending on the production intensity – roughly two (chicken) to seven (beef) kg of cereals, which could be used alternatively directly for food consumption (Messer & DeRose, 1998). In East Asia for instance, between the year 2000 and 2050 projections indicate an increase of about 300% of the amount of agricultural produce used for feed instead of food (Molden, 2007). Besides this shift, which is mainly fueled by a (slow but steady) increase of income world-wide, the general structural changes as globalization and urbanization are amplifying this pattern change. With over 50% of the global population living in urban areas (with further upward drift), the demand for pre-processed food is increasing. With increased processing the food waste is increasing as well, which adds up to the absolute quantity of food demanded in the future. However, the same demographic and structural changes are leading to a tendency of decreasing the quality of food consumed, not only in the urban but as well in the rural regions: The nutritional transition taking place in most countries, with different speed, but in the same direction and with the same consequences can be summarized as a shift towards a diet with more carbohydrates (sugar) and fat added with more pre-processed, industrialized and animal-based food. This tendency is increasingly associated with reduced physical activity and after all leading to increased prevalence of overnourishment and eventually obesity. This development is not only taking place in high-income countries and in urban areas, but also in low-income countries and the rural areas (FAO, 2014; Keding, Msuya, Maass & Krawinkel, 2011). So for instance, the adult prevalence rate for obesity is over 30% not only for the USA, but as well for Jordan, Venezuela, South Africa and Mexico (CIA, 2014). The health impacts associated with this development are obvious. For the low-income groups obesity is a challenge already, however, hidden hunger is another challenge, which is hitting more poor than ever. Due to the nutritional transition the consumption of carbohydrates (sugar) and saturated fat will lead even to increased micronutrient deficiencies.

All in all, FAO estimates that there is a need to increase the agricultural production by at least 70% between 2005/07 and 2050 to be able to meet the increasing demand based on the described different trends and developments (FAO, 2009). This turns the attention to the agricultural supply side and their challenges to improve FNS globally.

The biggest challenge for FNS from the supply side is indeed the question how to increase agricultural production through increased productivity in a sustainable manner and to reduce loss and waste at the same time. This challenge includes also the productivity increase in the whole food chain including processing. These days, from the global perspective, agricultural production can mainly be increased through raising the output of existing agricultural area, in other words increasing the area productivity. There are still some regions in which production increase can be achieved through expanding the agricultural area, but due to on-going loss of arable land, inter alias through soil degradation, area extension will not be a viable solution for the future (Nkonya, Koo, Marenya & Licker, 2011). If unsustainable agricultural productivity increase (incl. the agricultural processing industry) leads to higher pressure on the natural resources (mainly soil, water and biodiversity), agriculture will destroy the resources it depends on (Garnett et al., 2013). So sustainable intensification of agricultural production is moving more and more in the focus of research and development (The Montpellier Panel, 2013; Garnett & Godfray, 2012). Well-adapted technical innovations throughout the value chain (from seed and other input to production, trade, processing and utilization) are one crucial source of agricultural productivity improvement and simultaneously a reaction to the threat of unsustainable production practices. In addition, sustainable intensification adapted to country and local specific conditions may improve the quality of work and at the same time increase demand for agricultural labourer, which is crucial in countries with high percentage of young and unemployed rural population (Cheong, Jansen & Peters, 2013).

Besides being a driver of unsustainable utilization and overexploitation of natural resources and thereby destroying these essential resources and impacting on climate change, agriculture is also suffering under the direct and indirect impacts of unsustainable utilization of natural resources of other sectors. Looking at energy use and production, climate change with its complex causalities and effects exemplifies the extreme and inseparable interlinkages between agriculture and the other sectors: On the one hand, agriculture is the largest contributor of non-CO_2 greenhouse gases, with an estimated 56% contribution (US-EPA, 2011). On the other hand, climate change affects agriculture and will do so even more in the future. Temperature rise, extreme weather events and their impacts, among others on the hydrology of watersheds and groundwater resources, yield decline and price increases will force farmers to adapt their agricultural systems to these changes (Calzadilla et al., 2013).

Farming systems have to adapt to new environmental situations, sometimes benefiting but more often suffering. In general it seems that tropical regions will lose more than they will gain and at mid- to high latitudes the productivity may increase (Nelson et al., 2009; Easterling et al., 2007). Taking into account the broader picture of FNS, climate change will tighten the situation especially of the undernourished and poor people. The portion these groups are spending of their income on food, for example, will even excess the already very high level of around 70%, because it is predicted that – in addition to the forecast long-term, steady raising, normal food price increase – the extreme volatility of food prices will increase due to unpredictability of market and external conditions, mainly extreme weather conditions, especially droughts and floods.

The reaction of the agricultural sector to the challenges of climate change are manifold and include 1) mitigation through reducing fossil energy use and the emission of greenhouse gases; 2) adaptation through adapting production systems for instance breeding resistant varieties against drought and flood; 3) resilience through managing volatility of for instance water scarcity, flooding but also price volatilities. However, the resource-poor small-scale farmers are those who will have the biggest problems reacting to climate change through adaptation and resilience (Meybeck, Lankoski, Redfern, Azzu & Gitz, 2012; Glantz, Gommes & Ramasamy, 2009).

But besides climate change, which is on top of the agenda globally, there are other external factors influencing the agricultural sector and its sustainable productivity. The impact of these factors may be even worsened through climate change. Pandemic diseases for instance, like HIV/AIDS, the severe acute respiratory syndrome SARS and the Avian influenza, but also malaria and tuberculosis are determining the availability of and access to food as well as the utilization of potentially high-quality food. If for instance through HIV/AIDS the working generation of a farmer's household is wiped out or significantly decreased, it will be hard for the grandparent generation or other relatives to take over the food production and processing as well as the child-care (Agunga & Sundararajan, 2004).

Besides these challenges influencing directly the demand and supply of food, there are several other challenges regarding FNS of individuals, specific groups and world-wide. The limited or weak political and economic governance systems are impacting negatively on all sectors of national economy and society, but have significant impact on FNS for instance through policy-induced distortions in agricultural markets.

But also with a strong national governance system, FNS may not improve at the local level, if the newly emplaced laws and edicts are not implemented adequately at local level or intentionally bypassed. India's National Food Security Bill 2013, for instance, wants to secure "sufficient food grains to meet the domestic demand as well as access, at the individual level, to adequate quantities of food at affordable prices." However, it is predicted that the implementation at local level will lack far behind the expectations raised by this law and the preceding federal state programs, which leads to the claim of more efficient and transparent systems (Joshi & Dassani, 2013).

But not only weak governance systems at national level or within countries determine the degree of FNS in a country, but also the coherence and strength or weakness of the international governance systems influences significantly the availability and access to food and nutrition at country level. The global financial crisis with its peak in 2008 is one of the prominent examples, how existing or non-existing international regulations and agreements can impact on FNS of millions of people. The crisis – coinciding with and amplifying the food price crisis of 2007/2008 – forced especially poor and malnourished people to reduce the quantity of their food as well as the food quality (von Braun, 2008), besides reducing the expenditures for health and welfare services, with the consequences on hand. Although controversially discussed, the negative impact of financial shocks and speculation onto volatility increases of food prices and its impact on poor and undernourished people in low-income countries cannot be dismissed (HLPE, 2011).

Wrong or one-sided political decisions taken at national level in one country may have negative effects on other countries and their malnourished. During the food price crisis in 2008, some rice-exporting countries banned partially their rice exports in fear of not being able to supply the own population with sufficient staple food. This government policy decision caused on the very tight world-market for rice an additional price increase affecting the poor in all other developing countries (Dawe & Slayton, 2011).

In this context it is also important to mention that food and food prices are a weapon in or means for (mainly domestic) political unrest. Forced starvation is an internationally banned but widely utilized military strategy world-wide in the historic past as well as in present times. Most prominent and at the same time devastating examples are Stalin's forced famine in the Ukraine 1932/1933 with approximately seven million deaths (The History Place, 2014) and Hitler's forced famine of Leningrad's population 1941/1944 with approximately one million deaths (Pavlov, 1965), but also at present forced famines are taking place, for instance the siege of Homs from the Syrian army in 2013/14. In other settings, sudden food price rise or the substantial undersupply of certain staple crops in a country may lead to civil unrest like the food riots in Haiti 2008 and after all to the toppling of a government, as for instance happened in Tunisia end of 2010, which can be seen as the starting point of the "Arab Spring". This threat of unrest due to food price increases leads especially in weak political systems to inappropriate economic action of governments by stabilizing the (urban) food prices (mainly of the leading cultural food product, for instance bread) through fixed prices, subsidies and there like. All of these instruments may lead to the decrease of domestic food production due to missing or even negative incentives for farmers. When for instance the price, which farmers can achieve for cereals, is below the production costs, farmers will not continue to produce these produce or even stop farming at all.

Finally, natural disasters lead to short-term extreme food insecure situations. Due to lack of governmental support in the rebuilding phase, especially in weak governance systems, these short-term shocks may lead to a medium or even long-term food insecure situation of the people living in the areas hit by the natural disasters, from earth quakes to cyclones, but also unpredictable droughts and floods. Through early-warning systems and an ever improving efficient international support system, natural disasters have – in principal – been better controllable. However, through climate change the unpredictability, the force and the extremes are imposing higher threat to these disasters than ever before.

7.5 Political and human-rights approaches

Besides the more technical framework on FNS elaborated above, a political and a human-rights approach are gaining importance in the international discussion to fight food and nutrition insecurity.

The emerging concept of food sovereignty is a reaction to the structural adjustment policies combined with economic liberalization which were preferred solutions by the high-income countries and the international organizations like the World Bank and the International Monetary Fund (IMF) to solve the development crisis, esp. the food and nutrition insecurity in low-income countries (Bello, 2008; Rosset, 2006). These policies led to a reduction in state support for the agricultural sector in these countries, without the private sector taking over these tasks, and hence leaving mainly small-scale farmers in a vulnerable situation (Bello, 2008; Boyer, 2010). The concept of food sovereignty refers to the right of communities, peoples, and states to independently determine their own food and agricultural policies and thereby strengthening the status and importance of small-scale farmers and a locally-based, environmentally friendly and sustainable agriculture. The concept is a political approach and intends to improve FNS at local level by empowering small-scale farmers and their local communities to have better access to and control over productive resources and more social as well as political influence (Desmarais, 2008). The popularity of the concept of food sovereignty is increasing and several governments have already incorporated the concept of food sovereignty into their policies and legislation, e.g., Bolivia, Ecuador, Mali, Nepal, Nicaragua and Venezuela (Beuchelt & Virchow, 2012; Cotula et al., 2008; Beauregard, 2009).

Already since the last three decades, the human-rights approach of the human right to adequate food receives interests at international and national level to pressure for more progress regarding the eradication of hunger (De Schutter, 2010). The right to adequate food is a broad concept and is valid for and applies to all human beings in general, and thereby making it to a broader approach than the concept of food sovereignty (Beuchelt & Virchow, 2012). The right to adequate food ensures that all people should have the capacity to feed themselves in dignity and implies three types of state obligations: a) the state should not take any measures that arbitrarily deprive people of their right to food; b) the state should take relevant measures to prevent third parties from violating the right to food of others; c) the state should engage in activities intended to strengthen people's access to and utilization of resources so as to facilitate their ability to feed themselves (UN-CESCR, 1999).

When integrated into national legislation, as for example, in India, Nepal, Brazil, and South Africa, and given a functioning legal system, violations of the right to adequate food can be brought before national courts and hence, the right to adequate food can become a powerful tool (Beuchelt and Virchow, 2012). There have been successful court cases, where governments or municipalities have been forced by the court's decision to either provide food, enable economic access to food, or to change their policies and laws in favour of the marginalized groups enabling them access to food (De Schutter, 2010).

7.6 The impact of external factors on food and nutrition security

The agricultural sector (including the agricultural input as well as the food processing sector) provides employment and income to more people worldwide than any other sector (Cheong, Jansen & Peters, 2013), besides supplying the world's seven billion people with the essential food and nutrients for their lives (energy, protein and micronutrients). It is estimated that more than a billion people in developing countries are working directly in agriculture, which represents 48% of the developing-country workforce plus those, working in the upstream (input) and downstream (trade and food processing) segment of the agricultural sector, providing livelihoods to themselves and their families (Cheong, Jansen & Peters, 2013). These figures demonstrate the importance of the agricultural sector to the over-all economy not only of the low-income countries, but globally.

However, it is increasingly becoming obvious that finding agricultural sector-specific solutions to the above described challenges to global FNS are not viable in an increasingly interlinked world, in which activities in other sectors and in other geographical regions impact on specific situations in and solutions to FNS. Hence, achieving FNS is only possible by taking into account the interlinkages of the challenges described above. Besides the interlinkage between agriculture and health, which lead to the development of the concept of a nutrition-sensitive agriculture (Jaenicke & Virchow, 2013), special attention has to be given to the interlinkage of food security, the sustainable use and security of water (and land), energy and climate. This very broad and complex perspective of interlinkage and interaction between essential resources and sectors is the core of an approach called "Water-Energy-Food-Climate Nexus", which integrates policies, governance, management and technologies (http://en.wikipedia.org/wiki/Governance) across sectors and is gaining international recognition (Hoff, 2011). The interlinkages between water, energy and food have been increasing in the last decades, especially since alternative energy sources are searched for. Hence, focusing on one resource without taking into account the others is becoming utterly impossible: For a significant amount of people biomass is the most important source for their energy consumption. However, by over-utilizing the biomass production in an unsustainable way, the basis for their energy consumption as well as for their food production is endangered. In addition, the inefficient use of water for agriculture is hindering an efficient use of water for alternative energy production. Furthermore, the technologies used for hydraulic energy production are determining the possible level of irrigation. Finally, the challenges of this interdependence are becoming even more critical with the increasing impacts of climate change (Hoff, 2011).

The utilization of each of these resources as well as its level of productivity is driven by the specific demand. This demand is determined by the existing technologies for their utilization, the level of resource constraint and their own prices. However, the demand for one resource has interlinked impacts on the other resources and their utilization. Hence, the nexus approach tries to capture these negative but also positive externalities of one resource to the other. For instance, the biomass produced in agriculture and used for energy production cannot be utilized for food unless one utilizes the cascade effects, enabling a more efficient use of biomass and combining the different demands (Virchow & Denich, 2013). The nexus approach aims therefore to improve the efficiency of resource utilization through taking into account the environmental, social and economic externalities and strives for more coherence in sector-specific and cross-sectorial policies taking advantage of synergies and fostering increased collaboration of actors of the various sectors.

In future, the nexus approach will help to bring forward and to visualize the very complicated cause and effect chains of activities in another sector and different regions on the FNS situation of small-scale farmers and other malnourished groups. From the economic point of view, the demand for a certain product and the impacts of this demand will be determined by the factor prices of the means of production. However, the imbalanced global purchasing power is enabling consumers of high-income countries to demand products, which utilize a disproportionately high – and often unsustainable high – level of natural resources, which are consequently not available anymore for people from low-income countries, which would need those resources or the income from the utilization of those resources to secure their food and nutrition needs and to cover their basic livelihood. Despite the fact that many consumers strong in purchasing power are willing to be determined in their decision for consumables and equipment by social, ecological and economic criteria, the information is missing to base their decision on. Therefore, in future, producers and consumers may be confronted with certificates on the products not only regarding production (e.g., "organic") and marketing (e.g., "fair trade"), but also regarding the product's impact on the FNS situation of the malnourished people of the region of which the product or the resources for the product derive from. If such a label can be developed and implemented, it will have far-reaching consequences for consumers but especially producers in high-income countries, so also for product designers. The producers will have to prove that the product and the used resources do no harm to the FNS situation of the people in the specific region as well as that the utilization of the product will have no negative impact on the situation of malnourished people.

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Peter Stebbing

8 Energy

> *"All the energy with which man refuels himself is derived from the sun … Man's bodily energy can reach him only through the slender channels of millions of green plants."* William Vogt, 1949

8.1 Introduction

Modern human civilization is primarily dependent on fossil resources: in 2011 coal, oil and natural gas provided 81.6% of the total 13,113 million tons of oil equivalent (Mtoe) (IEA, a. 2013) energy consumed. They not only provide fuels for energy and transport but also a range of chemicals (organic chemistry, the chemistry of carbon) to create a variety of materials which play a key role in western consumer society including; plastics, fertilizers and pesticides etc. These fossil resources are finite but more profoundly, damaging to both the climate and the environment, consequently, an immediate change is prescribed in how we consider and use the world's resources. If we are to remain within 2°C of global warming then a substantial proportion of fossil fuel resources must remain in the ground, they have become stranded assets. Peak fossil energy is no longer our concern because we cannot use it anyway (McGlade & Ekins, 2015). Once again we see that the Earth cannot be managed by following the free market policies of neo-liberal capitalism which ignore the Earth's ecosystems and environment. Future profitability will be determined by our ability to cooperate and care for the Earth. Unfortunately, the exploitation of the Earth's fossil resources has become a habit on which the developed economies have become dependent during the 20th century. Surprisingly, even President George Bush actually appeared to recognize the problem in his State of the Union address in January 2006, when he said: *"'Here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world,' the former oil executive said. 'Tonight, I announce the Advanced Energy Initiative – a 22 percent increase in clean energy research at the Department of Energy, to push for breakthroughs in two vital areas,' Bush said. 'To change how we power our homes and offices, we will invest more in zero-emission, coal-fired plants; revolutionary solar and wind technologies; and clean, safe nuclear energy'"* (Bash & Malveaux, 2006).

The recoverable fossil fuel reserves are impressive; writing in 2003, Chow and colleagues estimated that there are *"almost 1 trillion metric tons of coal, more than 1 trillion barrels of petroleum, and over 150 trillion cubic meters of natural gas … and mineral resources important to energy generation include over 3 million metric tons of uranium."* These are unimaginable numbers and so a more appropriate question is what does the world consume in a year? The annual consumption in 2000 was 0.5% of the coal reserves (about 5 billion metric tons) and oil was 3% of the reserves and natural gas 1.6% of the reserves. The generation of electricity by nuclear power consumed about 2% of the uranium reserves (Chow, et al, 2003). Furthermore, the discovery of more reserves of fossil fuels were keeping pace with consumption and in 2003 were at all time highs! The total global energy consumption exceeded 370 exajoules equivalent to over 170 million barrels of oil per day with approximately 95% coming from fossil fuels. Biomass probably provides one-third of the energy requirement of the needs of Africa, Asia and Latin America according to the International Energy Agency (IEA). The IEA Key World Energy Statistics report for 2013 reveals an interesting comparison in the proportional changes of energy supply. The world total energy supply in 1973 was estimated to be 6,109,000,000 tons of oil equivalent (Mtoe) energy or 6,109 Mtoe. By 2011 the world energy consumption had more than doubled standing at 13,113 Mtoe.

The make-up of the energy provision in 1973 (86.6% fossil fuels) was:

› oil	46.0%
› coal	24.6%
› natural gas	16.0%
› nuclear	0.9%
› hydropower	1.8%
› renewables	10.7%

by 2011 the fuel shares were:

- › oil 31.0%
- › coal 28.6%
- › natural gas 21.3%
- › nuclear 5.1%
- › hydropower 2.3%
- › renewables 11.0%

(fossil fuels was still 80.9% fossil fuels.)

The comparison of the figures is really disappointing because we see that in 1973 the fossil fuels provided 86.6% of the world's energy and by 2011 fossil fuels were still providing a substantial 80.9% of the world's energy. However, while the proportions may have changed the quantities have collectively increased with more than double the energy being consumed in 2011 (IEA 2013). The drop of 5.7% in the use of fossil fuels by 2011 depressingly reflects the lack of political concern about the use of fossil fuels as a whole and global warming. However, cause for a little optimism was short lived because in 2013 *Vital Signs Online* (Gonzalez, & Lucky, 2013) reported that *"Coal, natural gas, and oil accounted for 87 percent of global primary energy consumption in 2012."*

Individually, the average person in a developing country consumes the equivalent of 6 barrels of oil per year and in a developed country nearly 40 barrels per year. Meanwhile, in the poorest 10% of countries, individuals consumed the equivalent of less than 1 barrel of oil per year. Consequently, as nations become richer their energy consumption increases with some exceptions (Chow, et al, 2003).

The world consumption of fossil fuels substantially increased between 1980 to 2001 with a 22% increase of petroleum consumption; a 27% increase in coal consumption and a 71% in natural gas consumption. Carbon dioxide emissions from the extraction and use of fossil fuels *"increased from 5 billion to 6.6 billion metric tons carbon equivalent"* over the same period (Chow, et al, 2003).

Despite concerns about global warming *"Global coal production increased by 6,941 million tons of coal in 2011, making it the fastest-growing fossil fuel. Spurred mainly by demand for growth in China and India, coal's share in the global primary energy mix reached 28 percent in 2011 – its highest point since record-keeping began in 1971"* (World Watch Institute, 2013).

During the last decade there has been much discussion at which point we would reach *"peak oil"*, the fear that demand for oil would exceed supplies. However, peak oil and peak coal are no longer concerns of any relevance as will be described. We all know that burning fossil fuels, such as oil and coal releases carbon dioxide into the atmosphere causing global warming by the greenhouse effect.

This chapter will introduce some basic information about energy and then consider the dilemma of fossil fuels because we now know that they are causing changes to the planet which will be severe. Every day our continued use of fossil fuels both exacerbates and hastens the impact of those changes which already include the melting of the ice at both poles and the glaciers. Consequently, this chapter describes the logic of leaving fossil fuel resources untouched and focuses on the use of the renewable energies, their benefits and problems. In the preparation of this chapter it is important to acknowledge the extensive reference which has been made to a review published in Nature written by Schiermeier, Tollefson, Scully, Witze and Morton (2008) entitled *Electricity without Carbon*.

Fossil fuels receive enormous subsidies from governments which, if we are to remain below 2°C of global warming, should be diverted to renewable energies whose slow adoption suffers from maintaining the established fossil fuel plant, processes, corporations and jobs. *"Fossil fuel subsidies undermine international efforts to avert dangerous climate change and represent a drain on national budgets ... For every $1 spent to support renewable energy, another $6 are spent on fossil fuel subsidies ... we estimate that the top 11 rich-country emitters (E11) spent $74 billion on subsidies in 2011, with the highest level of subsidies in Russia, the United States, Australia, Germany and the United Kingdom"* (Whitley, 2013). These figures reveal the political duplicity of at least some nations like Germany and the UK in their pretence to be moving towards sustainable energy. Furthermore, the use of energy requires a far greater integrated 'linking-thinking,' schesiological approach because single solutions to single problems are unsustainable and a historical consequence of our 'siloed' specialist thinking habits. Consequently, for example, our unlimited supplies of human sewage and bio-waste could provide natural gas saving the enormous demands on water and energy that both fracking and sewage treatment require. Furthermore, in 2012 while $674bn (O'Toole, 2013) was being invested searching for and developing new deposits of fossil fuels virtually none is being invested on behaviour change to consume less energy (Sovacool, 2014). Throughout this chapter related information is also provided to support a wider perspective of our energy problems.

8.2 Some basics: what is energy?

Energy is vital to human existence. Physicists tell us that *"the word "work" means the amount of energy involved in moving an object. Work is calculated as the amount of force multiplied by the distance"* (Vorderman, 2012). Furthermore, energy cannot be created or destroyed but only converted from one form into another. This conversion can take place in three ways:

- by mechanical work, for example in a chain drive as when we pedal a bicycle.
- by heat exchange, for example as in a steam engine.
- by electromagnetic fields, for example an electric motor (Wagner, 2008).

The primary sources of energy which Nature provides us with are of two kinds, firstly, those of fossil and mineral origin: coal, both black and brown, oil, natural gas, and the radioactive minerals for nuclear energy. Secondly, the renewables: hydro-electric power, biofuels, waste, solar power, wind, biomass, geo-thermal energy and tidal power. These 'primary energy' sources are not readily usable and must be converted into 'secondary energy' forms which can be delivered to – and used by the consumer. As we all know, oil is converted into petrol and solar energy is converted into electricity and both are delivered in different ways to the five major sectors of end-users which include: industry, transportation, agriculture, commercial and public services, and residential (Chow, et al, 2003).

8.3 Measuring energy

We need energy to work which is simply defined as the force or energy applied to an object times the distance an object is moved. Energy is measured by different unit systems which are difficult to visualize. However, a watt is *"a unit of energy per unit time. One watt is one joule per second"* (Lovins, 1977) and it takes about one joule of energy to lift an apple one meter (Vorderman, 2012) and so if you can do that in a second it was equivalent to one watt! A light-bulb's energy consumption is specified in watts (w) and the compact fluorescent lamp (CFL) requires 11w to produce the same amount of light as the old inefficient incandescent 60w light-bulb for a desk lamp, which is quite a saving. *"A kilowatt is easily thought of as an electric fan heater"* (Schiermeier, et al. 2008). Car engines are rated in horsepower or kilowatts (kW = 1,000w). 1 horsepower is equivalent to 745.69 watts which is not at all powerful. However, a Porsche Carrera has 400 horsepower or 298,276 watts or 298 kilowatts.

The meaning of unit terms is as follows:

- kilo (k) = 1,000w
- mega (M) = 1,000,000w
- giga (G) = 1,000,000,000w
- tera (T) = 1,000,000,000,000w
- peta (P) = 1,000,000,000,000,000w
- exa (E) = 1,000,000,000,000,000,000w

We can illustrate the increasing scale of power with some examples as follows:

- A watt = 1 joule per second.
- The energy of 1 kilowatt hour equals 3,600,000 joules or 3.6 megajoules (MJ).
- A computer + printer running for 7 hours uses about 1kilowatt (kW).
- A kilowatt is 1,000 watts or 1.34 horsepower.
- A household might use between 3000 - 6000 kilowatt hours (kWh) in a year.
- A power station's production is measured in megawatts (MW = 1,000,000 watts) and most modern trains require about 3 to 5 MW.
- A megawatt is a thousandth of gigawatt (GW= 1,000,000,000 watts).
- A gigawatt is a thousandth of a terawatt (TW=1,000,000,000,000 watts) and the output of the Hoover Dam on the Colorado River is 2.08GW (Bureau of Reclamation, 2009) which compares with one of the UK's largest nuclear power stations which produces about 1.2GW.
- The Three Gorges Dam in China has a 22.5GW capacity (22.5 million kilowatts) (An Lu, ed., 2012).
- In order to leave the Earth's atmosphere in 1969, "[T]he power output of the Saturn first stage was 60 gigawatts. This happens to be very similar to the peak electricity demand of the United Kingdom" (Hutchinson, 2013).

› In 2011 the total world energy provision/supply was 13,113 Million tons of oil equivalent (Mtoe) (IEA, a. 2013) which can be translated into 152,504.19 terawatt hours.

"Three-quarters (129 exajoules [EJ]) of global energy use for heat is currently met with fossil fuels. The production of heat accounted for around one-third (10 gigatonnes of carbon dioxide [GtCO$_2$]) of global energy-related carbon dioxide (CO$_2$) emissions. 40% of primary energy supply of natural gas, as well as 20% each of oil and coal are being used for heat production, with important impacts on energy security" (Eisentraut & Brown, 2014).

Finally, we should note that the *"Earth receives about 100,000TW of solar power at its surface – enough energy every hour to supply humanity's energy needs for a year"* (Schiermeier, et al, 2008).

8.4 The Fossil Fuels' paradox: the nightmare

Fossil fuels are derived from the remains of plants and animals which have formed into geological deposits over millions of years. The fossil fuel trinity of: oil, coal and natural gas provided 80.9% of the world's energy supply in 2011(IEA, a. 2013). Oil, older than coal, originated from the organic remains of plankton, foraminiferans and other single celled organisms living in the seas, brackish and freshwaters. These organisms were "*abundant long before the Palaeozoic Era, which began some 542 million years ago*" (Atwater, 2013).

Black coal was formed from the remains of plants and trees growing in swamp forests which died during the Carboniferous (carbon-bearing) period from about 359.2 to 299 million years ago (Waggoner, et al 1996). Natural gas is also formed from the remains of organisms and the most extensive deposits of gas bearing shales in the USA are the Marcellus shales laid down about 400 million years ago. However, shale strata have also been deposited at various times during both Palaeozoic and Mezosoic strata, a period ranging from about 540 million years ago up to 65 million years ago.

The formation of all three resources is basically the same process in which the organic remains undergo bacterial decay, are laid down and become compressed with the deposition of further geological strata. As the strata sunk they were not only compressed but also "cooked" by the warmth from the Earth's core. Consequently, oil, coal and gas are indirectly the sun's energy stored in the form of decayed organisms which have become either 'fossilized' as coal, or as gas or oil. Burning these fossil fuels now releases green house gases, CO_2 and methane which cause global warming.

In February 2006, Fred Pearce reported in the magazine New Scientist that *"If we burn all the fossil fuels that are left underground, the globe will warm by an average of up to 13 °C, according to the first serious assessment of how global warming might progress beyond 2100, the normal time frame of model predictions. That will wipe out most rainforests, destroy the fertility of many soils and leave the Arctic ice-free even in midwinter. London will be as hot as Cairo – except that, along with many of today's most populous areas, it will have been engulfed by an 11-metre rise in sea levels."* The research was conducted by the climate expert, Tim Lenton and colleagues (2006), according to whom: *"So far humans have released about 400 billion tonnes of carbon into the atmosphere, as carbon dioxide, by burning fossil fuels and destroying forests – enough to have already raised global temperatures by around 0.6 °C. Ten times as much carbon remains underground in reserves of oil, natural gas and coal … And unconventional fossil fuels like tar sands, oil shales and methane-rich ices called clathrates beneath the seabed may contain another 10,000 billion tonnes."*

So the big question is when should we stop extracting fossil fuels since their continued use will take us way beyond the projected safe target of 2°C of global warming. Indeed, the majority of scientists already believe that global warming is already set to go beyond 2°C (Adam, a. 2009). How, when and who will stop exploiting their fossil fuel reserves?

It appears that we have the danger of a 'commons' (see Glossary 'Tragedy of the Commons') in which there is no legislation to control any country burning or selling its fossil fuels. Furthermore, what international body will have the authority to demand the cessation of fossil fuel extraction and processing by the world's nations or will it happen by mutual consent? So far there is little evidence for this happening on a global scale relevant to mitigating climate change.

Further to the study by Lenton and his colleagues (2006) another study was published in 2009 reiterating the message that fossil fuels must remain in the ground (Adam, b. 2009). *"Total anthropogenic emissions of one trillion tonnes of carbon (3.67 trillion tonnes of CO_2), about half of which has already been emitted"* (Allen, et al, 2009).

Since the papers by both Lenton and (2006) and Allen (2009) and their colleagues business as usual has prevailed. *"Coal, natural gas, and oil accounted for 87 percent of global primary energy consumption in 2012, as the growth of worldwide energy use continued to slow due to the economic downturn, according to a new Vital Signs Online trend."* (Gonzalez, & Lucky, 2013).

Generally, political leaders and governments still fail to provide any kind of collective, coherent or consistent leadership for:

- systemic legislation for the development of renewable sources of energy.
- international plans for the changeover to renewable sources of energy.
- significantly reducing emissions.
- furthermore they substantially subsidize fossil fuels (Whitley, 2013).

A few notable exceptions include Costa Rica and Bhutan. Meanwhile, Germany hypocritically makes much of its *"Energiewende"* (energy turning point) but does not support the EU reductions on exhaust emissions for the luxury cars it manufactures. In addition, Germany's coal-fired power stations are (equal top with those of the UK and Poland out of 30 nations) the dirtiest and most polluting power stations in Europe undermining efforts to combat climate change (Carrington, 2014). The UK prime minister, David Cameron, in 2010 said that his would be *'the greenest government ever'* while in 2014 he offered the electorate the choice of blocking onshore wind-farms, were he to be re-elected in 2015. He has been re-elected and so we shall see what happens!

The really good news, however, has been that on 2 June, 2014, President Obama at last introduced legislation, through the Environmental Protection Agency, to significantly reduce emissions by 25% from the US's 1,600 power plants (Goldenberg, 2014). The head of climate change at the WWF-UK, Keith Alliot has said that ""*Many governments and businesses are clearly in denial over the threat posed by climate change and need to accept that we have to start leaving fossil fuels in the ground rather than dashing to develop new reserves. It's simply crazy to think otherwise." The problem is that right now, and for many people, it is leaving coal, gas and oil buried that seems the crazier option"* (Carrington, 2012). This is also confirmed by the fact that governments pay *"titanic subsidies for fossil fuels"* in order to reduce their prices. According to the International Energy Agency in 2011, the subsidies for fossil fuels amounted to about $523 billion while around the world subsidies for renewables amounted to only $88 billion! (Carrington, 2012). As we have already noted, Whitley (2013) reported that *"For every $1 spent to support renewable energy, another $6 are spent on fossil fuel subsidies"* (IEA, b. 2013).

Clearly, governments are not very concerned that *"Every year in the last few decades, CO_2 concentrations have been going up by about 2 ppm per year. Those changes go unnoticed but people pay attention to round numbers"* (Brahic, 2013) Ralph Keeling, the atmospheric scientist, said in an interview; and following the news that the Mauna Loa Observatory in Hawaii had recorded an atmospheric CO_2 concentration of 400ppm. The last time this level of CO_2 concentration occurred in the Earth's atmosphere was 3-5 million years ago when the world was also warmer.

So, like governments, corporations such as the Shells, British Petroleums and ExxonMobils of the world continue with business as usual because their top priority is shareholder value. *"And people see shareholder value as some magical thing independent of climate change" (Slezak, 2013). Consequently, despite the well established danger of releasing more carbon into the atmosphere "in 2012 alone $674bn was spent in the global economy on finding and developing new fossil fuel reserves."* However, *"these reserves could potentially become redundant and therefore worthless"* (O'Toole, 2013). Listed companies already have holdings of fossil fuel reserves exceeding by about 80% what they can utilize if global warming is to remain below 2°C. This is worrying, because why should *"the top 200 oil, gas and mining companies continue to allocate vast amounts in finding more reserves, and that more than $6tn will be allocated to developing fossil fuels over the next decade"* for a resource which must now remain buried because it cannot be used? (O'Toole, 2013). If we are to value our future these one-time resources are useless!

8.4.1 The paradox: peak oil is not the issue!

The peaking of fossil fuel resources such as oil and coal is no longer an issue (Heinberg, 2007) of concern since as Lenton et al's (2006) prophetic paper showed, we must now leave these carbonaceous resources untouched. Lenton et al's message received renewed publicity in the International Energy Agency's flagship report for 2012 with its *"truly global implications ..."* and *"... quietly devastating statement that no more than one-third of already proven reserves of fossil fuels can be burned by 2050 if the world is to prevent global warming exceeding the danger point of 2°C. This means nothing less than leaving most of the world's coal, oil and gas in the ground or facing destabilized climate, with its supercharged heatwaves, floods and storms"* (Harvey, 2013).

The Stranded Assets Programme at the University of Oxford's Smith School of Enterprise and the Environment was established in 2012 to systemically understand the risks in different sectors of abandoning fossil fuels as 'stranded assets.' In 2013 Atif Ansar, Ben Caldecott and James Tilbury published a study entitled *"Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?"* What is the aim of the fossil fuel divestment plan? The authors write: *"The aims of the fossil fuel divestment campaign are threefold: (i) 'force the hand' of the fossil fuel companies and pressure government – e.g. via legislation – to leave the fossil fuels (oil, gas, coal) 'down there'; (ii) pressure fossil fuel companies to undergo 'transformative change' that can cause a drastic reduction in carbon emissions – e.g. by switching to less carbon-intensive forms of energy supply; (iii) pressure governments to enact legislation such as a ban on further drilling or a carbon tax. Inspiration for the fossil fuel divestment idea leans heavily on the perceived success of the 1980s South Africa divestment campaign to put pressure on the South African government to end apartheid"* (Ansar, A., Caldecott, B. and Tilbury, J., 2013). The problem is now that with so much money invested into fossil fuel reserves, plant and people world wide and the search for new deposits alone annually totalling $billions: the question is will the world's fossil fuel industry be prepared to write off its assets to save the world from climate change or will capitalism ignore climate change? After all, from 2003 to 2010 a group of very rich US industrialists invested billions of dollars to promote climate change denial (Brulle, 2013) effectively hindering legislation to limit emissions.

8.4.2 We must abandon fossil fuels due to their emissions

A paper published in the first issue of *Nature* in 2015, *"reveals the profound geopolitical and economic implications of tackling global warming for both countries and major companies that are reliant on fossil fuel wealth. It shows trillions of dollars of known and extractable coal, oil and gas, including most Canadian tar sands, all Arctic oil and gas and much potential shale gas, cannot be exploited if the global temperature rise is to be kept under the 2°C safety limit agreed by the world's nations. Currently, the world is heading for a catastrophic 5°C of warming and the deadline to seal a global climate deal comes in December at a crunch UN summit in Paris"* (Carrington, 2015). The authors, McGlade and Ekins (2015) have calculated that 88% of the coal reserves must remain underground together with 52% of gas reserves and 35% of the oil if we are to avoid global warming beyond 2°C.

It was in March 1958 Charles Keeling began measuring the CO_2 in the atmosphere on the Hawaiian Island of Mauna Loa and every year the measurements have shown an increase of the CO_2 in the atmosphere producing the now famous 'Keeling curve'. In that first year, 1958, 316 parts per million of CO_2 were recorded (Nisbet, 2007) and by 2006 the average CO_2 concentration in the atmosphere had risen to 381.9ppm. Then, in 2012 above the Arctic, the 400 ppm was measured for the first time (Brahic, 2013). *"Daily mean carbon dioxide at Mauna Loa of Hawaii exceeded 400 parts per million (ppm) for the first time in May 2013"* (Kosaka & Xie, 2013). On July, 2014 the value recorded was 398.79ppm and by January 2015 the level recorded at Mauna Loa was 399.96 ppm. Our atmosphere will undoubtedly exceed 400ppm during 2015. CO_2 levels have been climbing by 2ppm per year over the last couple of decades (Brahic, 2013). The energy we use and *"Every gas-fired cooker or central heating boiler, every tank of petrol and every power station fuelled by coal, gas or oil has added a little more carbon dioxide to the air. Oil, coal and natural gas are the three wicked witches of the climate change story, because they are all dense repositories of carbon"* (Walker & King, 2008).

What are the emissions from fossil fuels?

The CO_2 emissions from the fossil fuels are:

- 2.7 kg of CO_2 per kg of hard or black coal,
- 3.1 kg of CO_2 per kg of brown coal,
- 2.3 - 2.7 of CO_2 per kg per liter of oil, *"depending on whether it is crude oil, diesel, gasoline, fuel oil"* (Wagner, 2007),
- 1.8 kg of CO_2 per cubic meter of natural gas,
- 1 kWh of electric power: average value for Germany is 0.65 kg of CO_2 per kWh and from black coal power stations 0.82 kg of CO_2 per kWh (Wagner, 2007).

These figures enable us to calculate individual CO_2 contributions, for example; if a car uses 9 liters of petrol to travel 100 kilometers (or 26 miles per gallon) then it will produce 21 kg of CO_2 emissions (2.33 kg CO_2 per litre x 9 liters = 21 kg of CO_2). Meanwhile, working on a *"PC with accessories for 7 hours uses 1 kilowatt hour of electric power, and therefore causes an average emission of 650 grams of CO_2."* (Wagner, 2007).

8.5 Which bridge to renewable Energy?

8.5.1 The romance with natural gas

The major component of natural gas or biogas contains 75 to 99 per cent methane (Schröder, et al. 2014). Methane has a global warming potential of 105 times that of CO_2 due to methane's interaction with aerosols already in the atmosphere (Shindell et al, 2009). Consequently, if only a few percent of the methane escapes into the atmosphere during extraction it annuls the benefit of natural gas during combustion over other fossil fuels. However, natural gas has now become a major energy source providing about 5% of the world's energy during the 1930s to more than 25% by 2001 (Kleinberg & Brewer, 2001). *"In 2011, the world's natural gas reserves and resources totalled around 772 trillion cubic meters. This figure is around 230 times higher than the amount of gas consumed globally in 2011. Resources account for the major share, amounting to 577 trillion cubic meters, with unconventional natural gas resources comprising around 60 per cent of the total natural gas resource base"* (Schröder, et al. 2014). Unconventional natural gas resources (employing unconventional technologies) include:

- coalbed methane, also known as coal seam gas (CSG), a form of natural gas extracted from coal beds.
- shale gas, extracted by fracking and the potential recoverable deposits worldwide might be around 157 trillion cubic meters. 28 per cent of gas production occurs offshore (Schröder, et al. 2014).
- methane hydrates from the sea bed. The worldwide deposits of methane hydrates are thought to exceed by about 10 times all known conventional natural gas deposits. Conventional drilling technologies extract oil and gas from hard sediments but methane hydrates occur in soft sediments and for which the technologies for methane extraction are currently being developed with prototypes already being tested and developed (Schröder, et al. 2014).

The frenzied rush for natural gas by fracking is not a long term answer to our energy problems. How can this be? Fracking is a process for extracting gas from shales deep in the earth which has a significant eco-footprint due to a number of problems such as escaping gas and risks of polluting land, water supplies, causing minor earthquakes and contributing to greenhouse gas emissions (Fischetti, 2012; Cantarow, 2013; Ingraffea, 2011). The reality is that burning natural gas for electricity is not the clean energy that politicians claim; in fact it is a dirty green house gas. When you burn methane you get CO_2 because the formula is this:

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

so burning 1 tonne CH_4 yields 2.75 tonnes CO_2!

"*Burning both coal and methane generates the GHG CO_2 (as well as other pollutants) i.e. neither coal nor natural gas are not clean GHG-wise, they are both dirty*" (Polya, n.d.). The real question is: what is the motive of politicians and why are politicians so keen to mislead people?

Furthermore, a Youtube presentation by the fracking expert, Dr A. Ingraffea, from the Cornell University's School of Civil and Environmental Engineering, provides a most authoritative explanation (Ingraffea, 2011) of the fracking process and its problems.

A problem of greater significance is the destabilization of marine methane hydrates or clathrates as they are also known. Methane hydrates are a mixture of ice and methane gas lying within the sediments located within the top few hundred meters of the sea bed. The freezing conditions and the water pressure at the depths at which methane clathrates occur is normally a stable environment. However, as a consequence of global warming the oceans too have begun to warm causing the methane hydrates to thaw and destabilize and release plumes of methane bubbles (Mienert, 2012). Methane bubble plumes are now found in the Gulf of Mexico, the Arctic Ocean and along the coast of Norway and the Carolina Rise off the east coast of North America, also known as the Blake Ridge. The Carolina Rise hydrate destabilization where methane is bubbling up from depths of 800-1200 meters below the sea's surface covers an area of 10,000 square kilometers. The scientists who described the Carolina Rise destabilization, Phrampus and Hornbach (2012), estimate that there are about 2.5 gigatonnes of methane now destabilizing but this may only be a fraction of the methane hydrates destabilizing globally. Methane hydrates form one of the largest reservoirs of organic carbon on the planet. The danger is that further green house gas emissions could create a positive feedback of warming the oceans and causing further release of methane from sea bed methane hydrates.

Most recently (24 August 2014) about 570 seafloor methane plumes have been detected by sonar at depths between 50 and 1,700 m between Cape Hatteras and the Georges Bank along the northern US Atlantic margin (Skarke et al, 2014). Currently, seepage is being triggered by ongoing warming of intermediate waters and the Gulf Stream current. The scientists suggest that there could be tens of thousands of methane seeps. The irony of the methane hydrates now pluming is that here is gas for free while the US is using enormous quantities of energy and water for fracking to extract methane from shales about 2 kilometers underground which should be left in the ground (Ansar, Caldecott, & Tilbury, 2013). The fracking industry should divert its energy and technology to collecting methane off-gassing from the methane hydrates in the sea bed.

"Although gas hydrates threaten profound global climate change, they may also offer an important environmental benefit: a vast supply of clean energy" (Kleinberg & Brewer, 2001) If only it were clean. There are known gas hydrate deposits at about 100 locations around the world and from about one fifth of these sites samples of hydrates have been recovered. The other four fifths of the hydrate sites are inferred from geological, geo-physical or geochemical evidence. The hydrates are not stable at the Blake Ridge location where there have already occurred massive sub-sea slumps which can make the exploitation of hydrates difficult. However, there are less risky deposits which could be economically viable. The only hydrate reservoir commercially exploited up to 2001 was in the west Siberian Arctic and associated with the Messoyakha gas field (Kleinberg & Brewer, 2001).

A country with nearly no natural resources, Japan, has been pioneering research into exploiting the methane hydrates as an energy resource. The first trial to extract methane gas from the frozen hydrates conducted by the Japan Oil, Gas and Metals National Corporation (JOGMEC), has been praised as a remarkable breakthrough on 12 March (2013). The research drilling ship Chikyu had bored through 270 meters of sediment to reach the methane hydrates and the trial produced an average gas flow of 20,000 cubic meters per day for six days. It is unfortunate that the USA have drastically cut their methane hydrate development because they have enough onshore shale gas (Cyranoski, 2013) which they are extracting by hydraulic fracking.

Terrestrial Fracking versus marine Methane Hydrates

The pros and cons of the extraction of natural gas from shale deposits compared with the collection of natural gas from the methane hydrates found mainly on the edge of continental shelves deserves some consideration. Only the Japanese have made a real effort to develop the technology of collecting gas from methane hydrates and with some success as has been described.

The advantage of mining the methane hydrates from the sea bed is that it would help to mitigate climate change if the methane were captured instead of escaping into the sea and the atmosphere. This is because the warming oceans are beginning to melt and destabilize the methane hydrates (Phrampus & Hornbach, 2012) releasing the methane gas which is bubbling off in fumaroles into the sea (causing acidification) and also entering the atmosphere. However, as we know methane gas is a potent greenhouse gas with a global warming potential 105 times that of CO_2 (Shindell, et al, 2009). It would therefore be a win-win situation for both the economy and the climate if at least some of this methane were captured. The expense (but also employment) would be in developing the means for accessing the methane hydrates. Marine oil platforms such as Deepwater Horizon operate in waters of 5,000 feet depth (1,524 meters) and the *"The Gulf Stream consists of anomalously warm water at depths as great as*

1,000 meters below sea level.” However, the warming “Gulf Stream has the potential to thaw and convert hundreds of gigatonnes of frozen methane hydrate trapped below the sea floor into methane gas, increasing the risk of slope failure and methane release.” Already an “… area of active hydrate destabilization covers at least 10,000 square kilometers of the United States eastern margin, and occurs in a region prone to kilometers-scale slope failures” (Phrampus & Hornbach, 2012). Obviously, the location of gas wells would avoid geologically dangerous areas. Unusually, for fossil fuel acquisition, the mining of the methane hydrates could, to some extent, protect the climate. We already know that the oceans are acting as heat sinks and if the methane hydrates around the world destabilize, as may be happening, then it might cause an *“extreme global warming events like the Palaeocene – Eocene thermal maximum (PETM) and trigger widespread ocean acidification”* resulting in a warming of 5-6°C together with other impacts (Zachos, et al. 2005; Zachos, et al. 2003; Higgins & Schrag, 2006).

A superficial consideration of some of the aspects of obtaining methane on land from shales and from methane hydrates at sea is interesting. The exploitation of methane hydrates currently being developed by the Japanese will incur a different range of costs compared to hydraulic fracking on land. Costs such as using drilling ships, which once in position do not have to drill 2 km through the Earth’s crust to access the gas but several hundred meters (Cyranoski, 2013). A problem with methane hydrates is refreezing within the reservoirs under the sea bed during extraction of the gas. So far several strategies have been developed to release the methane from the ice; these include pumping down hot water to melt the ice to release the methane which is expensive or by pumping and depressurization. Another technique is to replace the methane with CO_2 which could provide a sequestering strategy (Schröder, et al. 2014). So far however, there are a number of problems to solve such as loose sediment blocking the pumps. Consequently, despite the Japanese success in so far developing the technology for the commercial extraction of methane from the sea floor it is estimated by the Japanese team director, Koji Yamamoto, to be 10 to 20 years behind the technology of methane extraction from shale strata by hydraulic fracking (Cyranoski, 2013). Meanwhile, some of the costs and problems of hydraulic fracking include:

1. Logistical costs of transporting tanker loads of water and fracking chemicals to well heads.
2. Large amount of energy is required for drilling the bore and pumping enormous quantities of water under high pressure upto 2 km underground and then horizontally in order to frack the shale strata.
3. The cocktail of fracking chemicals is toxic. *“A 2011 congressional report found that of the 2,500 hydrofracking chemicals used, over 650 of them contained “known or possible human carcinogens …” The congressional committee noted that “Companies are injecting fluids containing unknown chemicals about which they may have limited understanding of the potential risks posed to human health and the environment.” … every one million gallons of fluid blasted underground contains 10,000 gallons of chemicals”* (Prud’Homme, 2014). Meanwhile, the industry likes to claim that the chemicals used in hydraulic fracking *“are no more harmful than “what’s underneath your kitchen sink””* (Prud’Homme, 2014). However, this is merely condescending rhetoric since the cleaning agents under the sink are toxic, carcinogenic, corrosive, and *“regularly contain phthalates, synthetic musks, and triclosan – chemicals that pose a wide range of hazards to human health”* including developmental problems (Ashton & Green, 2006).
4. A portion of the water forced into the strata to release the gas returns to the surface as flowback. The volume may be anywhere between 3 to 80 %, (Prud’Homme, 2014) while other sources quote a narrower range of 10 to 40% *“of the water and chemical solution mixture injected at high pressure into deep rock strata surges back to the surface during well development”* (Shackford, 2014). The *“murky liquid, thick with salts, sulfur, chemicals, minerals, and proppants”* may also include radioactive minerals (Prud’Homme, 2014).
5. The polluted water must be managed and purified. However, *“there are business pressures” on drillers to “cut corners … It’s cheaper to dump wastewater than to treat it”* (Prud’Homme, 2014). Domestic sewage and water treatment works do not normally have the capability

to treat "flowback" water. However, another strategy is to pump it deep underground.
6. Accidents have resulted in the escape of this water causing pollution.
7. Geologists cannot know with 100% certainty how the shale strata 2km below the surface may behave (Ingraffea, 2011).
8. A sealed well may blowout causing pollution when fissures from an active well being 'fracked' meet up with those of a sealed well.
9. Fracking can cause minor earthquakes.
10. The concrete of sealed wells can deteriorate after several decades or more allowing pollution into water tables.
11. The large quantities of water required for fracking in the south west USA has added to the water stress of the region (Goldenberg, b. 2014) competing with agricultural needs! These are just some of the problems. Nonetheless, one cannot help reflecting on the possible long-term pollution and future threat to water security because this is a geo-engineering experiment on a scale never before undertaken. The long term risks are unknown.
12. In the US, the average amount of gas leaking from a fracked well is 3.3% with an upper estimate of 7.9%. How does a level of 3.3% leaked gas from fracking, added to the cost of burning the gas to generate electricity, translate into GHG emissions compared with burning coal? Dr Gideon Polya (Polya, n.d.), formerly a professor for biochemistry at La Trobe University, Australia, provides the calculations comparing the pollution and emissions from gas and coal. He concludes that the cost of burning gas plus the cost of a 3.3% leakage makes gas, as an energy source, 1.2 times dirtier than the pollution from Hazelwood, *"the dirtiest coal-fired power station in Victoria,"* Australia. If there are 2.6% leakages then burning gas will be as dirty as coal and if leakages reach 7.9% then burning gas will be *"roughly 2.1 times as dirty as Hazelwood"* (Polya, n.d.)!

"Methane is 105 times worse than carbon dioxide (CO_2) as a GHG on a 20 year time scale and major systemic gas leakage from the hydraulic fracking of shale formations has led Professor Robert Howarth, [and colleagues, 2011] Cornell University, Ithaca, New York, to conclude that "The large GHG footprint of shale gas undercuts the logic of its use as a bridging fuel over coming decades, if the goal is to reduce global warming. We do not intend that our study be used to justify the continued use of either oil or coal, but rather to demonstrate that substituting shale gas for these other fossil fuels may not have the desired effect of mitigating climate warming."

The Samsung Heavy Industries shipyard in South Korea is now building the biggest ship in the world for Shell, called the *Prelude*, it is 12 meters short of half a kilometer! The Prelude will exploit the Prelude gas field located about 100 miles-north west of Australia. It will operate by extracting natural gas from deposits under the sea bed (not methane hydrates) and process the gas on board into liquid natural gas (LNG) which can then be offloaded into LNG carriers. The plan is for the Prelude to remain moored over the gas field for about 25 years (Shukman, 2014).

8.5.2 The trilemma of natural gas

Let us summarize a number of facts.

The Arctic has apparently passed a tipping point and within a decade or two will be ice free in summer (Pearce, a. 2012; Smol, 2012).

› This means that with the reducing ice cap (IPCC, 2014) the Arctic seas will become still warmer.
› Glaciers are shrinking almost worldwide (IPCC, 2014).
› The West Antarctic Ice Sheet (WAIS) has also started to melt (Rignot, 2014; Goldenberg, c. 2014); an event scientists previously thought would not happen for decades, possibly even centuries.
› The CO_2 content of the atmosphere has reached 400ppm and will continue to rise (Clark, 2013; Brahic, 2013).
› We know that methane hydrates are destabilizing in many locations in the Arctic and from over 10,000 km2 off the east coast of America (Phrampus, & Hornbach, 2012).
› This century's warming hiatus has now been explained (Chen & Tung, 2014) and the warmth of global warming has been taken up by the Atlantic Ocean so that now a warmer Gulf Stream is destabilizing the methane hydrates.

- We know that methane does not have a global warming potential of 20 or 30 (despite what many authors say) but 105 times that of CO_2 because of its interaction with aerosols in the atmosphere (Shindell, et al, 2009; Polya, G. (n.d.); Howarth, et al, 2011). The 'spin' politicians and others give to natural gas as a clean source of energy is not true, it is dirty like coal and oil.

All this information tells us that we should already have stopped the use of fossil fuels. Furthermore, natural gas is not a bridge to reach 100% renewable energy.

So natural gas is a trilemma.

- We have made enormous investments to extract natural gas through fracking on land and marine projects like Prelude and the Japanese project for exploiting the methane hydrates.
- However, natural gas releases green house gases with similar levels to coal (not forgetting the leakages).
- Further emissions will cause further warming to the atmosphere and the oceans. Warmer oceans could destabilize more methane hydrates to produce an event similar to a *Palaeocene – Eocene thermal maximum (PETM)* and a warming of 5-6°C which would bring with other impacts (Zachos, et al. 2005; Zachos, et al. 2003; Higgins & Schrag, 2006). Does the strong risk of climate change beyond 2°C due to our continuing use of natural gas make nuclear energy worth reconsidering?

8.5.3 Nuclear energy: dream or nightmare?

The meltdown of the nuclear reactor in Chernobyl in 1986 and the subsequent fallout of radioactivity across Europe caused a bad press which influenced the perception of nuclear power for a generation. The 2011 Fukushima meltdown disaster has now had the same impact on another generation. However, according to the latest figures of the International Atomic Energy Agency, by the end of 2013, 434 nuclear reactors were in operation and 371 gigawatts of energy were produced throughout the year. 149 reactors were shut down and 72 reactors were under construction around the world of which about 28 were being built in China (International Atomic Energy Agency, 2014).

Costs

There are two types of reactors: light water reactors and breeder reactors. Most of the world's reactors are light water reactors which generate electricity at a cost of between US$0.025 and US$0.07 per kilowatt-hour. The technological capability which has made this possible is the result of decades of research (Schiermeier, et al. 2008).

Capacity

Uranium, a trace element, is the source of radioactive energy for nuclear power and the finite supply of fuel is the limitation. However, there are approximately 5.5. million tonnes of uranium around the world (Schiermeier, et al. 2008) and there are probably reserves as yet undiscovered which would double the known supply. However, due to the uncertainty, the top figure for recoverable supply may be as much as 35 million tonnes. Annually about 66,500 tonnes of uranium fuel are used around the world at which rate there is an estimated supply for about 80 years. The price for uranium is about US$130 per kilogram (Schiermeier, et al. 2008). The chief uranium deposits exist in Saskatchewan, Canada, and other major producers include Kazakhstan and Australia. Uranium occurs in high concentrations of about 2% in the Canadian deposits but elsewhere it is found in lower concentrations.

Benefits

"Nuclear power has relatively low fuel costs and can run at full blast almost constantly – US plants deliver 90% of their rated capacity" (Schiermeier, et al. 2008). Furthermore, uranium is fairly ubiquitous as a resource and therefore, unlike oil it is not threatened by world politics. Twenty five tons of uranium are required by a nuclear power station per year and compared to producing the same amount of energy from coal, coal requires about 2.5 million tons of black coal (Wagner, 2007).

Nuclear power provides the ideal energy source during the change over period from fossil fuel dependency towards 100% renewable sources because generating electricity from fission produces no greenhouse gases or emissions that create smog or acid rain (NEI, 2014). Currently, fossil fuels provide over 80% of our energy needs and which continue to add to the climate's greenhouse gas burden exacerbating the impacts of climate change.

Writing in 2008, Schiermeier and colleagues reported that breeder reactors require further development before becoming commercially viable. Currently, nuclear power stations use their fuel once. However, a breeder reactor creates more fuel than it uses as it converts uranium to plutonium and potentially it could be possible to get 60 times more energy from uranium (Schiermeier, et al. 2008). Unfortunately, *"Plutonium is the nuclear nightmare"* … because … *"it is the key ingredient in nuclear weapons. And even when not made into bombs, it is a million-year radioactive waste legacy that is already costing the world billions of dollars a year to contain."* (Pearce, b. 2012) However, fast breeder technology might become a reality with a new reactor design called PRISM (standing for Power Reactor Innovative Small Modular) which *"its chief consulting engineer and fast-breeder guru, Eric Loewen, says is a safe and secure way to power the world using yesterday's nuclear waste."* The company responsible for the development, the U.S. corporation GE Hitachi Nuclear Energy (GEH) plans to test the technology at Sellafield on the northwest coast of England because Sellafield has the largest store of plutonium in the world. If plutonium can be used it will solve the problem of its storage because it has a half-life of 24,100 years and a *"typical 1,000-megawatt reactor produces 27 tons of spent fuel a year"* (Pearce, b. 2012).

Handicaps & Externalities

Enormous quantities of earth have to be moved and processed for extracting uranium (Wagner, 2007). Consequently, uranium mining has a large ecological rucksack. In Australia uranium mining in the Kakadu National Park has been the cause of controversy between the government and the indigenous peoples. In India, Canada, Niger and Botswana other indigenous peoples are also opposed to uranium mines in their lands (Vidal, 2009) but commerce nearly always has precedence.

The over-riding problem with nuclear power is how to safely deal with the radioactive waste although finding the political solution appears to be more difficult than finding the technical solution to long term storage of the waste. An additional problem is the proliferation of nuclear arms (Schiermeier, et al. 2008) which is difficult to separate from the nuclear power generation. In addition, another problem which cannot be ignored is the security risk of a nuclear reactor and its potential as a target for terrorists.

The nuclear technology is capital intensive in the short term but costs over the long term are low due to the relative long life of nuclear power plants. Constructing and running a nuclear power plant requires, highly trained professional staff which are not numerous.

In Japan prior to the Fukushima accident in March, 2011, nuclear power provided 30% of Japan's energy and there were plans to increase to 50% by 2030. However, following the Fukushima accident, the government published a White Paper in October 2011, proposing that *"Japan's dependency on nuclear energy will be reduced as much as possible in the medium-range and long-range future"* (World Nuclear Association 2014). The Fukushima accident had an impact around the world and in particular caused Germany to confirm its strategy of becoming nuclear free while generally influencing the nuclear power strategy of some other nations.

Conclusion

Predictions about the future proportion of power which will be generated by fission in 2030 or 2050 is difficult to determine following the Fukushima disaster. However, these problems aside, nuclear power is actually one of the greenest sources of energy, at least in terms of green house gas emissions. The problem of waste management is a long term problem but a local one whereas the dangers of climate change are both long term and global in their impact. Furthermore, there are the added dangers of climate tipping points. Since nuclear power is emissions free, it could at least provide the ideal bridge to 100% renewable energy sources rather than natural gas and the other fossil fuels. The continued use of these energy sources as a bridge to renewable energy is very questionable given that the world is already undergoing extensive environmental changes due to green house gas emissions. These changes include: melting of both ice caps and glaciers, methane hydrates destabilizing, permafrost melting, increased ferocity of storms and droughts, loss of meteorological stationarity, etc.

8.6 Renewable energy: the hopeful dream

Renewable energy, also known as alternative energy (that is alternative to fossil fuels etc.), is derived from replenishable or inexhaustible sources such as: hydro-power, biomass, windpower, solar power, geothermal energy, wave & tide energy, energy harvesting, waste and finally human waste. Renewable energy is regarded as a substantial answer to our climate change problems despite the lack of political action in many countries to move away from the fossil fuels. In the rest of this chapter we will review, albeit briefly the different kinds of renewable energy. As has already been mentioned, this account is based on the *Nature* review by Schiermeier, et al (2008).

8.6.1 Hydropower

There are about 48,000 large dams over 15 meters high with a reservoir of more than 3 million m^3 in the world and half of which are in China. Together they provide about 800 gigawatts of energy which is almost one fifth of the electricity consumed worldwide. In addition there are many smaller dams. Worldwide these dams store about 6,000 km^3 which also provides irrigation for 30-40% of the 271 million hectares irrigated worldwide for food production (wwf.panda.org, 2014). More than 3,300 additional dams are planned to be built by 2030 (Grill, et al. 2015).

Of all the renewable energy resources dams come first. 160 countries exploit hydropower and it is a ubiquitous resource, a factor which contributes to its success. It is the major source of energy in several countries and more than 50% of the world's hydropower is produced in Brazil, Canada, China, Russia and the USA (Schiermeier, et al. 2008). It is seldom that hydropower can exploit 50% of a river's power and more usually less than 30% is possible. The use of hydropower in Europe already exploits about 75% of what could be technically possible. The greatest realization of hydropower's potential capacity is in Asia.

Costs

The cost of a dam per megawatt capacity is between US $1-5 million and during the twentieth century US $2 trillion was spent on hydropower (wwf.panda.org, 2014). Large dams with a high drop between the reservoir water level and the turbine are both the least expensive and more productive than small dams with a low drop. The annual operating costs are and between, 0.8 – 2% of the capital costs and the electricity is competitive with coal and gas at US$0.03 - 0.10 per kilowatt hour. The International Hydropower Association estimates that hydropower generation could triple with sufficient investment (Schiermeier, et al. 2008).

Benefits

Hydropower's great benefit is that it requires no fuel or fuel extraction or refining and transport infrastructure such as is required for the fossil fuels. Dams can respond quickly to changes in demand because it depends on the supply of water. Uniquely, dams can be built to store energy by pumping water back up into the reservoir when excess energy exists as a means of recovering at least some of the energy later. In addition to providing water for irrigation, reservoirs can also contribute to flood control as well as providing recreational facilities.

Handicaps & Externalities

Unfortunately, not all regions are especially well endowed with rivers for the development of hydropower, for example the Middle East. Furthermore, the surface area from man-made lakes and reservoirs worldwide occupies the same area as two Italy's. Consequently, a substantial problem is that during the second half of the last century *"more water evaporates from reservoirs than is consumed by humans"* and exceeds industrial and domestic consumption. In 1995 industrial and domestic consumption of water was less than 150km^3 whereas evaporation from reservoirs was more than 200 km^3 (Shiklomanov, 1999). Dams affect many people and millions have been relocated in India and China to enable the construction of large dams. Large areas are flooded for the reservoir behind the dam and the submerged and rotting vegetation releases large quantities of green house gases (Schiermeier, et al. 2008). In addition, land is lost for agriculture and ecosystems.

The ecosystems associated with rivers, wetlands and floodplains (riparian ecosystems) although incompletely understood due to their complexity, suffer significantly from the effects of damming. The evaporating water from the reservoir can increase the salt content of the water which when used for irrigation may cause salinization of croplands. Riparian (i.e. riverbank) ecosystems provide a range of ecosystem services including the mitigation of flooding or the reduction of flood damage, removing toxins and purifying water, recharging of water tables, the sequestration of carbon, retention of sediment, provision of a diversity of habitats for different species of fish and other fauna and flora (Chivian & Berstein, 2008). When the water flow is dammed then riparian ecosystems decline, riparian species can no longer survive nor provide the same ecosystem services. *"Twenty seven percent of all North American freshwater fauna populations are now considered threatened with extinction, a trend mirrored elsewhere around the world"* (Gleick, 2003).

Researchers at McGill University (Grill, et al. 2015) have found that: *"48% of the world's river volume is moderately or severely affected by dams today – and that figure would nearly double if all dams planned or under construction are completed in the future"* (to 93%). The McGill University team's research provides strategies for *"assessing the impact of any existing or planned dam"* by measuring the fragmentation or disruption of a river's flow and the proportion of water stored in reservoirs (Grill, et al. 2015). They have *"found that prolonged and prolific dam building has resulted in large-scale deterioration of the majority of global river basins, with at times heavy to severe impacts."* The team found that *"Permanent dam disruption of river systems can have effects from species to ecosystem levels and from local to global scales"* and furthermore *"Dams can have cumulative effects many hundred kilometers downstream and upstream of the barrier"* (Grill, et al. 2015). (qv. Glossary: The Kogi people).

Conclusion

Hydropower is a *"cheap and mature technology"* (Schiermeier, et al. 2008). Unfortunately, its environmental impacts are incompletely understood but recognized as being substantial. There is little room for further development of hydropower because it is a mature technology. However, there is potential for micro-turbines and 'run-of-river' schemes and water wheels which used to be used by millers for grinding flour in the past. Although they are five times more expensive than larger schemes (Schiermeier, et al. 2008), nonetheless, with the current interest and development of the 'off-grind' power there could be much potential for micro-turbines. Furthermore, some communities have already set up their own micro-turbines on local rivers, for example the Lancashire Co-housing community has set up the Halton Lune Hydro project (Cahn, 2013). Altogether, over 200 similar projects have been accepted by the UK Energy Authority. Grill and colleagues (2015) suggest that small to medium dams should be considered and waterfalls included in planning strategies. These proposals are in line with the 'soft' energy strategies of Amory Lovins (1977) and Jeremy Rifkin (2011) as preferable to large capital projects.

8.6.2 Biomass

"The controlled use of fire was a breakthrough invention that allowed cooking, the production of warmth and light, and protection from predators. Evidence of cooking extends back to 790,000 …" (Brown, 2009). Biomass, namely in the form of grass and wood for fire, has accompanied mankind and been his first energy provider for hundreds of millennia. Today, biomass is still an important, even essential source of energy for more than two billion people who mostly use it for fires and cooking. Biomass is also used to generate electricity and in 2005 the World Energy Council estimated that biomass's potential capacity for electricity generation was at least 40 gigawatts. In conventional power plants biomass can supplement coal or gas. Many co-generation plants are able to not only utilize biomass but also capture the heat in addition to generating electricity and consequently utilize up to 85-90% of the derived energy.

The production of biomass depends on 3 requirements: land surface to grow the feedstock, the efficiency of photosynthesis (about 1% or less) and the reliability of rainfall. Three kinds or *"generations"* or kinds of biomass can provide the feedstock for bio-fuel production:

- 1st generation bio-fuels are produced from feedstocks which have traditionally been grown for food so that, for example, corn and vegetable oils are used for producing ethanol and bio-diesel respectively.
- 2nd generation bio-fuels are made from non-food feedstocks which require advanced processes to derive ethanol from the cellulose of plant cells and are produced from a feedstock like sawdust.
- 3rd generation bio-fuels are also made from non-food feedstocks such as algae to produce a fuel indistinguishable from normal (i.e. fossil) petroleum (Buckley, 2014).

In 2007 it was estimated by the Organization for Economic Cooperation and Development (OECD) that probably 500 million hectares of land were available for rain-fed biomass production which could provide 68,000 terawatt hours and when converted to electricity could provide 3 terawatts at an efficiency of 40%. The IPCC estimates were even higher. However, the land might have other potential than for electricity production. Furthermore, turning biomass into bio-fuel is not as efficient as simply burning it for energy. In 2008

Schiermeier et al. thought that *"Bio-fuels might easily beat electricity generation as a use for biomass in most settings."*

Six years later (in 2014) *"A new generation of industrial plants can make liquid fuels from almost any organic scraps – from corn stalks and wood chips to urban rubbish"* (Krieger, 2014). This is confirmed by the new plant being built by GreenSky, London. *"Each year, the facility will take in some 500,000 tonnes of the city's waste and will transform the organic component into 60,000 tonnes of jet fuel, a similar quantity of diesel fuel combined with petrol-like naptha, and 40 megawatts of power."* This will power all British Airways flights out of London City airport when ready by the end of 2015. Supporters argue that the *"novel catalytic techniques and compact designs will make second-generation bio-fuel plants not just environmentally friendly, but also profitable enough to compete with petroleum based fuels without subsidies"* (Krieger, 2014).

Costs

The price of electricity generated from biomass varies greatly according to the type and availability of the biomass and to the cost of which must be added the logistical one of transport. The capital cost of a biomass plant is about the same as fossil fuel energy plants. Depending on the power plant the cost of the electricity can range from US$0.02 - US$0.09 per kilowatt hour. The main problem for new biomass power plants is finding locally available (to reduce transport costs) and reliable feedstock fuel (Schiermeier, et al, 2008). This means that bio-fuel plants should be small which, however increases the capital cost per megawatt.

In the USA genetic engineering has been used to modify the *bacterium Escherichia coli* to produce fuel by digesting and ferment alginate and the other sugars in algae and seaweeds. Although some other countries cultivate seaweed for food, animal feed, fertilizer, or polymers the US does not farm seaweeds (Stokstad, 2012) despite its extensive coastlines. The potential of single-celled algae are also being explored since 'algal farming' would use bodies of fresh, brackish, saline and wastewater so that it would not be competing with terrestrial food production. *"The path to commercialization may … require millions of dollars, the potential for algal biofuels to contribute to national goals of reduced dependence on fossil fuels, reduced CO_2 emissions and greater energy security are worth the investment"* (Pienkos, Laurens & Aden, 2011). A new kind of farming could therefore develop, but *"researchers calculated that replacing 1% of the US gasoline supply with ethanol would require growing seaweed over nearly 11,000 square kilometers."*

Benefits

Plants are carbon neutral and are themselves renewable. The technologies for generating power from biomass are efficient and if equipped with carbon-capture-and-storage hardware then biomass is effectively removing CO_2 (sequestering) from the atmosphere and not merely carbon neutral. Consequently, this is the only technology capable of acting as a carbon sink.

Handicaps & Externalities

The world has a finite area of land for agricultural use and food should be the priority. Unfortunately, some national subsidies and unregulated markets has meant that market mechanisms drive how much land is used for food production and how much for biomass production for energy. Consequently, there is an ethical question to be addressed here whether neo-liberal capitalism, profit and the markets (i.e. profits) should decide how much land is devoted to growing food and/or fuel. Some form of global management is needed rather than the mindless markets. *"The United Nations Food and Agriculture Organization estimates that nearly 870 million people of the 7.1 billion people in the world, or one in eight, were suffering from chronic undernourishment in 2010-2012"* (World Hunger Org, 2013). In 2007 the number of people suffering from hunger was 845 million *"with 16,000 children die needlessly each day from hunger-related conditions"* (Hunger Report, 2007). Meanwhile, the European Union, with little forethought for the consequences, voted to replace 10% of fossil fuel petrol with bio-fuel in order to reduce greenhouse gas emissions by 20% (Upfront, 2010). The Institute for European Environment Policy (IEEP) estimated that between 4.1 to 6.9 million hectares of land will need to be cleared to grow and provide the bio-fuel. However, the clearance of tropical forest releases about 170-240 metric tons of carbon per hectare (Righelato & Spracklen, 2007). The total carbon emissions for the planned bio-ethanol production would be equivalent to putting between another 12 to 26 million cars on the roads. In order to fulfill these plans land in Africa was acquired to reach a 2020 target to reduce CO_2 emissions by 20%. Furthermore, the irrigation for growing the crops would require millions of liters of water to derive a Megawatt hour of energy: specifically …

- corn ethanol irrigation would require: 2,270,000-8,670,000 liters
- soybean biodiesel irrigation would require: 13,900,000-27,900,000 liters (Service, 2009).

> *"In 2008 a confidential report based on the most detailed analysis by the World Bank reported that "biofuels have forced global food prices up by 75% – far more than previously estimated …" (Chakrabortty, A., 2008, p.1) The policy adviser to Oxfam, Robert Bailey said that "Political leaders seem intent on suppressing and ignoring the strong evidence that biofuels are a major factor in recent food price rises." continuing that "While politicians concentrate on keeping industry lobbies happy, people in poor countries cannot afford enough to eat." (Chakrabortty, 2008) The World Bank estimates that rising food prices have pushed 100 million people worldwide below the poverty line. The report argues that both the US and EU drive for biofuels has had the greatest impact on prices and food supply. Since 2002 and February 2008 food prices rose by 140%. Meanwhile the push to provide biofuels continues with the Tana river wetlands in Kenya to be drained for ethanol production (Rice, 2008)"* (Stebbing, 2011).

Biomass is surely going to contribute to the world's future energy requirement, but this case classically illustrates the interconnectivity of our world in which apparently solving one problem creates many more which in 2008 (Chakraborrty, 2008) included:

1. not reducing carbon emissions and therefore the basic plan was an EU government failure.
2. increasing food prices by 75%.
3. pushing 100,000,000 people into poverty.
4. destroying the Tana river's wetlands ecosystem in Kenya (Rice, 2008).

In recognition of their incompetence the EU Council decided that biofuels should provide only 5% of total transport energy consumption. However, this was raised to 6% after lobbying by the bio-fuel and agriculture sectors and now will be raised further to 7% ! (Mathiesen, 2013).

This tragic case shows little concern for those whose lives were most affected by the externalities and more concern for others to maintain their income and mobility.

Compost is energy too …

Compost is an energy resource too since it fertilizes and provides the nutrients for plants to be able to grow and produce either food or biomass for energy.

Conclusion

The EU biomass fiasco is an example of how we all need a much more holistic perception when problem solving because this example perfectly illustrates that solving a problem within a box is not a solution. Rather we need to systemic design solutions which embrace the externalities and consequences way beyond the immediate problem.

Ethically, 1st generation bio-fuels are not a solution to our energy requirements when millions of people have insufficient food and so many children are dying of malnutrition. The Esso company used to have an advertising campaign with the quip *"Put a tiger in your tank"* but the situation of 1st generation bio-fuels begs the question "How many deaths to the liter." In a globalized world we must recognize the consequences of our actions because our economies are interdependent and our choices impact on peoples unseen. Meanwhile, 3rd generation bio-fuels could well come into their own. *"Micro-algae hold great promise because some species are among the fastest growing plants alive and are therefore one of the best sources of biomass, while other species have been estimated to produce between 18,700 and 46,750 liters of oil per hectare per year, nearly a hundred times more than soya beans' 468 liters per hectare per year"* (Trent, 2012).

8.6.3 Wind

Wind power has made an increasingly rapid contribution to the generating capacity of a number of nations. *"Globally capacity has risen by nearly 25% in each of the past five years, according to the Global Wind Energy Council"* (Schiermeier, et al. 2008). In 2008, the World's installed capacity was 94 gigawatts. The potential for wind power is vast because the movement of the Earth's atmosphere is estimated to be hundreds of terawatts. It has been calculated that 2.5 million of the larger wind turbines located at 13% of sites with wind speeds of at least 6.9 meters per second could produce more than 72 terawatts of energy (Archer & Jacobson, 2005).

In the USA more plans exist for increasing wind power than for coal and gas together. In 2007 alone the US added 5.3 gigawatts to its wind generating capacity amounting to 35% of the nation's new power generation capability. However, on a global scale the numbers remain small because wind farms generate only 20% of their capacity (Schiermeier, et al, 2008). In recent years the growth of wind power has been slowing so that *"The global wind power capacity grew by 21 percent in 2011 – lower than the 2010 rate of 24 percent and markedly lower than the 2009 rate of 31 percent"* (World Watch Institute, 2013).

Costs

Wind power is competitive with coal, at least at the lower end of its price range of $0.05-0.09 per kilowatt hour. The installation costs for onshore wind farms are about US$1.8 million per megawatt and for offshore developments $2.4 – 3 million. However, with government subsidies the costs can be well below those of coal which has encouraged the boom. In 2008 the limit to the installation of wind farms was the production of turbines. However, some governments have caused a slow down by subsidizing fossil fuels and reducing subsidies to wind power. The technological development has been spectacular because in 1981, a wind farm with an array of 50-kilowatt turbines was capable of producing electricity at $0.40 per kilowatt hour and by 2008 the wind farms can produce 30 times the energy at one-fifth of the price (Schiermeier, et al, 2008).

Benefits

Once wind turbines have been built and erected the only additional cost is maintenance since they require no fuel. The increasing size and reliability of wind turbines is enhancing their productivity. Germany has been a strong adopter of wind power technology and by 2008 *"its combined capacity of 22GW supplied less than 7% of the country's electricity needs. Britain, which has been much slower to adopt wind power, has by far the largest offshore potential in Europe – enough to meet its electricity needs three times over"* (Schiermeier, et al, 2008). Furthermore, by developing less than 5% of the North Sea, Europe could meet 25% of its electricity requirement. In 2013 *"The share of renewable energy sources in Germany's gross electricity consumption rose significantly in 2013 to reach 25.4%, with an amount of 152.6 billion kWh. This represents a continuing increase of two and a half percentage points compared to the previous year (with 22.9%). Wind energy provided a share of 35% of all renewable energy sources in 2013."* Germany has a *"target of 25 GW of offshore wind power installed by 2030."* As a consequence, *"The use of wind energy in Germany has avoided 41.7 million tons of carbon dioxide equivalents for greenhouse gas emissions in 2013"* (Klein & Barth, 2013). The International Energy Authority also reports that globally *"While wind power installed capacity increased 12% over the 2012 level, electricity production increased 21% in IEA Wind member countries." Furthermore, "At the close of 2013, wind generation was meeting nearly 4% of the world's electricity demand (WWEA 2014) with 318.1 GW of wind power operating in 103 countries (GWEC 2014)"* (Weis-Taylor, 2014).

Handicaps & Externalities

As everyone knows, the wind does not blow all the time and furthermore, the windiest places, like wave power, are often far away from habitation and therefore may require infrastructure development to deliver the energy from remote locations. Despite these handicaps *"providing up to 20% of a grid's capacity from wind is not too difficult"* (Schiermeier, et al, 2008). In addition to its irregularity, wind power tends to be a low density source so that 10 watts per square meter is considered a very high yield. Consequently, the land for a wind farm needs to be cheap or simultaneously used for other purposes. The location of onshore wind farms can result in local resistance from communities due to the perceived unsightliness of onshore wind farms. Offshore wind farms are consequently favoured and can also be more productive where sea breezes are frequent.

Large wind farms with many turbines tend to slow the wind down as the wind's power is extracted by the turbines which could therefore have a local warming effect (Keith, et al. 2004). Another problem of turbines is the large number of bird casualties caused by birds colliding with the turbines. Furthermore, the turbine blades loose their aerodynamic efficiency as the bodies of insects, which also collide with the blades, stick to their surfaces.

Conclusion

A global provision of a terawatt or more is certainly possible with large installations on the plains of China and the USA together with more offshore installations.

In addition to wind farms there is much potential for built-environment wind turbines (BWT) which can be *"installed on the roofs of buildings, side-mounted to a building, integrated into the building design, or otherwise operate in the urban setting. This new Recommended Practice will extend the consumer label to small wind turbines in the built environment"* (IEA Task 27). Task 27 of the International Energy Agency is working on recommendations for the installation of wind generators in city environments. Micro-turbines exploiting windpower could make a substantial contribution to the generation of local, domestic energy following the concept of Jeremy Rifkin. In his book *The Third Industrial Revolution* (2011) he proposes that all houses have their own power plants exploiting and sharing energy derived from each house's solar and wind generators. The wide dispersal of micro-power generators has the advantage generating power despite regional weather differences. Large installations do not have the same benefit.

8.6.4 Solar power

Photosynthesis is the miracle that enabled us to exist at all! However, plants, bless them, can only convert about 1% or less of the solar energy they receive (on a good day) into utilizable food but more often only 0.2-0.5% of the sun's energy (Street & Öpik, 1984). Let's remember that the *"Earth receives about 100,000TW of solar power at its surface – enough energy every hour to supply humanity's energy needs for a year"* (Schiermeier, et al, 2008). The problem is not merely capturing the sun's energy however, but storing it – this is the real problem. It is a problem very much in search of economical solutions.

The photovoltaic technology is under continual development and its efficiency is improving, unlike photosynthesis. In the first decade of this century the standard solar panel converted between 12-18% of the sun's energy. However, the world's leading solar cells are from Fraunhofer and can convert 44.7% of the sun's energy. Unfortunately, they are too expensive for the commercial market and are used only by specialist clients like NASA (Shahan, 2014). In the commercial range it was estimated in 2008 that the installed solar capacity was about 9 gigawatt, however, the actual quantity of electricity generated was a lot less due to the limitations of cloud cover and night time (Schiermeier, 2008).

There has been a strong development of solar power so that in the five years from 2002 to 2008 the quantity of solar cells shipped worldwide increased six times so that the total capacity that was installed by 2008 was 9GW.

In addition to solar panels there are solar thermal systems designed to heat water and which are available for private consumption. Larger installations employ arrays of mirrors in parabolic arrangements which focus the sun's rays onto a central tower which heat's up a fluid and drives a turbine to generate electricity. Such installations require a climate with many cloud free days. Ideal locations for such installations include the Sahara Desert, the Gobi and Atacama Deserts and the Great Basin in the USA. Arrays of photovoltaic panels could be built up to 7 to 8 kilometers across.

Costs

In addition to the installation costs, the costs of manufacturing solar panels in 2008 were about US$1.50 - 2.50 per watt's worth of generating power and so prices were in the US$2.50 - 3.50 range per watt (Schiermeier et al, 2008). *"What this means in terms of cost per kilowatt hour over the life of the installation varies according to the location, but it comes out at around $0.25-0.40"* (Schiermeier et al, 2008) However, since 2008 production costs have fallen significantly and today the JinkoSolar Company in China is now producing solar modules for less than US$0.50 per watt (Wesoff, 2014).The installation costs will also drop when solar panels are automatically installed when buildings are built.

Benefits

The Sun's unlimited power, is free, widely dispersed and not polluting. Generally, it is not unpopular and of little geopolitical, environmental or aesthetic concern in comparison to nuclear, hydro, or wind power. Photovoltaics are relatively easy to install and are ideally suited to off-grid generation and areas where there is little or no infrastructure (Schiermeier et al. 2008). It seems that both photovoltaic and solar thermal technologies have further potential for development with the certainty of producing power more cheaply.

Handicaps & Externalities

Obviously, solar panels cannot function at night nor during cloud cover and so consequently, solar power has the lowest capacity factor of 14%.

Photovoltaic solar panels need a small amount of silver for the reaction to create electricity. However, as Prof Armin Reller and Frau Diessenbacher in their Chapter 8 on resources point out; silver is a finite resource and it has been calculated that supplies may become exhausted in about 22 years (circa 2036). As the technology develops there may well be requirements for other rare earth elements which are mostly exported from only a few countries. In the case that political tensions should develop then supply chains could be cut or limited due to trade embargoes etc.

It is also recognized that *"stationarity (– the idea that natural systems fluctuate within an unchanging envelope of variability ...) is dead because substantial anthropogenic change of the Earth's climate is altering the means and extremes"* of our weather patterns (Milly, 2008). The destabilized weather patterns and storms of increasing ferocity means that we need to anticipate the destruction of solar panel installations from roofs and elsewhere. Consequently, solar panels as architectural add-ons may not be the best solution but rather solar panels should become fully integrated inbuilt architectural components.

Proposals are being considered for large solar installations in deserts and the German Aerospace Centre proposed that by 2050 that a number of photovoltaic and solar thermal plants in North Africa and the Middle East could be providing Europe with power. Such a project would also require a new network infrastructure for the electricity distribution systems and a different political climate to that which currently exists. In some locations, for example in Germany, solar panel arrays have been placed on agricultural land which poses the question whether this is really the best use of the land. Naturally, installations on buildings and integrated within the fabric of the building provide excellent opportunities for solar panel installations. Other locations include reservoirs and other bodies of relatively still water on which solar panel arrays can be floated. This technique is being developed by GEITS (Kasper, 2014).

The storage of energy remains a problem, however, Jeremy Rifkin's Third Industrial Revolution (2011) could provide a solution to the energy storage with a fully integrated network of idle electric and hybrid cars whose batteries could provide capacity for "loading" and "unloading" electricity (Schiermeier et al, 2008).

Conclusion

Solar power with the potential for further technological development (so long as production of the technology is not limited by the necessary mineral resources) would appear to have a major role as a carbon free technology in the future. The technology of energy storage remains a problem and its development still needs to catch up for real benefits to be achieved. There is no doubt that in lower latitudes solar energy has great potential while in higher latitudes cloud cover is a limiting factor.

The increasing investment in solar energy is bringing good news so that John Vidal was able to report in June 2014 that *"Britain and Germany have broken records for generating solar electricity in the last few weeks, according to new industry figures.*

Germany generated over half its electricity demand from solar for the first time ever on 9 June, and the UK, basking in the sunniest weather of summer during the longest days of the year, nearly doubled its 2013 peak solar power output at the solstice weekend.

France, Italy, Denmark and other countries are also believed to have generated record amounts in June" (Vidal, 2014). Meanwhile, the UK is to increase its dependency on fossil fuels and cut subsidies to both solar energy farms and onshore windfarms (Harvey, 2014). The *"Move to cut subsidies for large-scale installations is condemned by green activists and renewable power companies"* (Harvey, c. 2014). Neo-liberal capitalist politics demonstrates yet again its lack of commitment to achieving a sustainable future.

8.6.5 Geothermal

The Earth's molten core contains unimaginable quantities of heat within an envelope of rock which is a poor conductor of heat. However, as a consequence of the rock it is hard to access the heat for power generation except where there are hot springs. Nonetheless, there are a few locations suited to geothermal power exploitation in several countries, *"only five of those – Costa Rica, El Salvador, Iceland, Kenya and the Philippines – generate more than 15% of their electricity this way"* (Schiermeier, et al. 2008). Geothermal power installations around the world provided only 10 gigawatts of electrical energy and the capability is growing slowly and has been completely overtaken by wind. Heat is lost from the Earth at the rate of about 40-50 TW per annum which is equivalent to about a little less than one tenth of a watt per square meter but *"For comparison sunlight comes in at an average of 200 watts per square meter"* (Schiermeier, 2008). An MIT study in 2006 proposed that with more advanced water injection technology it could be possible to develop 100GW capacity of geothermal energy in the USA. However, it would require a great deal of investment and globally it might be possible to generate a terawatt of energy which was as much as hydro-electric power produced in 2008.

There is enough energy at relatively shallow depths of approximately 60 meters which can provide heating to houses and business with small geothermal heat pumps. *"In 2008 for example, over 300,000 heat pump systems are in operation for heating purposes in Germany; the technology is mature. Well designed heat-pump systems make it possible with an input of one kilowatt hour of electricity to obtain 3 to 4 kW hours of heat from the soil to heat a building"* (Wagner, 2008). Furthermore, processes are being developed to exploit the temperature gradient difference of 30°C per thousand meters (Wagner, 2008).

Costs

The geology of the locality is a critical factor and some especially favourable localities which have a lot of hot circulating water could, if developed, generate electricity at a cost of US$0.05 per kilowatt-hour. However, with technological development, low grade areas could also be exploited more profitably but they are currently too expensive to tap.

Benefits

Geothermal energy provides a consistent power supply and requires no fuel of course! *"At 75% geothermal sources boast a higher capacity factor than any other renewable"* (Schiermeier, 2008). The drilling technologies developed by the oil and gas industries, notably for fracking, makes geothermal energy of greater interest than the oil industry's developments.

Handicaps

It appears that exploitation of geothermal energy with technologies on a large scale, while possible, have still to be demonstrated. Furthermore, high-grade resources are uncommon and poorer resources occur unevenly. There are dangers associated with geothermal energy; for example the water which brings up the heat can carry chemicals which could contaminate aquifers. In addition, some geothermal fields also have CO_2 which can leak to the surface (Schiermeier, 2008).

Conclusion

There is doubt that geothermal power will overhaul wind and hydro-power, however, the recent developments in drilling capabilities might open up new possibilities. Tester, (2006) an author of the MIT report, *The Future of Geothermal Energy* suggests that an investment of US$1 billion over a decade could greatly increase capacity (Schiermeier, 2008).

8.6.6 Oceanic energy

"Recognition of the need to reduce carbon emissions to limit impacts of future climate change has put marine renewable energy (and all other renewables) back on the agenda, both in Australia and internationally" (Hemer & Griffin, 2011). The oceans have the potential to provide continuous power since there is always tidal movement due to the gravitational pull of the sun and the moon on the Earth producing about 3TW of tidal energy. Perhaps not as much as one could expect from such mighty forces! Geographically 1TW of this potential energy is in waters shallow enough to be exploited. France has 80% of the tidal-stream power available around Europe, unfortunately however, it is little more than a gigawatt (Schiermeier, et al. 2008). Several forms of kinetic power are provided by the seas: ocean current (non-tidal), tidal energy, and wave energy. So far, however, oceanic kinetic energy has been little exploited since it requires a suitable geography.

Wave power

Ocean waves have an estimated energy of more than 100TW and the European Energy Association has calculated that between 1 to 10 TW is accessible but much less can be recovered with the existing technologies. About 2% of the world's coastlines have waves which could offer about 500GW with machines working at 40% efficiency. Consequently, it seems that without substantial technological development wave power is unable to provide energy as cheaply as hydropower (Schiermeier, et al. 2008).

Many designs have been developed for generating energy from wave power but even the most promising designs remain in the testing and development phase. Designs include machines like articulated snakes (attenuators) in which 4 or more cylinders are connected together and riding the waves causes movement at the joints between the cylinders to generate power. Another design are point absorbers which, moored to the seabed, have floating components which bob up and down with the wave movement. There are also designs built on a rocky shoreline in which waves overtop a sluice through which water then drives a turbine as the water escapes. A refinement of this principle employs a tapered channel which constricts the waves causing their amplitude to increase as the channel narrows. The water then tumbles over the constricting walls to flow into a reservoir from which the water then escapes through a turbine. Waves are also directed into the funnel by large triangles on the seabed helping to focus a wide wave front into a narrow front (Williams, 1984). The concept was developed by scientists in Oslo who formed the company Norwave. The installation was built at Toftestallen in Øygarden. *"Next October [1985], the power station will begin to provide heat and light for the local coastal community. It will be produced at an estimated cost of 5.1 pence per kw/hour. The Norwegians reckon it could be ideal for island communities where generator fuel is expensive"* (Williams, 1984). *"The installation was completed in 1985 and the project ran for three years until a storm in 1988 wiped out the power plant"* (d'Anjou, 2011).

Two other devices depend on wave oscillation; one is an arm tethered to the sea bed moving in response to wave surges like a pendulum; the other oscillating device is a water intake like a blow-hole found in some sea cliffs. The column of air inside the artificial blow hole is compressed and decompressed by the rising and falling waves which thereby power a turbine. (Callaway, 2007). However, none of these concepts have so far been installed on any scale. One company based in Edinburgh, Pelamis Wave Power, has tested its Sea Snake 750-kilowatt wave machine off the Orkney Islands, Scotland (Callaway, 2007) and the company has also installed machines off the Portuguese coast which generate about 2.25MW (Schiermeier, et al. 2008). In Australia the company *"Oceanlinx has been testing a 600-kilowatt machine off Port Kembla, New South Wales, since 2005, and is working on a larger, 2-megawatt model"* (Callaway, 2007).

Tidal power

Barrages across bays and estuaries offer the potential for exploitation of tidal power where the barrage, acts like a dam, with turbines driven by the tidal movement of the water in and out of the impoundment. The world's largest tidal power plant is on the Rance estuary in Brittany, France and produces 240 MW and has been in use for over 40 years. Another tidal barrage has been proposed for the Severn Estuary in the UK which could generate up to 8GW, however, it has remained only a proposal for many years. In addition to barrages there are also tidal stream systems in which turbines located under water, like an underwater windmill, generate energy where there is a strong tidal flow. Such a system was installed in the mouth of Strangford Lough in Northern Ireland during the summer of 2008 and generates 1.2 MW of electricity (Schiermeier, et al. 2008).

Ocean Currents

The East Australian Current flows southwards towards New South Wales and off Brisbane flow speeds of more than 2 meters per second have been recorded. However, *"If five such lines of turbines were installed (at 100km intervals spanning the high-current stretch) of coastline, the total production would be 44 TWh/yr, or 17 per cent of Australia's total present usage (254 TWh/yr). Any installation approaching this magnitude would, however, be likely to have a considerable effect on the physical properties of the East Australian Current, while also being a very significant hazard to navigation and possibly also to marine life"* (Griffin & Hemer, 2011).

Costs

Barrage costs are similar to those for the construction of large dams, for example US$30 billion or more. The proposed 8GW Severn Estuary project has been calculated at a cost of $4million per megawatt of energy. The British Carbon Trust, which encourages investment in non-carbon forms of energy, produced a report in 2006 and calculated that *"the costs of tidal-stream electricity in the $0.20-0.40 per kilowatt hour range, with wave systems running up to $0.90 per kilowatt-hour"* (Schiermeier, et al 2008). Unfortunately, the existing technologies are too expensive for large-scale production to bring the costs of electricity down to levels viable and comparable to other sources such as hydropower.

Benefits

Tidal movement is entirely predictable and consequently barrages do offer the possibility for power generation on a nationally significant scale. Furthermore, tidal power is consistently reliable whereas wind and waves are unpredictable although waves are more reliable than wind.

Handicaps & Externalities

Waves and tides are not geographically available to all nations and even those to whom they are available then it does not mean that having a coastline is automatically suited to the development of wave and tidal power. *"Barrages have environmental impacts, typically flooding previously inter-tidal wetlands, and wave systems that long stretches of dramatic coastline might be hard for the public to accept"* (Schiermeier, et al. 2008). Sites around the world with good potential for wave power include *"Australia's west coast, South Africa, the west coast of North America and western European coastlines."* The cost of the building and the implementation of marine turbines capable of surviving and withstanding the power of waves for several decades is expensive. Furthermore, there is the cost of connection to power grids because suitable locations are often remote (Schiermeier, et al. 2008). *"Energy companies with outdated power grids could also dash the hopes of wave-energy supporters. Designed to handle large, centrally located power plants, many utility company networks are unprepared for the dispersed nature of renewable energies. "Historically, their role in this was to say 'over my dead body,'" says Thorpe [of the consultancy firm Oxford Oceanics, UK], "The last thing they wanted was a wave energy device on their network"* (Callaway, 2007).

Conclusion

Tide and wave power may probably remain a marginal option on a world scale but the particular geography of certain coasts might offer potential combined with further technological development and as the pressure to reduce greenhouse gas emissions increases. Consequently, for the time being, while coal, oil and gas retain their dominant position as energy providers there was at least a surge of interest in ocean energy. So for example *"Some of Australia's more advanced marine energy developers, Oceanlinx (founded as Energetech in 1997), Carnegie Wave Energy (who designed the CETO unit, 1999), and United States based Ocean Power technologies (founded in 1994 by an Australian inventor) commenced operation during this period of strong growth in interest in marine renewables"* (Hemer & Griffin, 2011). The tide will turn as the effect of global warming becomes more pronounced and governments will be forced to investing in more renewables.

There are two major unpredictable dimensions about the oceans: the first is the impact of rising sea levels and the second is the interaction of the oceans with climate and weather. The oceans are a thermal sink absorbing the heat from the atmosphere created by increasing global warming which in turn fuel tropical cyclones. Between 1970 and 2006 sea surface temperatures have increased by about 0.2°C (±0.06°C) per decade (Cheung, Reg, & Pauly 2013).

As a consequence there has been an increase in both the power and duration of hurricanes since the mid-1970s (Emanuel, 2005). Furthermore, overall changes brought about by global warming mean that the concept of 'stationarity' is now irrelevant. 'Stationarity' is *"the idea that natural systems fluctuate within an unchanging envelope of variability."* Now however, *"Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapo-transpiration, and rates of discharge of rivers"* (Milly, et al., 2008). So far we built structures to withstand the climate extremes we have so far experienced within the stationarity envelope, but because climate change will bring more extreme events then the example of the destruction of the Norwave installation built at Toftestallen in Øygarden, Norway illustrates the difficulty. Another possible danger could be solar panels: are they attached to buildings in anticipation of withstanding weather extremes beyond the stationarity envelope?

8.6.7 Waste

There can be no doubt that waste is a valuable energy resource of which the Western consumer culture has an enormous abundance. This is illustrated by the contents of a landfill site such as in Måsalycke in Sweden which was analyzed and found to contain:

- 28.7% paper
- 18.6% wood
- 16.9% fine soil-like particles
- 10.3% stones etc.
- 6.5% plastic
- 6.2% garden waste

- › 4.9% metal
- › 2.4% hazardous waste
- › 2.1% nappies/diapers & sanitary towels
- › 1.2% food waste
- › 1.2% textiles
- › 0.6% rubber
- › 0.2% leather
- › 0.1% glass
- › 0.1% electronics

(Douglas, 2008).

Furthermore, some small countries, like the United Kingdom has limited space for 'landfill' for burying rubbish. This problem has been solved by several UK cities (Bristol and Leeds) which now pay to send their waste to Norway for incineration. The Klemetsrud plant in Norway incinerates 300,000 tonnes of pre-sorted waste after what can be recycled has been removed. The rest of the *"waste thrown out by millions of households from Norway, Britain and elsewhere is turned into heat and electricity for the city of Oslo"* (Price, 2013). Four tonnes of waste has the energy equivalent of one tonne of oil which could heat a home for six months, furthermore, little energy is used to transport the waste since much of it comes from the urban area of Oslo. The waste is dropped into an incinerator where it is burnt at 850°, the remaining ash contains metals which are recycled. The heat boils water which powers a turbine to produce electricity or else the hot water is piped directly for heating 56,000 homes and public schools throughout Oslo.

This development is not without some problems, for example the incinerator depends on a continuous supply of rubbish and Norway and Sweden has created an overcapacity and is now dependent on the supply of more and more rubbish. The Friends of the Earth, Norway chairman Lars Haltbrekken ranks the incineration option as fourth after firstly;

1. Reducing waste
2. Reusing waste
3. Recycling materials

and then

4. incineration for energy production
5. and when none of the forgoing are possible then the waste could be buried in landfill.

In Oslo food and organic waste is also rotted down to provide biogas which powers some of the city's buses. *"One kilogramme of food waste produces half a liter of fuel. Use all of the organic waste they have and they will be able to power 135 buses year-round in Oslo. If this whole project were repeated across Europe, Pal Mikkelsen believes it would make a huge difference.*

"I think it would mean we get a lot better level of self-sustainability when it comes to energy. If it's done properly it would also mean a lot more materials' recovery. And a sharp decrease in the landfill." With tight controls to clean up the gases from the burning, Oslo believes converting waste into energy will help it to halve its carbon dioxide (CO_2) emissions within 20 years" (Price, 2013).

In the USA, Covanta has 41 waste-energy plants and on average they produce about 550 to 750 kilowatt-hours of electricity per ton of waste. Similarly to their European counterparts the recyclable materials are removed and *"Covanta claims to recycle 400,000 tons of metal per year"* (Pyper, 2011). One plant in Arlington, Virginia incinerates "about 350,000 tons of municipal waste per year" (Pyper, 2011) and generates 23 megawatts of electricity supplying 20,000 homes. The waste is incinerated at a temperature of 1,700°F (926°C). The energy is generated with minimal pollutant levels because of the series of technological processes employed to remove pollutants, although there are concerns about the adequacy of these measures. Altogether, there are about 86 waste-to-energy plants in the USA producing a total of about 2,700 MW which is enough for 2 million homes. In Europe there are more than 400 waste-to-energy plants and another 300 facilities in 40 countries around the world (Pyper, 2011).

Costs

The US Environmental Protection Agency estimates that a new waste incineration plant costs US $1million with larger plants costing three times as much (EPA, 2014).

Benefits

In 1987 Cynthia Pollock authored a report for the Worldwatch Institute, *"entitled Mining Urban Wastes: the Potential for Recycling, points out that consumers and policy makers are just beginning to realize that there is no real 'away' for throwaways"* (Moore, 1987). However, three of the benefits of incineration, besides the generation of energy, are the saving of space required for landfills, thereby saving the risk of toxins from landfills seeping into the water table and mitigating the release of methane from landfill sites.

It is of historical interest that in 1987, the British paper, The *Sunday Time*s reported that *"The cost of burying household waste (90% of all waste is buried in the US) is increasing at an astonishing rate as suitable sites run out and local authorities are forced to pay more for land on which to dump the detritus of modern living. The authorities in the city of Philadelphia now pay US$90 a ton to dispose of waste. Seven years ago it paid $20"* (Moore, 1987). Moore was referring to Cynthia Pollock's Worldwatch Institute report already cited above.

One might imagine that one of the problems of waste is that it is a mass of mixed materials. However, the Norwegian market leader company, Tomra (see Sources below) for example, which initially achieved success with reverse vending machines (i.e. machines receiving returned bottles, cans etc.) uses automatic waste sorters equipped with spectrometer sensors and air jets (mechanical fingers) to separate waste. They employ a portfolio of sensors, including: electromagnetic, color sensors, X-rays, visible light spectrometry, lasers, radiometry, and infra-red technologies to separate different kinds of waste (household, packaging, car shredders, electronic scrap, etc.). The separation of waste provides the key for recycling.

Handicaps & Externalities

One estimation is that *"More than 90% of materials currently disposed of in incinerators and landfills can be reused, recycled and composted"* (GAIA, 2012; Platt, et al, 2008). Furthermore, *"Providing subsidies or incentives for incineration encourages local governments to destroy these materials, rather than investing in environmentally sound and energy conserving practices such as recycling and composting"* (GAIA, 2012). Laura Haight from the New York Public Interest Research Group (NYPIRG) *"points out that more energy is saved by reusing materials instead of destroying them. Also, rather than being burned, biomass could be composted and used for energy recovery, she said." Furthermore, "waste-to-energy facilities continue to emit most air pollutants at emission rates that are greater than coal-fired power plants on a per megawatt-hour (MWh) basis."* (Pyper, 2011). Specifically, *"In 2009, New York incinerators emitted a total of 36% more mercury than its coal plants"* (GAIA, 2012). However, more modern incinerators have various filters to curtail the emission of pollutants, nonetheless, lethal ultra-fine particulates are still emitted which can cause heart attacks, cancers, strokes and pulmonary disease etc. (GAIA, 2012). In addition to harmful pollutants incinerating waste also contributes to climate change by emitting more CO_2 than coal-fired power plants which emit on average (according to the US EPA) 1,020 kg of CO_2 per megawatt hour (2,249 lbs/MWh of carbon dioxide) whereas on average, incineration plants emit 1,355kg of CO_2 per megawatt hour (2,988 lbs/MWh of carbon dioxide) (EPA, 2014). Serious concerns indeed.

Conclusion

Clearly, there are issues for and against waste-to-energy power plants. Haight (Pyper, 2011) makes the point that the issue is not simply either incineration or landfill for waste but rather re-using and recycling makes better use of our resources together with using biomass waste to generate energy. The emissions from incineration also remain a serious issue and although the emissions may have been reduced, greater efficiency will achieve greater acceptance of waste-to-energy power plants.

The Global Alliance for Incinerator Alternatives (GAIA) web site against incineration presents their well referenced argument as follows: *"No new incinerators have been built in the U.S. after 1997, due to public opposition, identified health risks, high costs, and the increase of practices such as recycling and composting. In recent years, the incinerator industry has tried to expand their sector by marketing their facilities as "Waste to Energy" (WTE), using misleading claims"* (GAIA, 2012). Furthermore, if burning waste is seen as a solution there are concerns that it may defer the development of infrastructures for re-using artefacts, recycling materials and the creation of circular economies.

Incineration is final. Landfill with all its disadvantages offers the potential of resource recovery which incineration does not. *"Americans throw away 317 aluminium cans every second of every day. Around half of these, totalling 680,000 tonnes of aluminium each year, dodge the recycling and end up in landfill. Given that the cost of aluminium peaked at US$2700 per tonne in July [2008] this means America is burying up to US$1.83 billion worth of metal per year. Atkins estimates that there is now more aluminium in US landfills than can be produced from ores globally in one year. And it's not only aluminium that is lurking down there … One tonne of scrap from discarded PCs contains more gold than can be produced by 16 tonnes of ore" then incineration begs a serious question"* (Douglas, 2008). Although much of the metal is sorted out before waste is incinerated, this does question the finality of incineration for a variety of our resources. Furthermore, how long can we not recycle and re-use all of our waste? The incineration of our waste becomes an ethical issue, doesn't it, when an estimated 90% (Platt, Ciplet, Bailey, & Lombardi, 2008) could be recycled?

8.6.8 Energy harvesting

The concept of using human energy to power devices was Trevor Baylis's idea, who, about fifteen years ago, developed the wind up radio (McKie, 2008). Today there are a variety of innovations for harvesting kinetic energy. This can be captured from low level vibrations, for example, from human movements so that magneto-elastic materials can produce a magnetic field which when deformed and connected to a transducer can generate an electrical current (Mullins, J., 2008). The power can be used for small electrical devices ranging from heart pacemakers to mobile digital equipment. *"Technologies that harvest energy from movement could see your every move charge a mobile device, or even a building. Such people power could provide an alternative to mains charging of electronic gadgets, reducing energy consumption and greenhouse gas emissions"* (Knight, 2010).

Rome (2005) and his colleagues have developed a backpack generator which converts the mechanical energy from the vertical movement of the load into electricity while walking. The design produced 7.4 watts of power during normal walking. *"This electricity generation can help give field scientists, explorers, and disaster-relief workers freedom from the heavy weight of replacement batteries and thereby extend their ability to operate in remote areas"* (Rome, et al, 2005).

An architectural firm, *Facility:Innovate*, is developing energy harvesting from crowd movement, for example, in shopping areas, stations, airports, sports stadia, discos and locations where people are funneled through entrances or along corridors. Electricity is generated by pneumatic devices under tiles which when walked upon and slightly depressed drives air through a turbine which generates electricity. Pedestrians only notice a slight movement as if they had walked onto a mat. The company estimates that about 1 kilowatt-hour of energy could be generated daily from each device (Knight, 2010). Another company, *Pavegen systems* (see Sources), has developed a tile system harvesting energy from pedestrians. At the Paris marathon they laid out 1500 square feet (140 m2) of tiles several hundred meters from the finishing line and the contestants running over the tiles generated 4.7 kilowatt-hours of energy which was enough to recharge 2000 cell-phones or power 50 LED street lamps (Knight, 2010).

Instead of using special floor tiles, one scientist, Zhong Lin Wang from the Georgia Institute of Technology in Atlanta wants to use piezoelectric nanowire generators which can be inserted as pads into footware (Knight, 2010) and which when pressed, generate a current. The idea of energy harvesters in boots is an idea which military researchers in both the UK and USA are also investigating (McKie, 2008).

An Israeli company called Innowattech Energy Harvesting Systems (see Sources) has developed and patented piezoelectric (PE) generators which can be installed beneath roads when they are being built or resurfaced. Other PE generators can be located into the sleepers of railway tracks. *"The company estimates that such devices under a half-mile of a busy highway could generate enough electricity to power 250 homes"* (Rouse, 2012).

Benefits

Our lives are unimaginable without movement and energy and piezoelectric technology enables us to harvest energy from the interaction between two surfaces as movement occurs. Consequently, there is ample opportunity for energy harvesting especially when one reflects on how much movement occurs from the passage of pedestrians through city thoroughfares to the movement of traffic on roads, railways and aircraft landing on runways around the world.

Conclusion

It must seriously be questioned why it is with such innovations capable of exploiting the ubiquitous occurrence of movement that these technologies do not receive greater government support and make faster progress. It is an unfortunate political fact that subsidies go not to the most deserving but to those with powerful and established lobbies (… fossil fuel industries).

8.6.9 Human Waste

> *"There are currently over 50,000 wastewater treatment works (WWTPs) operating in the European Union yielding a total of about*

7.9 million tonnes of dry solids (tds) in year 2000" (Hall, 1999).

Just as the greatest resource on the planet is human creativity another human resource, excreta is probably the greatest available resource of which we make the least use. Unfortunately, our instinctive disgust and prudishness has deterred us from fully developing and exploiting this enormous and valuable resource. Through the course of evolution we have evolved an avoidance behaviour of human excrement due to the danger of pathogens and disease (Curtis, de Barra & Aunger, 2011). Consequently, we have developed sewage treatments which sterilize our excreta so that it can somehow, somewhere be got rid of 'safely,' for example in the oceans. In so doing we have broken one of nature's cycles by removing it and making it unusable when it could be used to provide fertilizer and energy. We compound the problem by using large quantities of energy and water to process and sterilize the sewage for its safe disposal. Water, sewage and energy, instead of being managed within an integrated system are instead fragmented into specialized and separate corporate utilities. A sustainable approach demands an integrated systemic strategy for the management of human excrement.

"There is also a major flaw in the sewage treatment systems of developed countries where enormous amounts of energy are used to aerate and treat sewage; Anaerobic Digestion treats sewage and also produces energy rather than consumes it" (Appropedia, 2013). Human waste produces less biogas than can be produced from livestock manure and other feedstocks due to the efficiency of our digestive system and so 1000 lbs (453 kgs) of human waste produces only about 0.6 m^3 biogas (House, 2006) which is enough for the cooking needs of up to 2 people. However, this comparatively low energy output needs to be placed against saving the energy and water required to sterilize raw sewage. Furthermore, David House (2006) in the revised edition of his *The Biogas Handbook* originally published in1978, provides "*a compendium of the art and science of using anything once alive to produce gas for powering light, automobiles, ovens, tractors, water heaters, furnaces and various contraptions.*" A serious question is: why is the drive so strong for shale gas and its enormous investment and environmental costs when, were the investment to be made, every sewage works could be generating energy and fertilizer from human faeces? The suspicion emerges that the energy industries want it that way more for their own benefit rather than for any concern for the environment and ultimately the consumer.

Benefits

The great benefit of human waste is that it is free and the supply is regular. So what are the possibilities of human urine and excrement for energy (and the recycling of other components)? Of course there is fertilizer (containing trace elements) as pellets, biochar briquettes (which is a porous charcoal made from organic waste) and phosphorus seeds too, but also biogas production, and hydrogen gas production. The fertilizer promotes the development of humus in the soil and supports the development of the soils biota, microbes etc. which further add to its fertility (Reed and Shaw, 2007). Human waste could be used as a fertilizer for biomass feedstocks for energy production. Meanwhile, biochar has enormous potential for soil enrichment, especially for degraded soils in Africa where it has been found to increase yields by 32%. Biochar can also affect the movement of water through soil helping to drain clay soils while retaining moisture in sandy soils. Biochar also has enormous potential for the removal of pollutants in a variety of situations (Cernansky, 2015).

Singapore has a limited supply of water and so saving the use of water for sanitation is important. Scientists at Nanyang Technological University (NTU), have developed a toilet (the No-Mix Vacuum Toilet) which uses about 10% of the water previously required for flushing. In addition the aim is to convert all the waste to resources. The separated liquid waste, urine, is processed so as to recover nitrogen, phosphorus and potassium for fertilizers. The solid waste goes to a bio-reactor to produce bio-gas containing methane which can be converted into electricity. Finally, the waste from the bio-reactor is mixed with soil to create compost (Nanyang Technological University, 2012). The extraction of nitrogen, phosphorus and potassium is important because *"The analysis of different removal and recovery techniques for nutrients in urine shows that in many cases recovery is energetically more efficient than removal and new-production from natural resources"* (Maurer et al, 2003). Although we are primarily concerned with energy we should not forget that fertilizers are important for growing biomass. Phosphorus is a key component of life and fertilizers. *"Humans excrete*

3.3 million tons of phosphorus annually" and although the *"phosphorus in human waste is only about 10 per cent" of mined phosphate rock"* (Tweed, 2009) *"mineable resources of this essential nutrient are limited"* (Elser & Bennett, 2011) with 'peak phosphorus' production forecast for about 2030. Already one waste water treatment firm, Ostara, in Oregon, USA, is producing a slow-release fertilizer pellet called *Crystal Green* containing phosphorus from sewage (Tweed, 2009). The pellets resemble small rice grains.

Another toilet was developed at Caltech by Prof Hoffman which *"uses solar power to break human waste into hydrogen gas and leftover solids. Hoffman and his team at Caltech showed how the toilet could store hydrogen in fuel cells as an energy source. The toilet treats waste on the spot and syphons off hydrogen for later use as energy"* (Gooder, 2012).

Meanwhile, at the University of Colorado another team of researchers and students have developed a solar-biochar toilet planned for developing countries. The toilet creates biochar briquettes made from biochar and in addition, the toilet also produces re-usable but not potable water. The toilet waste is heated and decomposed by concentrated sunlight transmitted through fiber-optic cables and turned into biochar for improving agricultural soils. The interdisciplinary team was composed of environmental engineers, a biological-chemical engineer, a solar-thermal designer and an expert in sanitation and hygiene for developing countries. The team was awarded a grant of nearly $780,000 from the Gates Foundation (Linden, 2012). *"A preliminary analysis indicates that a household-sized system for a family of four could be developed at a cost of 5 to 10 cents per person per day. An intermediate-scale system for community facilities also will be evaluated as part of the grant."*

The UK company, United Utilities, is generating biogas from one of its waste water sewage plants which provides 15% of its own energy requirement. In addition, the company has also developed another technology which transforms human excreta into dry odourless pellets for application as an agricultural fertilizer which is being tested and provided free to some farmers in the UK (BBC, 2009).

Finally, Bill Gates made publicity by supporting the development of a technology which produces energy and drinking water from human faeces. *"The Omniprocessor, which has been developed by Janicki Bioenery, a small family-run company north of Seattle, is a compact waste treatment plant that can process sewage for a community of about 100,000 people. Unlike modern sewage plants, which squander huge amounts of electricity treating waste, the technology combines incineration, steam power and filtration technologies to ensure no energy is wasted in the process.*
Its star turn is to generate 11,000 liters of high-grade drinking water a day – and that is just the start. The processor derives enough energy from the faecal matter it incinerates to run the unit, with 150kw a day spare to export to the grid. It also produces ash, which can be commercially valuable as a soil amendment" (Slavin, 2015).

Handicaps and externalities

It is incomprehensible why politicians are so keen on fracking for methane when everyday we produce a resource that could provide quantities of biogas, fertilizer and energy. However, perhaps design has a role to perform by producing information for communication to the public, policy makers and other stakeholders about less environmentally damaging technologies for producing biogas which already exist and are known to work. Fracking is not without its dangers especially human error.

"The treatment and disposal of sewage sludge is an expensive and environmentally sensitive problem ... The challenge facing sludge managers is to find cost-effective and innovative solutions whilst responding to environmental, regulatory and public pressures. Recycling and use of wastes are the preferred options for sustainable development, rather than incineration or land-filling, but with sewage sludge this is not straight forward because of perceptions over contaminants, pathogens and its faecal origin, particularly by the food retailers ... There are currently over 50,000 wastewater treatment works (WWTPs) operating in the European Union yielding a total of about 7.9 million tonnes of dry solids (tds) in year 2000... reaching at least 8.3million tds/y by 2006" (Hall, 1999). What a fantastic resource! But what if these wastewater treatment works were all equipped with anaerobic digesters for methane and fertilizer production?

We must reconnect ourselves back into natures cycles.

8.7 Saving energy and Energy efficiency

The term *'saving energy'* is sometimes used interchangeably with *'energy efficiency'*. However, they are different and so lets be clear. *'Energy efficiency'* means achieving the same result with less energy, this is simply demonstrated by the compact flourescent (CFL) bulb which uses about 5 times less energy than the incandescent bulb while producing the same level of illumination. The 'new' 11watt CFL bulb produces the same level of lighting as the 'old' 60watt incandescent bulb; a strategy we should all adopt (Vaughan, 2009). 'Saving energy' or 'energy conservation' simply involves strategies such as turning off lights in vacant rooms or other behavioural adaptations such as not leaving equipment on 'standby.' 'Standby' is a classic example of a small action repeated millions of times that has a big impact. It has been calculated that in Germany the electricity for standby equipment uses the energy produced by two nuclear power plants (Wagner, 2008).

At the national level the European Union has set the target to improve its energy efficiency by 30% by 2030. The EU commissioner for energy, Günther Oettinger, said: *"Our aim is to give the right signal to the market and encourage further investments in energy-saving technologies to the benefit of businesses, consumers and the environment."* Furthermore, *"the goal would result in cost savings for consumers, as infrastructure and appliances from buildings to fridges would all have to be made more efficient to comply with the new rules."* However, *"Energy efficiency experts and green campaigners were critical of the new efficiency target,… which some said was inadequate to the challenge of tackling climate change and saving on imports.*

Monica Frassoni, president of the European Alliance to Save Energy, said: "The European commission appears to have lost credibility. Its supposedly leading role aiming to build a low carbon economy around an energy efficiency target, shows an obvious lack of ambition in the final proposal. The proposal is clearly not based on a real scientific assessment and a serious cost-benefit analysis, otherwise a target between 35% and 40% would have been proposed"" (Harvey, b. 2014).

Meanwhile, in the UK, the government's energy saving policy, the Green Deal, has failed because of inadequate support for householder's and the high cost of repaying loans for insulation. Consequently, there has been a drop of more than two thirds for applications for financial support because of government changes to the regulations no longer encourage, as it did before, the insulation of domestic properties (Harvey, a. 2014). A report stated that more than 600,000 cavity walls were insulated in 2012 but only 170,000 cavity walls were insulated in 2013.

Politicians, as illustrated by those in the UK, have shown themselves to be frequently ineffective and/or duplicitous in regard to reducing greenhouse gas emissions. The UK government has severely cut subsidies for renewable energies (Harvey, 2011); meanwhile worldwide *"According to the International Energy Agency (IEA), in 2012 global fossil fuel subsidies totalled $544bn (£323bn; 392bn euros), while those for renewables amounted to $101bn. The International Monetary Fund (IMF) puts the total for hydrocarbons nearer $2 trillion"* (Anderson, 2014).

Consequently, it is imperative that we all become Earth Stewards. If we can save energy then we will reduce the emissions of greenhouse gases. How can we save energy? If we consider for a moment that energy plays an unconsciously prevalent role in our lives, certainly for those living in the so-called economically developed nations. There are numerous ways to save energy and they fall within three main headings: behavioural measures, organizational measures, and investments (Wagner, 2008):

› Behavioural measures can include energy saving driving habits to measures saving heat in our homes. For example, wearing an extra pullover in winter and lowering the heating by 1°C can save about 5% energy costs.
› Organizational measures might include the reduction of energy by ensuring that rooms are only lit so long as they are occupied. Transportation might shift freight from road to rail when the goods are not urgently required etc.
› Investments include the purchase of more efficient and economical plant rather than waiting for old plant to wear out before necessitating replacement.

According to Professor Wagner (2008) behavioural and organizational measures have the possibility for making savings of up to 10% without and any loss to the standard of living.

Energy savings can be made in many indirect behaviours because the expenditure of energy is a virtual cost in so many products, activities and choices that we make in a consumer society. Energy savings can easily be made by:

- drinking tapwater (and perhaps filtering it) rather than buying water in plastic bottles. (The global bottled water consumption in1997 was 80,649,000 cubic meters and rose to 154,381,000 cubic meters by 2004. *"The worst culprit was Europe at 53,661 thousand cubic meters in 2004 – a surprising figure when you consider it also has some of the world's most reliable and clean supplies of tap water."* (in 1997 Europe consumed 34,328 thousand cubic meters) (Brown, 2009). The manufacture of plastic bottles from crude oil and the transport of bottled water has an enormous ecological footprint. (Plastic is also a toxic hazard.)
- 30-50% of the global food production is wasted. (Institute of Mechanical Engineers, 2013)
- hang washing up to dry rather than using a tumble-dryer. *"An average drying-machine cycle uses just over 4kWh of energy and produces around 1.8kg CO_2."* In the UK it is thought that about 60% of households have a tumble dryer which equates to about 14 million households (Fry, 2008)
- etc.

At the municipal level energy can be saved in diverse ways, here are just two examples:
Lighting accounts for about 6% of global greenhouse gas emissions. *"Los Angeles spent around $15 million and pumped out 111,000 tonnes of carbon to light up its streets … councils want to find ways of making lighting smarter and more efficient."* Energy for street lighting can be saved by using smart lights which have sensors to switch the street lights on when pedestrians are detected and off after they have gone (Rutkin, 2014). Copenhagen has established the Danish Outdoor Lighting Lab (DOLL) to investigate sustainable street lighting because *"the city hopes to install smart lights as part of a quest to become carbon-neutral by 2025."* In addition each street light can be powered by a combination of solar and wind energy. Furthermore, lamp posts for street lighting can carry micro-turbines as well as solar panels, a practice employed in the city of Hebei, China.

Large cities have their own micro-climate and are frequently a 1°C warmer than the surrounding region on which they also have a significant influence. *"A study, published in the journal Nature Climate Change, found that the heat thrown off by major metropolitan areas on the US east coast caused winter warming across North America.*
Winter warming was detected as far away as the Canadian Prairies. In some remote areas, temperature rose by as much as 1°C under the influence of big cities, which produced changes in the jet stream and other atmospheric systems, the study found.
Researchers found a similar pattern in Asia …" (The Guardian Weekly, 2013).

Throughout many cities of the world during the summer months air conditioners are on to keep offices and homes cool. However, air conditioners create a positive feedback, since attached in ranks to the exteriors of office blocks and housing they add their own warmth to the city's climate. It has been found that by growing an envelope of plants on rooftops and walls has the effect of substantially reducing local temperatures by as much as 11°C depending on the city. Alexandri and Jones (2006) at the Welsh School of Architecture, University of Cardiff, Wales, used computer modeling to investigate the effect of plant covered roofs and walls. *"Green surfaces lower local temperatures in two ways. Firstly, the green surfaces absorb less heat than typical building coverings and so radiate less heat back into the immediate vicinity. Secondly, plants cool the air through the evaporation of water as they transpire"* (Upfront, 2007). Alexandri and Jones found that the air would be cooler around every building when its walls and roofs were covered with vegetation. The computer model revealed that if buildings in Riyadh, Saudi Arabia, were covered in vegetation it could lower the average temperature between the buildings in the urban canyons by about 9°C and top temperatures by as much as 11°C, while in London and Montreal temperatures could be lowered by 4°C (Alexandri, & Jones, 2008).

8.8 Conclusion: Mother Earth is not open to negotiation

The example of the sterilization and treatment of human sewage which requires large quantities of both energy and water does not appear to make much sense for a sustainable future with more people and more needs and finite resources. Instead, human sewage can be used for energy production, despite not being an optimal biogas producer it would save the water and energy consumption required for the alternative sterilization in sewage treatment. Furthermore, there are many areas around the world where agricultural land has been degraded and the export of biochar briquettes could be a way of sequestering carbon and enriching the world's degraded soils and helping to raise the productivity of agriculture. So by treating human sewage in anaerobic digestors we are potentially able to:

1. save the water used for sterilization of human sewage.
2. save the energy used for sterilization of human sewage.
3. create biogas for energy from human sewage.
4. create biochar briquettes from human sewage.
5. enrich agricultural soil with biochar briquettes.
6. produce slow release phosphorus fertilizer pellets from human sewage.
7. sequester carbon from human sewage for enriching the soil.

This suite of benefits is a win-win-win saving and producing a range of benefits for achieving a sustainable future. It simply does not compare to the wasteful sterilization and preparation of human excrement for its disposal out at sea or elsewhere! However, it does require a a change to a systemic holistic approach and simultaneously freeing ourselves from "… because that's the way its always been done."

Evolution optimizes the pressures on an organism to enable it to adapt to its environment. Human excreta is a problem which illustrates how our wims and prejudices cause us to act unsustainably, breaking natures cycles and wasting the resources of water and energy. We need to change our behaviour in fundamental ways to reach a sustainable future.

We need to think far more creatively and connectedly, so that by identifying connections we can sustainably solve problems en suite rather than solving a problem as if it existed in isolation causing other problems elsewhere. We have to think way beyond the design box. Unfortunately, thinking in terms of maximum profits seldom promotes sustainability. Indeed, as we know through the work of Trucost, the large corporate profits are only possible because Nature has paid the price with its destruction and pollution. How can we move from profit to sustainability?

Copenhagen's DOLL hopes in the future *"to incorporate other types of smart city services into their living lab. The same network that monitors miles of lighting can be configured to manage parking spaces or water meters. "People don't want to solve one issue and then having to do a major investment again to solve the next issue and the next and the next," says John Baekelmans of Cisco, a project partner. "There is a variety of technologies which you need to tie together in a way to make it a seamless experience"* (Rutkin, 2014).

Baekelmans' point is a *"game changer"* and confirms that we can no longer look at solving individual problems in isolation. The EU legislation to replace 10% of transport fuels with first generation feedstock was a disaster causing hunger and poverty to millions. Energy has to be seen at least as a "trilemma" in which food and the environment are the other two factors (Tilman, et al 2009). However, water is a key resource on which the environment and ecosystems, food and energy are also intimately dependent. The situation is better described as a *"quadrilemma"*.

8.8.1 Third Industrial Revolution, (Rifkin, 2011)

Rifkin's energy thesis is of great significance because he proposes that the *"five pillars of the Third Industrial Revolution will create thousands of businesses and millions of jobs, and usher in a fundamental reordering of human relationships, from hierarchical to lateral power, that will impact the way we conduct business, govern society, educate our children, and engage in civic life. The five pillars of the Third Industrial Revolution are:*

1. *shifting to renewable energy;*
2. *transforming the building stock of every continent into green micro-power plants to collect renewable energies on-site;*
3. *deploying hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies;*
4. *using Internet technology to transform the power grid of every continent into an energy internet that acts just like the Internet (when millions of buildings are generating a small amount of renewable energy locally, on-site, they can sell surplus green electricity back to the grid and share it with their continental neighbors); and*
5. *transitioning the transport fleet to electric plug-in and fuel cell vehicles that can buy and*

sell green electricity on a smart, continental, interactive power grid.

The creation of a renewable energy regime, loaded by buildings, partially stored in the form of hydrogen, distributed via a green electricity Internet, and connected to plug-in, zero-emission transport, opens the door to a Third Industrial Revolution. The entire system is interactive, integrated, and seamless. When these five pillars come together, they make up an indivisible technological platform – an emergent system whose properties and functions are qualitatively different from the sum of its parts. In other words, the synergies between the pillars create a new economic paradigm that can transform the world" (Rifkin, 2014). Kilowatts could become its own currency since every household, having its own generating capacity could trade and exchange energy. The electric car becomes a kilowatt account holder (a sort of mobile credit card) or with its battery charged from the home generators (solar/ wind/ biogas) can provide energy to the central grid building up kilowatt credit.

Rifkin's *Third Industrial Revolution* (TIR) embraces much more than the issue of sustainable energy. The TIR "*will connect everyone and everything in a seamless network.*" Furthermore, the democratization of manufacturing through 3-D printing will enable everyone, he proposes, to be their own manufacturer. As a consequence transport costs will drop since products will be produced locally. Resource costs will also drop to 10% of the costs of the raw materials normally required for traditional manufacturing.

Rifkin's TIR sounds wonderful. However, converting the building stock into "*green micro-power plants to collect renewable energies on-site … deploying hydrogen and other storage technologies in every building … to store intermittent energies*" seems to be over-focused on energy. As Cisco's Baekelmans pointed out "*a variety of technologies*" need to be tied together because while Rifkin is focusing on a global strategy for energy it needs to apply not just to all utilities. Furthermore, the utilities are an integrated system so that power is generated by organic-waste, wind and sun; water is collected from the roof and recycled, etc. etc. The idea of a truly sustainable home becomes very exciting.

8.8.2 Soft Energy Paths and Reinventing Fire, (Amory Lovins, 1977 & 2013)

Way ahead of his time Amory Lovins (1977) first wrote about energy efficiency in his book "*Soft Energy Paths – towards a durable peace*" when he proposed the transition towards what he then called 'soft technologies' for providing energy. The tradition is for nations to follow the 'hard strategy' of building centrally coordinated, large installations such as nuclear power stations, hydro-electric dams, coal powered generating stations with enormous overheads such as transmission lines and transformers and the whole supporting infrastructure and administration. However, these installations are enormously expensive and inefficient because, as it were, one size is used to fit all requirements for energy. Lovins (1977) writes "*Plainly we are using premium fuels and electricity for many tasks for which their high energy quality is superfluous, wasteful, and expensive, and a hard path would make this inelegant practice even more common. Where we want only to create temperature differences of tens of degrees, we should meet the need with sources whose potential is tens or hundreds of degrees, not with a flame temperature of thousands or a nuclear reaction temperature equivalent to trillions – like cutting butter with a chainsaw.*" (A similar problem exists with water provision where we use drinking quality water for flushing lavatories and watering the garden!) Lovins defines 'soft' strategies by five characteristics:

1. "*They rely on renewable energy flows that are always there whether we use them or not, such as sun and wind and vegetation …*
2. *They are diverse, so that as a national treasury runs on many small tax contributions, so national energy supply is an aggregate of very many individually modest contributions, each designed for maximum effectiveness in particular circumstances.*
3. *They are flexible and relatively low technology – which does not mean unsophisticated, but rather, easy to understand and use without esoteric skills, accessible rather than arcane.*
4. *They are matched in scale and in geographical distribution to end-use needs, taking advantage of the free distribution of most natural energy flows.*
5. *They are matched in energy quality to end-use needs, a key feature …*" because "*People do not want electricity or oil nor such economic abstractions as "residential services," but rather comfortable homes, light, vehicular motion, food, tables and other real things …*" After doing the calculations Lovins points out that the

enormous infrastructure of centralized "hard" path energy means that 29% of a householder's electricity bill is for the product – electricity. The other 71% is for:

- "*19% to transmission equipment,*
- *24% to distribution equipment,*
- *21% to operation and maintenance of all that equipment (including metering ... and billing),*
- *about 6% to profit and arithmetic discrepancies in the analysis.*"

In his most recent publication, *Reinventing Fire* (2013) he describes a range of integrated strategies for moving towards sustainable energy which will enable:

- the closure of all 580 US coal plants
- use 0 energy from coal, oil or nuclear sources
- reduce greenhouse gas emissions by 82-86%
- saving the $160 billions of economic losses due to blackouts
- etc.

8.8.3 The unarguable Logic

1. **Foresight:** In 1978 a paper was published in the journal Nature, by J.H. Mercer and entitled "*West Antarctic ice sheet and CO_2 greenhouse effect: a threat of disaster.*" The paper's abstract said that "*If the global consumption of fossil fuels continues to grow at its present rate, atmospheric CO_2 content will double in about 50 years. Climatic models suggest that the resultant greenhouse-warming effect will be greatly magnified in high latitudes. The computed temperature rise at lat 80° S could start rapid deglaciation of West Antarctica, leading to a 5 m rise in sea level.*"
2. **Coal, natural gas, and oil, the holy trinity of g.h.g. emitters:** "*Coal, natural gas, and oil accounted for 87 percent of global primary energy consumption in 2012, as the growth of worldwide energy use continued to slow due to the economic downturn, according to a new Vital Signs Online trend*" (Gonzalez, & Lucky, 2013). However, governments (i.e. Australia, Canada, France, Germany, Japan, Italy, Poland, Russia, Spain, United Kingdom and the United States and the G20) are duplicitous in their concerns to cut emissions and reduce the use of fossil fuels because "*For every $1 spent to support renewable energy, another $6 are spent on fossil fuel subsidies (IEA, b. 2013).*" **(Whitley, 2013).**
3. **400ppm CO_2:** "*At the current time (13 July, 2014) the value recorded is 398.79ppm and during 2015 our atmosphere will undoubtedly reach 400ppm. After that the climb will continue at 2ppm per year as it has done for the last couple of decades (Brahic, 2013).*" (cited above)
4. **West Antarctic Ice Sheet past tipping point:** "*Global warming: it's a point of no return in West Antarctica. What happens next?*" so ran the Observer newspaper's headline on 17 May 2014, (36 years after J.H. Mercer's paper describing his concerns about the effect of the doubling of CO_2 emissions) followed by Eric Rignot's (a NASA glaciologist) account of the NASA Conference where the results of his team's researches were presented. *"Last week saw a 'holy shit' moment in climate change science. A landmark report revealed that the collapse of a large part of Antarctica is now unstoppable ..."* and *"What's more, its disappearance will likely trigger the collapse of the rest of the West Antarctic ice sheet, which comes with a sea level rise of between three and five meters. Such an event will displace millions of people worldwide"* (Eric Rignot, 2014). The research was confirmed in a second paper by another team from Washington University. "*... both studies came to broadly similar conclusions – that the thinning and melting of the Antarctic ice sheet has begun and cannot be halted, even with drastic action to cut the greenhouse gas emissions that cause climate change*" (Goldenberg, a. 2014). Greenhouse warming and ozone depletion can intensify the westerly winds in the southern hemisphere which play a key role in transporting (comparatively warm) water into the cavity underneath the West Antarctic ice sheet and its extension, the ice shelf, and between the sea floor (Schmidtko, et al, 2014).
5. **Methane hydrates destabilizing:** Clearly, we must limit, better still stop, greenhouse gas emissions immediately. The warming hiatus, when during the first decade of the new millenium scientists were confused that there appeared to be no global warming despite climbing emissions, has now been explained.

"In the 21st century, surface warming slowed as more heat moved into deeper oceans. In situ and reanalyzed data are used to trace the pathways of ocean heat uptake. In addition to the shallow La Niña – like patterns in the Pacific that were the previous focus, we found that the slowdown is mainly caused by heat transported to deeper layers in the Atlantic and the Southern oceans, initiated by a recurrent salinity anomaly in the subpolar North Atlantic" (Chen & Tung, 2014). The enormously serious consequences of ocean warming has been confirmed by Phrampus and Hornbach (2012) who *"show that recent changes in intermediate-depth ocean temperature associated with the Gulf Stream are rapidly destabilizing methane hydrate along a broad swathe of the North American margin. The area of active hydrate destabilization covers at least 10,000 square kilometers of the United States eastern margin, and occurs in a region prone to kilometer-scale slope failures … This destabilization extends along hundreds of kilometers of the margin and may continue for centuries. It is unlikely that the western North Atlantic margin is the only area experiencing changing ocean currents; our estimate of 2.5 gigatonnes of destabilizing methane hydrate may therefore represent only a fraction of the methane hydrate currently destabilizing globally. The transport from ocean to atmosphere of any methane released – and thus its impact on climate – remains uncertain."* As noted above, if gigatonnes of methane were to enter the atmosphere from melting methane hydrates as happened 55 million years ago during the Palaeocene – Eocene thermal maximum (PETM) it will bring about similar changes that occurred then. These included rapid and serious acidification (Zachos, et al. 2005) of the seas and a positive feedback of global warming since methane has a global warming potential of a 105 times that of CO_2 (Shindell, et al. 2009) and a temperature rise of about 5-6°C (Zachos, et al. 2003; Higgins & Schrag, 2006). That would make civilization untenable.

6. **Delay increases costs:** Clearly, all additional greenhouse gas emissions will now make future life on the Earth more difficult for those who follow us. *"The White House released a new report, "The Cost of Delaying Action to Stem Climate Change," which finds that for each decade of delay, the costs of climate change mitigation will go up by 40 percent. The report was conducted by the White House Council of Economic Advisers. The Council reviewed 16 separate studies on various methods of climate change mitigation and sought outside advice to come to its conclusions"* (AAAS Policy Alert, 2014).

We cannot trust that human innovation will deliver a technology to remove CO_2 emissions from the atmosphere. Although, a recent lead may be a reason for cautious optimism. *"By hydrogenating CO_2, scientists can transform a greenhouse gas into methanol, a desirable fuel."* (Szuromi, 2014) Could Graciani et al's (2014) research using a copper-ceria interface lead to a breakthrough so that CO_2 becomes a resource rather than a pollutant? (Graciani et al, 2014). Time will tell but we have not a minute to loose. We are in a race to reduce emissions, in which renewables have a crucial role to play, before we trigger a tipping point causing the methane hydrates to release the methane they hold frozen in the ocean beds.

In the meantime, there is only one ethical act, we should already have stopped using all fossil fuels and work towards the complete adoption of renewables as fast as we can to stop further CO_2 emissions. The 6 points just listed confirm that the fossil fuels do not provide a bridge to reaching 100% renewable energy generation due to the emissions that each of the fossil fuels create. Furthermore, governments and corporate energy providers want to use fossil fuels because of their vested interests in these industries although their assets should be stranded if we are to remain below 2°C. However, even 2°C may be academic due to points 3, 4 and 5 summarized above. Nuclear energy has been made into a monster due to the localized problem of storing spent fuel for thousands of years, however, the problem of continuing greenhouse gas emissions will bring about an increase beyond 2°C which will significantly change the entire planet for all life forms and us.

It remains for us all to reduce fossil fuel energy consumption as much as possible and convert to renewable energy as soon as we can. In this design has a key role to play in many dimensions from communication and contributing to public awareness to the design of facilities for the lateralization of energy generation (Rifkin, 2011).

8.8.4 The Double Energy Transition

Many will have heard of the German term *"Energiewende"* which means 'energy transition' from the generation of energy from fossil fuels, to renewable energy sources such as wind, solar, geo-thermal and hydro-electric generation. We might also reconsider nuclear energy since *"Independent studies have assessed nuclear energy's life-cycle emissions and found them to be comparable to wind, solar, geo-thermal and hydro-electric generation"* (NEI, 2014). However, because of the fear of nuclear tragedy such as occurred at Fukushima and Chernobyl there is major opposition to nuclear energy. The dangers of either a natural disaster, human accident or sabotage are compounded by our incomplete ability to control the consequences. Furthermore, there is the problem of the safe deposition of the spent radioactive fuel for thousands of years and the concern and danger of burdening future generations with the care of spent radioactive fuel. However, if there is concern for future generations about spent radioactive fuel then the climate that future generations will inherit from our use of fossil fuels must also be a cause for similar concern. Afterall, the impact of fossil fuels will be global climate change whilst that of radioactive waste will be a comparatively local problem. Should the use of nuclear power as a bridge to 100% renewables be reconsidered in the light of the continued use of fossil fuels and their continuing contribution to global warming?

Our conclusion refers to a 'double energy transition.' What is the second transition? The second transition is the decentralization of energy generation. This is because our society's demand for energy is increasing and this is an enormous problem because …

1. *"The more energy a society uses, the more interdependent it tends to become, both within itself and in relation to other societies.*
2. *The more interdependent a society becomes, the more complex it becomes, and the more man-designed and man-controlled its economic, ecologic, and political systems and sub-systems become.*
3. *The more complex and interdependent the systems and subsystems, the more vulnerable they become to design failures …"* (Miles, 1976) (for the completion of this quote from Miles see Politics in the Glossary). This is nicely illustrated for us by the famous northeast power blackout that occurred in the United States on August 14, 2003. It began with a power line brushing against some overgrown trees and the failure of the alarm system. The outcome was a cascade of power failures (Minkel, 2008).

Therefore the strategies proposed by Amory Lovins (1977) using 'soft energy paths' to replace 'hard' energy paths of centralized infrastructures like coal fired and nuclear power stations. Lovins writes that the distinction between the two paths depends *"not on how much energy is used, but on the technical and sociopolitical structure of the energy system … the social structure is significantly shaped by the rapid deployment of soft technologies"* which depend on renewable energy as cited above. This is the Third Industrial Revolution which Jeremy Rifkin (2011) describes in which the building stock generates its own power and houses are equipped with micro-turbines, solar panels etc. The system is networked and so able to move energy to areas with a deficit but it is primarily self-sufficient.

A double energy transition is now essential. It is a transition in which firstly, as is well known, power generation is based on renewables and not on fossil fuels. Secondly, power generation should be decentralized, with local installations throughout the building stock with a lateral rather than a hierarchical organisation (Rifkin, 2011). This transition will provide much for designers to do in bringing us closer to a sustainable future. Above all the seriousness of our dilemma must be communicated to all stake holders and policy makers as clearly and graphically as possible.

8.9 References and further reading

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Armin Reller & Joshena Dießenbacher

9 Are There Enough Resources for Our Lifestyle? How Resource Strategy Leads From Wasting Materials to Using Them

"The essential concept of sustainability was embodied in the worldviews and traditions of many indigenous peoples, for example; it was a precept of the Gayanashagowa, or Great Law of Peace (the constitution of the Haudenosaunee or Six Nations of the Iroquois Confederacy) that chiefs consider the impact of their decisions on the seventh generation to come." Richard Heinberg, (2007)

9.1 Introduction

One should think Francis Bacon would rejoice. Imagine the scientist and statesman sitting in a modern lecture hall somewhere in today's world. The floor heating giving off a cozy warmth, and only in the corner of his eyes, through the floor-to-ceiling windows, does the Englishman register the raging thunderstorm that is tearing at the trees and pouring torrents of water outside. At the lectern is the Dutch atmospheric scientist Paul Crutzen. Man, Crutzen says, has become the greatest natural force on Earth and is impacting the natural environment to a degree never seen before. He calls this phenomenon the "Anthropocene" (Crutzen 2002). Francis Bacon (1561-1626), one of the founding fathers of the modern natural sciences, a figure surrounded by legend in the history of science, would probably rejoice. Or would he?

For Bacon – born in an age in which humans unstintingly strove for the ability to defend themselves against a nature perceived as harsh and overpowering – the "end" of science and technology was to provide humans with *"the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible"* (Bacon 1997 [1626], qtd. in Stengel, 2013). Almost 400 years later, mankind can lay claim to this latter achievement. It has "effected" many things: the depletion of the ozone layer, global warming, air pollution and acid rain, and also the siltation of the once-mighty Aral Sea in Central Asia. These are the kind of incisive transformations which Crutzen, a Nobel Prize winner, alludes to in his intermittently acclaimed 2002 article, "The Geology of Mankind," (Crutzen, 2002) in which he coined the term Anthropocene. The human power to "effect all things": it has grown to the point where Francis Bacon might rethink his ambitions.

In this situation we would do well to become aware of our influence and make sensible use of our "power." After all, power and responsibility are inextricable linked to one another, and we have known this long before it became a stock phrase of political rhetoric. Still, the global consumerist society is not (yet) living up to its responsibility. It seems highly paradoxical: humans have striven to leave their "self-incurred immaturity" (Kant 1999 [1784]) behind ever since the Enlightenment, but now – for all their advances in technology and globalization, for all their progress, as it were – they have entered a new condition of immaturity. This immaturity concerns everyday life, the goods and products with which we surround ourselves, which we use and consume. We may call it "material immaturity" or "consumerist immaturity" and define it as the lack of awareness modern human beings, on average, have of the materials around them. This new immaturity is the consequence of the increasing (and self-accelerating) differentiation of modern societies. The new production and value chains have, *"over the last 20 years in particular, created highly ramified processes and complex logistics that make it difficult to identify the origins of materials, even for experts"* (Marschall, Meißner et al., 2013, p.195).

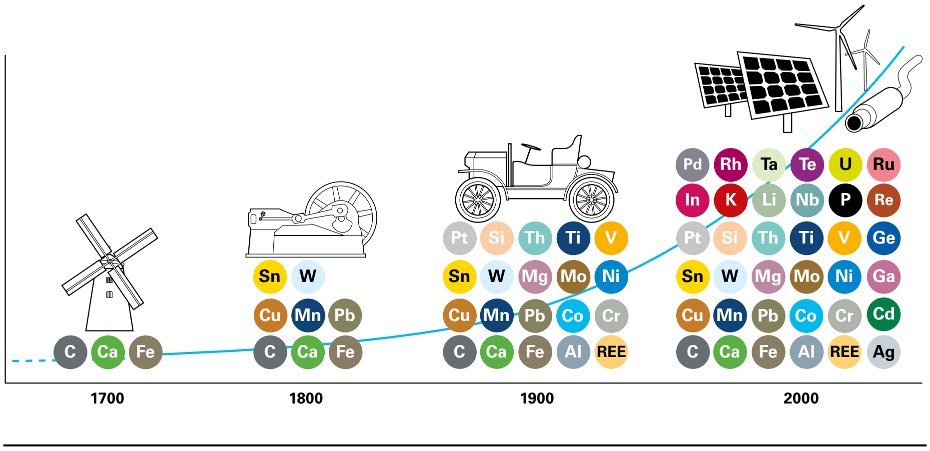

Figure 1: Increasing diversity of materials in applications. (Zepf/BP 2011)

9.2 Lifestyle, Consumption, and Resource Use: Why We Need Material Histories

In the twentieth century the global production of goods increased 40-fold, which has engendered a staggering dynamic[1]. A few clicks will get us a new pair of trousers, a stainless-steel coffee maker, or a 70-inch LED TV. With the breakthrough of online retailing around the year 2000[2] at the latest, limitless possibilities emerged for "shopping" and for the transnational exchange of goods. We can buy anytime and anywhere, from our personal computer, our tablet, or our smartphone – a procedure continually simplified by special "shopping apps." In Germany alone, the total revenue of online and mail-order retailing increased by 15.6 per cent to a total of 39.3 billion euros in 2012 (Der Handel, 2013). In competition with conventional retail, online shops continually attempt to become faster and thus more attractive to customers. U.S. online retailer Amazon recently applied for a patent on algorithms that can calculate order processes in advance and initiate them before the customer has placed his order. At the same time, the retail giant is considering the option of delivery by drone. Science fiction scenarios of flying objects of all sizes crisscrossing the sky are evoked and, all of a sudden, seem anything but fantastic.

One thing is clear: we are surrounded by a multitude of products and goods that embed us in global contexts whether we like it or not. In these contexts, the mobility and diversification of materials in the geo-, bio-, and technosphere have expanded to historic proportions (cf. Reller 2013). The number of elements in the periodic system that are used in manufacturing is increasing continually (figure 1).

Over the last few decades, these developments have multiplied not only the consumption of fossil and mineral resources but the overall consumption of nature by mankind. The 1980s are a landmark in this development: since that period, more materials are being taken from earth than the planet has the capacity to regenerate in the long term. Meadows et al (2009) estimated that in 1999, 1.2 planet Earths would have been required to regenerate all the resources being consumed at that time.

The global production of aluminium illustrates the increasing consumption of resources: it has grown by nearly 1,000 per cent between 1950 and 2000 (Meadows et al., 2009, p. 9). From the coca cola bottle, the coffee capsule, and the jeans button all the way to alloys used in automotive engineering, aluminium is required in all areas of technology and everyday life. According to United States Geological Survey data, the static

1 The underlying infrastructural system (railway, street, water, air) has developed into a powerful and expansive mega system to which the consumer only gives occasional attention, as in complaints about the many trucks on the streets. The growing economic significance of the courier, express, and parcel services (CEP) shows in the German job market as well. In 2012, almost 375,000 people were working for a courier, express, or parcel service (BIEK, 2012, p. 23, cited in Holst and Singe, 2013).

2 One milestone was the foundation of the online bookstore Amazon in 1994.

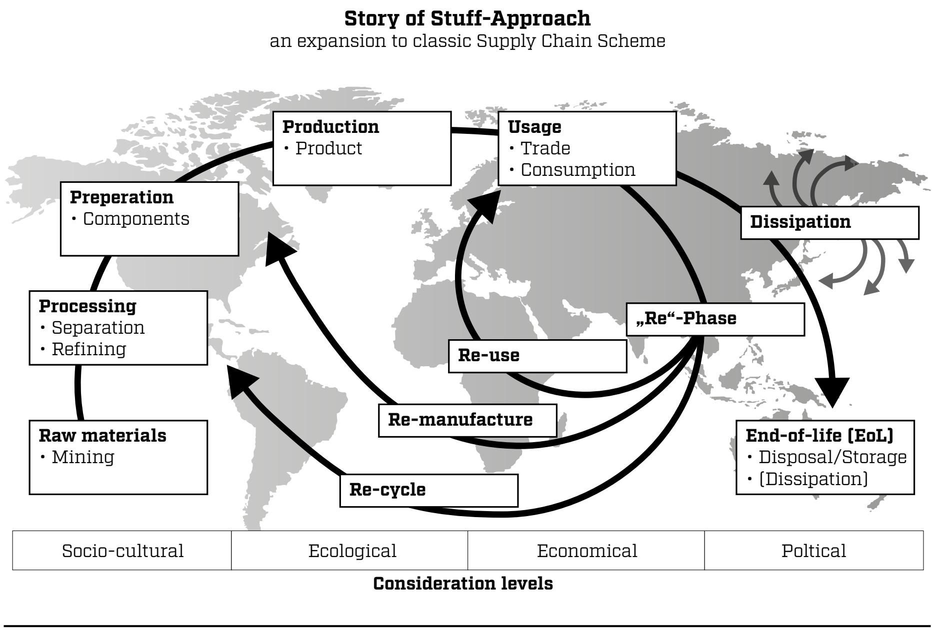

Figure 2: Schematic illustration of a resource chain and its spatiotemporal impact. (Volker Zepf / Armin Reller)

range[3] of bauxite, the main aluminium ore, amounts to roughly 106 years (USGS, 2013).

Many resources, however, are problematic not because of their range but because of the ways in which they feed into the value chain: their effects on the environment, for example, or the social and ethical circumstances of their extraction. The material-biological dimension needs to be taken into account as well: during and after their use, resources cause dissipation, that is, their particles spread in the biosphere.

The extent and risk of dissipating a resource originally limited to the geosphere is strikingly illustrated by the example of titanium dioxide. Titanium dioxide (TiO_2) is a little-known versatile compound with manifold applicability. It is not only the most important white pigment (for wall paint) but is also used for cosmetic products (sunscreen, toothpaste) and in the food industry (for optical-aesthetic reasons, for example in salami casings), among others.

The global production of titanium dioxide is correspondingly impressive: about 6.5 million tons of ilmenite and rutile, the two most important titanic minerals, were produced in 2010 – huge amounts, the usage of which dissipates them around the planet.

The dissipation of nanoscale titanium dioxide via sunscreen can easily be grasped: the substance is washed into the sea, the sewage system, or it literally gets under our skin. Since the effect of titanium dioxide on the human-environmental system is difficult to gauge so far, these dissipation processes seem to be a matter of tacit acceptance, of "known ignorance"[4] (on *ignorance* cf. Beck, 1996, Wehling, 2001, and Böschen et al., 2004), and of hazardous practices.

In order to use resources sustainably, it will be necessary to reduce the amount of known (and unknown) ignorance and to replace it with a solid store of knowledge. As consumers or product designers, we need to find our way through the complexity of substances, to make informed decisions in the spirit of sustainable

3 The static reserve is the ratio of current reserves to the current annual production of a resource. It states how many years' consumption are possible at the current production rates with fixed reserves.

4 The concept of ignorance has been meeting with considerable attention in sociological debate for about 20 years; it explicitly includes scientific ignorance. A well-known example for scientific ignorance is the emergence and belated discovery of the "ozone hole" (Wehling, 2011, p. 465). Examples for "known ignorance" are technologies like mobile communications or genetics, which are in use even though blind spots remain with regard to their consequences.

consumption. It is for this purpose that an interdisciplinary circle of scientists grouped around the Department of Resource Strategies and the Environmental Science Center at the University of Augsburg has developed the concept of *material histories*[5].

The main innovation of this concept is its narrative approach. Material histories narrate the "life" of various substances that humans use every day, in large amounts, without giving any thought to them. Material histories "follow" substances – or products and their materials – through space and time (figure 2). *"Material histories thus sketch the main lines of development of substances and identify the global networks of human interactions in which substances are embedded"* (Marschall, Meißner et al., 2013, p. 196). Cultural, historical, geographic, economic, sociological, and material-scientific aspects contribute to these histories, as do the very specific stations of the value chain, the usage phase, and the after-usage phase (recycling, dissipation).

Material histories are an instrument of analyzing and communicating. They can provide new knowledge but also inspire to achieve a sustainable treatment of resources. They may serve as background information for the practical decisions taken by experts at the various stations of the value chain. In the book series Stoffgeschichten (Material Histories; oekom publishing), volumes on dust, aluminium, milk, carbon dioxide, cocoa, dirt, wood, and coffee have appeared up to this point.

9.3 Going Astray and Searching for New Transformations of Materials

"The Stone Age did not end for lack of stone. And the Oil Age will end long before this world runs out of oil." [6] James Canton, Chairman of the Institute for Global Futures

Among the questions regarding sustainability, our energy system takes top priority, and in times of the "energetic turn" proclaimed by the German government every schoolchild is aware of this. In order to make our (fossil) energy system sustainable it urgently needs to be reconsidered from and transformed into a post-fossil direction. As yet, mankind is still on a drip: the infusion bag on which it depends contains a mixture of oil, natural gas, and coal, which the biosphere has filled with the remains of plants and animals over millions of years – that is, in the final resort, with ancient, stored solar power. Between 1950 and 2000 the consumption of coal increased by about 400 per cent, that of mineral oil by about 700 per cent (Meadows et al., 2009, p.9). There is widespread consensus that this needs to change – not necessarily because we know that supply is limited, but mainly because anthropogenic climate change forces constraints on an oil-addicted world.

From "decarbonization" (cf. WGBU, 2011) to the post-fossil and low-carbon society, a number of terms has been proposed for the intended restructuring of the energy system. Work on the technologies necessary for this restructuring is going ahead at full speed. It is quite probable, therefore, that this paradigm change and the investments motivated by it will be regarded as having catalyzed the sixth Kondratjeff cycle (cf. Hauff and Kleine, 2009, among others) by future generations – rather than rivaling candidates such as biotechnology, nanotechnology, and nuclear energy. It is well known that the first Kondratjeff cycle[7] and the Industrial Revolution were fueled by the invention of the coal-fired steam engine. 230 years and many innovations later, however, one thing has remained constant in energy technology: the global demand for energy, which has grown by 25 per cent between 2000 and 2008 alone, still relies on fossil primary energy carriers (coal, mineral oil, natural gas) for 80 per cent of its supply (Wagner, 2011, p. 65). The proportional share of black coal in global primary energy consumption is even growing. It

5 The concept was originally developed and applied in university courses; it was developed in more detail at the Environmental Science Center; put to the test in exhibitions (Staub [Dust] 2005; CO_2 2007; Stickstoff [Nitrogen] 2012), a book series (Stoffgeschichten [Material Histories], oekom publishers, Munich, since 2004), and academic teaching; and applied in industrial and educational contexts (Schmidt et al., 2007).

6 Cited in Kaku 2012, p. 321. (our trans.)

7 In 1926, the Russian scientist Nikolai D. Kondratjeff (1892-1938) first described the fluctuations of global business activity as "long waves" (Kondratjeff, 1926).

has increased by 2.5 per cent in 2012, mainly because of the demand generated by the People's Republic of China, which accounts for 50 per cent of this increase (BP, 2013).

Going Astray: Fracking, Deep-Sea Drilling, Biofuels

Ironically – even tragically – the importance of transitioning to a post-fossil age finds its most urgent expression in our increasingly elaborate and ecologically harmful procedures for the extraction of natural gas and oil.

In Europe, a controversial debate has emerged around the practice of hydraulic fracturing, in which oil and gas are squeezed from slaty sedimentary rock and which creates considerable environmental problems (Umweltbundesamt 2012, p.7). While some investment banks nevertheless praise fracking as a revolutionary energy source, many consumers and environmentalists associate the procedure with menacing images. Igniting a cigarette lighter under a water pipe causes a darting flame: a key scene from the American documentary Gasland, which caused considerable insecurity in 2010 by taking its audiences along an investigation of the damages caused by fracking, which is a widespread practice in the United States.

Equally problematic are the deep-sea oil reserves, which can only be recovered through considerable effort and grave ecological consequences (deep-sea drilling). Off the coast of the state of Rio de Janeiro, for example, large oil fields have been located beneath enormous salt beds, at a depth of 6,000 meters below sea level. The concession rights were auctioned off to Shell, Total, two state-owned Chinese concerns, and Petrobas, a parastatal Brazilian oil company. According to media reports, other bidders kept away because "the thing is risky and expensive" (Fischermann, 2013, our trans.). Further north, in Canada, equally risky projects are being undertaken. The Athabasca oil sand mines in the province of Alberta, which are considered the third-largest oil reserves on earth, are being extracted at undiminished speed. The mines extend over an area of 149,000 square meters of virgin forest. One of the environmental problems caused by extraction is that oil sand has a bitumen ratio of up to 10 per cent: in fact, the term "oil sand" is a euphemism; "tar sand" would be more accurate. In order to extract the bitumen from this compound, the oil sand is mixed with hot water and caustic soda. The result of this procedure is a broth of heavy metals and other toxic substances that is stored in basins. Moreover, the procedure leaves a disproportionate substance and energy footprint: two tons of oil sand are required for each barrel of crude oil (Lux 2012, p. 26).

Another dubitable way of extracting resources is the shift toward fuels based on biomass. These fuels can be gained from a variety of renewable resources: oil plants, crops, sugar beets, sugar cane, forest wood, scrap wood, wood from fast-growth plantations, special energy plants, and animal waste. Praised as a game changer just a few years ago, biofuels today have a equivocal reputation. Their production is held responsible for hunger, land speculation, and predatory cultivation (see Smith, 2013). A 2008 World Bank document leaked to the public attributes three fourths of the price increase for staple food to biofuels – an increase assumed to have amounted to 140 per cent between 2002 and 2008 (Mitchell, 2008). In 2001 around 100 billion liters of biofuels were produced, requiring an estimated four per cent of arable land worldwide, at an upward rate.

Phosphate: Sufficient Deposits But …

The intensified cultivation of oil plants contributes to the increasing use of mineral phosphate fertilizers. Phosphate is gained from phosphate rocks such as apatite or phosphorite; the major deposits of these rocks are located in Morocco, which accounts for two thirds of global reserves. After nitrogen, phosphate is the most frequently used fertilizer[8] worldwide and a major factor for global food safety. Yet phosphate will not run out anytime soon, despite numerous media reports to the contrary[9]. USGS data suggest that the current deposits will last another 300 years at the very least (USGS, 2013b). Currently the global annual production amounts to about 220 million tons of phosphate rock. Such estimates, however, are subject to continuous recalculation.

8 Phosphate compounds can be found in the carrier molecules of the genetic information of all life forms. They are necessary for the energy metabolism of cells and for many other biological processes.

9 See for example the headline, "The Fate of the World Depends on Phosphate. But It Might Run Short Soon" (Die Welt, 2013).

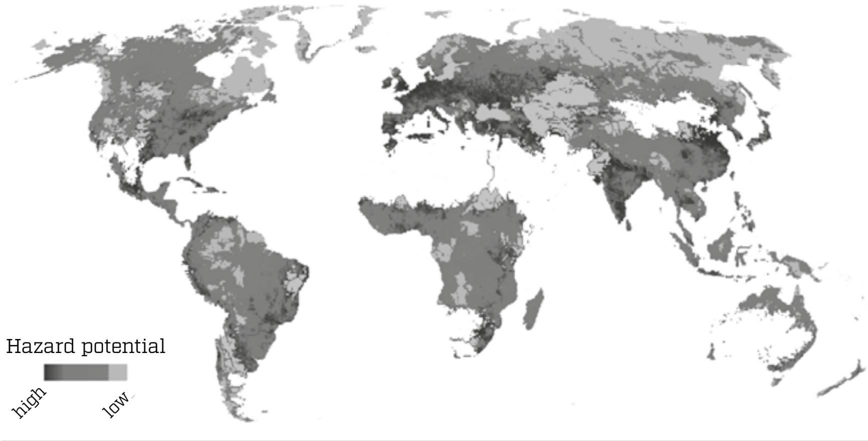

Figure 3: Global freshwater enthropication. (Hutner, 2013)

More problematic than its supposed scarcity is the environmental damage caused by the use of phosphate fertilizers. Phosphates are usually contaminated by uranium and cadmium, heavy metals that reach the biosphere via fertilization. Besides, overfertilization leads to the enthropication (excess of nutrients) of waters (see Fig. 3). If the soil contains more phosphate than it can store, rainfall can eluviate the substance (cf. Hutner, 2013). In the worst case, the waters acidify and become toxic environments for animals.

On the other hand, phosphate has enabled the population growth that has occurred since the beginnings of industrialization, and we will need it to feed a still-growing global population. It is important, therefore, to use phosphate efficiently and to advance phosphate recovery methods via recycling and reprocessing procedures like those pursued by the "German Phosphorus Platform[10]" (Deutsche Phosphor-Plattform) founded in 2013.

9.4 Low Carbon Society – Not Without Rare Earth Metals

These detours and wrong directions in energy supply indicate that we still have a long way to go before we become a "low carbon society." The scientific advisory board for global environmental questions of the German federal government is calling for a "great transformation," (cf. WGBU, 2011b) a structural change away from fossils, which it regards as urgently needed and which requires a "global contract for a climate-compatible and sustainable international economic order" (WGBU, 2011b, p. 2). Sociologists, for their part, regard this transformation as an "epistemic blessing": "It is not often that you get an opportunity to observe change on this scale in modern society," as Johannes Weyer, a sociologist of technology, said at the 2008 convention of the German Sociological Association (Weyer, 2010, p. 385).

In the wake of the debate around the "low carbon society" another era is passing: that of the combustion engine, which is being replaced by the electric motor. This is an epochal development in that the reign of the combustion engine has been *the* mobility paradigm of modern society for over a century. The shift toward the electric motor illustrates how seemingly ossified structures and paths can be caused to change by technical innovations and a changing socio-cultural context (cf. Weyer, 2008, p.385).

It is difficult to estimate, however, at which speed the shift from the combustion engine to the electric motor will actually happen. To a significant degree this will depend on consumer behavior and the ambitiousness of car companies. More importantly, however, electrically powered vehicles still lag behind combustion-engine ones when it comes to range and costs – factors determined by the batteries necessary for storing electric energy. Storage technologies that guarantee a sufficient lifecycle *and* cost-efficiency are a work in progress. Resources such as lithium (see below) for

10 The German Phosphorus Platform is sustained by the *Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS* (see http://www.deutsche-phosphor-plattform.de/).

storage technologies and platinum for fuel cells play an important role in these developments[11]. In the realm of transportation, then, we are practically shifting from a dependence on carbon compounds (gas) to a dependence on metals and from carbon-dioxide emission to a type of mining that may well have greater effects on humans and the environment.

On the level of substances and technology – at the interface of the geosphere and technosphere – the transformation of our energy system, which Germany has begun under the label of "energy transition" (Energiewende), has one main consequence: the emergence of technologies for creating and storing energy, and thus an enormous demand for functional materials and metals. Like mobility, information, and communication technology, energy technology depends on rare earth metals and their specific chemo-physical attributes. The increasing production of catalytic converters, airplane turbines, flat screens, mobile phones, and solar power systems has boosted demand for these metals in recent years (cf. SATW, 2010).

But what, really, are rare earth metals? There is no consensus in science or industry, no list that could clarify which metals qualify as rare and what distinguishes these from so-called strategic or critical metals (for a survey see Reller and Zepf). There is, however, a geochemical definition according to which those metals are rare whose concentration in the Earth's crust does not exceed a 0.1 weight percentage[12] (Skinner, 1979). Examples for such metals include gallium, indium, iridium, palladium, rhenium, rhodium, ruthenium, and several metals from the IUPAC-defined group of rare earth elements. Sometimes the term "technology metals" is used as a hyperonym (cf. Hagelüken, 2013).

It is evident, then, that mankind increasingly depends on resources that are stored in mines somewhere in the geosphere of the planet. It extracts these resources from their original compounds and spreads them over the techno- and biospheres. This raises important questions: how long will these resources last?[13] And how do we deal with the fact that many important resources can only be found in a few countries, which gives powerful monopolies to the governments and economies of these countries? The answers to these questions can be found in the scientific discipline of resource strategy.

Resource Strategies as a Response to New Challenges

A clear-sighted resource strategy can enable us to determine the resource flows essential for guaranteeing humane conditions of life, and to anticipate the complex dynamic of such flows. At the same time, such a resource strategy should – with support from material histories – be able to identify the risks we will be facing in the near and distant future, to develop solutions for various problems, and to assess the feasibility of these solutions (Reller, 2013, p. 126). For this ambitious undertaking to succeed, we need to draw on a catalogue of weighted relevant criteria in order to examine whether current resource usages can be continued in a sensible manner and whether innovative resource usages are possible and sustainable. Against this background, criticality becomes a crucial evaluative tool. Criticality refers to the application of a set of quantitative and qualitative criteria to examine the feasibility, usability, and sustainability of value chains. Factors analyzed with this method include:

- › geological availability and technological mineability,
- › the concentration of the metal to be mined,
- › the occurrence of by-metals (are they toxic or radioactive?),
- › social and economic parameters,
- › environmental impact[14],

11 The energy density of fuel cell systems is clearly higher than the energy density reachable by lithium systems today and in the near future.

12 The 12 most common elements account for about 99 per cent of the weight of the earth crust. The other 76 elements of the periodic table thus account for less than one per cent. Silicon, for example, contributes 27 per cent; sodium contributes about 3 per cent.

13 Quantified specifications of resource reserves like those of the United States Geological Survey (USGS) should never be taken as absolute. Reserves are examined statically so that mistaken interpretations occur on a regular basis. A specification is "only a mathematical snapshot of a dynamic, developing system" (Becker-Platen and Wellmer, 1999, p. 115, our trans.).

14 Many low-wage countries, in which intermediate products are fabricated as cheaply as possible with scant regard for environmental regulations and under burdensome workplace conditions, face disastrous social consequences and large-scale pollution of ecosystems.

› dissipation,
› geopolitical parameters.

The example of rare earth metals[15] shows the importance of geopolitical parameters in resource mining. At the moment, more than 90 per cent of rare earth metals are extracted and refined in the People's Republic of China (cf. Reller and Zepf, 2011). For a long time China was able to offer these coveted metals at very low cost, especially because environmental pollution did not have to be taken into account. This has been changing in recent years. The Chinese began to institute environmental regulations and curbed exports. Their monopoly has had a palpable effect on the global market. The changes have led to a steep increase in research on recycling methods and substitutes for rare metals.

Excursus #1: Silver: Solar Cells, Catalysts, Solders, and More

Because of its high conductivity, silver, a precious metal, is used in many different contexts, including for example catalysts, conductive chips, solders, and solar cells. With its considerable demand for silver, the solar industry has become an important actor in the global market in recent years.

Several established systems are currently in use in photovoltaics. Their efficiency levels vary between about 10 and 25 per cent, with 25 per cent only being reached by gallium-arsenide thin-layer cells.

The most common photovoltaic systems are thin-layer models based on amorphous silicon, thin-layer cells based on cadmium telluride, and solar cells made from crystalline silicon.

Almost all crystalline photovoltaic modules contain significant amounts of silver, which discharges the electric energy generated from the cell surface. Since the production of photovoltaic systems has been increasingly rapidly since 2008, the industry's demand for silver is growing as well. Currently the photovoltaics industry is using around 1,500 tons of silver (Wirth, 2014, p. 72). Since the silver price grew to nearly 50 dollars per troy ounce in 2011 there have been debates around supply security, so that the industry is weighing the use of copper as a substitute. Given that an estimated 24,000 tons of silver were produced in 2012 and that reserves are estimated at 540,000 tons, silver theoretically has a remaining range of 22 years (USGS, 2013f).

Excursus #2: Copper: Coins, Electrical Conductors, Handicraft, and More

Copper is not only the metal of modernity; it was the metal of antiquity as well. Easy to process, the heavy metal was already used by the oldest cultures known to historians. The Roman Empire is regarded as the largest preindustrial producer of copper, at an estimated rate of 15,000 tons annually (Boutron, Candelone et al., 1996, p. 247).

Today, too, copper is an inevitable part of everyday life, especially because of its best-known application as an electric conductor. Besides, it is an important material in the tinsmith and sanitation industry and, given its antibacterial qualities, a popular material in the construction of public buildings.

Copper deposits are spread across the globe, the largest reserves being in Chile, Australia, and the United States. In 2012 Chile contributed most prominently to global production, furnishing 5 million tons out of the 17 million tons produced overall (USGS, 2013e). The USGS estimates copper reserves to amount to roughly 680 million tons, so that the material has a theoretical range of 40 years.

An interesting factor in this context is the resource policy of the People's Republic of China, which has average copper reserves. An emergent country and (since 2014) the largest trading nation on Earth, China requires – among other resources – enormous amounts of copper for infrastructure and construction projects as well as its industries generally. For this reason, the Chinese started to buy "shares" in resource-rich East Africa and especially in the African copper belt from the year 2000 at the latest, thus introducing a new, non-ideological phase of postcolonialism. "The deal is always the same: resources for infrastructure. The practical details can be studied in Congo, where a mega-deal was completed in 2007. In a mere 7-page contract, Congo agreed to provide ten million tons of copper and 600,000 tons of cobalt, while China pledged to building nine billion dollars' worth of infrastructure in return: 3,400 kilometers of paved roads, 3,215 kilometers of railways, 31 hospitals, 2 airports," German business monthly ManagerMagazin reported in 2013 (Hirn, 2013).

15 Rare earth elements include the elements scandium, yttrium, and lanthanum from subgroup 3 of the periodic table as well as the so-called lanthanides, for example cerium, neodymium, or praseodymium. A detailed analysis of deposits and uses has been undertaken by Volker Zepf (2013).

Excursus #3: Rare Earth Elements: Cell Phones, Notebooks, Wind Engines, and More
In recent years, rare earth elements (REE) have experienced such a boom and have been discussed in the media so often that even the average citizen has heard of them by now. The 17 metals grouped under this heading are not really rare; the term was coined when they were discovered in 1787. "Rare" then meant "strange" or "astonishing," which is how a lieutenant of the Swedish army described the ore he found on a Swedish island in that year.

Because of their special chemical and physical attributes, REE are used in many key and emerging technologies. Europium, for instance, is a red luminescent material in TV screens. REE are in particular demand for small-size, high-power magnets. These neodymium-iron-boron magnets are used in a variety of technologies ranging from vibration motors in cell phones to electrical motors all the way to ship propulsion engines and wind engines.

An estimated 80% of the current global production of neodymium takes place in Bayan Obo, China, the largest rare-earth mine worldwide. The mine is surrounded by kilometers of sludge ponds, which are not only toxic but also extremely hazardous, since radioactive thorium can be released when rare earths are extracted from the mineral monazite. As a result, the Malaysian company Lynas, for example, is struggling to preserve acceptance for its refinery, which accumulates radioactive substances.

Up to 2013, the REE supply situation in the global market was shaped by China's monopoly. Not least because of the problems caused by this situation (see above), a number of mining projects are currently being planned in countries including South Africa, Canada, India, and Russia. In Australia a new REE mine opened in 2012/13. According to USGS data, 111,000 tons of REE were mined in 2012 and reserves amount to 110 million tons, half of which are in China (USGS, 2013c).

Excursus #4: Lithium: Smartphones, Notebooks, Electric Cars, and More
So far, lithium has mainly been used in the glass ceramics industry and, to a smaller extent, for grease and batteries. In battery production, the light metal is rapidly gaining significance at the moment because of its specific chemical attributes. The growing demand for rechargeable batteries, which are needed for portable devices like smartphones, notebooks, and tablets, led to a steep increase in global lithium production in 2012. Given that the electronic mobility sector, too, requires large amounts of lithium for rechargeable batteries, demand is estimated to increase further in future years (USGS, 2013d).

Significant lithium deposits can be found in the United States, Australia, Chile, Bolivia, China, Zimbabwe, Portugal, Argentina, and Brazil. It is Chile, however, that leads these countries, with over 70 per cent of deposits being located there (ibid.). 37,000 tons of lithium were produced worldwide in 2012 (just under 26,000 tons had been produced in 2006) (ibid.).

9.5 We're Going Mobile – But Not Without a Circular Economy

The economic system as we know it today received its main impulses from the mobilization of materials and goods. After the invention of the railroad, in the first half of the nineteenth century, enabled the quick supply of coal and raw materials and the subsequent transportation of goods, the process of all-encompassing mobilization has ceaselessly advanced.

Today, in the age of global trade, in which *materials, human beings, and information are highly mobile*, this process seems to have reached its peak – and to have arrived at a caesura, or rather a reinterpretation, at the same time.

After all, information has become dematerialized at first glance only. In fact, the increasing demand for sending and receiving systems has dramatically increased resource consumption. The same holds true for mobility. Traffic density is continually increasing whether by land, sea, or air. And while the end of the combustion engine may be approaching, alternative mobility systems require considerable amounts of energy and resources as well.

The smartphone industry, for example, is characterized by an extremely rapid production cycle, with many users following current supply and acquiring the most recent device on the market every year. The data confirm this: in 2013, the telecommunications sector accounted for half of the global market for information and communication technologies (Bitkom, 2013). Around 16 million smartphones were sold in Germany in 2012, with a total revenue of five billion euros (Bitkom, 2012). The smartphone, however, is just one aspect of a much larger and more consequential phenomenon that we call the "popularization of equipment." This term refers to both the short innovation cycles and the explosive growth of the entertainment electronics sector in the last decade. It turns out that the miniaturization of equipment such as mobile phones, cameras, and laptops has reduced the consumption of materials per unit and thus made resource use more efficient. This positive effect, however, is obliterated by a rebound effect as the huge number of units leads to higher resource consumption on the whole (cf. Santarius, 2012). A *secondary rebound effect* can be observed where a technology requires extremely pure materials (cf. Reller, 2013, p.185). The popularization of consumer goods seems to amount to a *tertiary rebound effect*: the exploitation of primary resources increases further; the quality of substances used for production becomes more specific, more diversified, and more energy-intensive; and the dissipation of strategic resources accelerates because of their swift proliferation around the globe (ibid.). A smartphone, for example, requires some 40 different metals, from cobalt to tantalum, rare earth metals, copper, and nickel all the way to silver and gold. While each individual cell phone only contains a few milligrams of rare metals, these add up to a large overall sum: a ton of scrap cell phones contains more silver than can be extracted from a ton of ore (on average, 250 grams per ton of rock extracted). By now, the procedure called *urban mining* – the use of secondary raw materials – is often more profitable than "primary" mining.

It is time, therefore, to widen our concept of mobilization so that it encompasses a cyclical economy able to keep resources that have already been extracted "mobile": to make them available for continual reuse. In the face of global population growth and finite resources, it is of the utmost social, economic, and ecological importance to rethink our handling of resources, to move from *wasting* resources to *using* them. It must be our aim to secure the availability of resources now and in the future. We need to preserve resources, enhance efficiency, and institute a cyclical economy, all the while paying attention to distributive and intergenerational justice. The cultural (re-) appropriation of cyclical processes found in nature is probably one of the biggest challenges faced by high-tech modernity.

The list of "tasks" we have to undertake, in any case, is long. Technical and consumptive processes and products need to be designed in a way that the substances used for them can be recovered and used as secondary resources. To this end, recycling needs to be part of the planning process from the stage of product design onward; existing recovery logistics need to be improved with regard to economic and ecological responsibility and feasibility; industry and politics need to advance resource-efficient systems such as leasing and deposit networks.

All of this, however, depends on finding a solution to a technical problem: we need to find a way to reduce the variety of materials in high-tech products (c.f. Hagelüken, 2013). As indicated above, rare metals are used, in infinite quantities, for the construction of such products and thus carry a high dissipation risk. Substances like indium, germanium, and gallium are sometimes vapor-deposited onto other substances in such a wafer-thin manner that they cannot be recovered in an economical manner at the moment. Both the industry and the sciences are researching appropriate dissolution procedures. The *Fraunhofer Project Group Materials Recycling and Resource Strategies IWKS*, for example, is working on innovative concepts for such issues as recycling, material flows, waste, and resources in cooperation with industrial partners.

9.6 Outlook: Knowledge as Key

Climate change, the destruction of rainforests, the extinction of species, soil erosion, the pollution of water, air, and land, among many others: mankind has put massive pressure on the global ecosystem through its lifestyle, its consumption habits, and its resource and energy waste. Underneath this problem is what we might call the *liberal dilemma*: the individual actions that lead to a resource-intensive lifestyle are neither legally nor morally problematic in themselves. It is only the sum of their aggregate consequences that creates grave problems (Huppenbauer, 2013, p. 177). Against this background, the ethicist Markus Huppenbauer (ibid.) regards the proliferation of resource-oriented virtues[16] as the central prerequisite for reaching spe-

16 The concept of sufficiency is frequently discussed in this context. For a synopsis see Oliver Stengel (2013).

cific social and environmental goals. Such virtues, he suggests, will disburden the individual actor from continually having to reflect on the actions demanded in certain situations.

Of course, laws cannot prescribe virtuous and responsible behavior. Huppenbauer puts his hopes on a long-term reflection and education process. Material histories, for instance, are an excellent tool for fostering resource-oriented virtues. Their charm lies in their direct relevance for the individual reader. They begin with the jeans he is wearing or the coffee he drinks. In the final analysis, however, material histories are just one of many instruments and opportunities for spreading information about the responsible use of our planet and its resources. These very resources, by virtue of the electronic products made from them, enable us to acquire knowledge as quickly and as flexibly as never before. And knowledge, after all, is the most fascinating resource of all: the only resource that increases when used.

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Peter Stebbing

10 Pollution, poisons and profits: toxicity for designers

"There are currently more than 80,000 chemicals in consumer goods, with little or no safety information about their impact on human health." (Environmental Working Group, 2009)

"… the exact number of chemicals marketed globally is unknown … One guide is the number registered with the EU which stands at around 144,000. Of these, roughly a third are thought to be harmful … but "the vast majority have not been assessed for human or environmental safety."" Davies & Sanderson, 2014

"Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea." Eriksen, et al., 2014

"EU plans to tackle air pollution that causes tens of thousands of premature deaths and make countries recycle more of their rubbish are to be scrapped, according to leaked documents. At risk are a clean air directive designed to reduce the health impacts from air pollution caused by vehicles, industry and power plants, and a waste directive that would set states the target of recycling 70% of waste by 2030." Arthur Neslen, 2014

"Apparently, every chemical that is introduced into the environment can enter the unborn child. What we don't know is what the long-term effects of these substances are." Pieter Sauer, (Anon. a. Up Front, 2005)

"EU plans to tackle air pollution that causes tens of thousands of premature deaths and "Numerous animal studies report that several phthalates (particularly DEHP and DBP) induce a marked reduction in foetal testosterone and insulin-like growth factor-3, resulting in a syndrome of male reproductive abnormalities … In addition to shortened anogenital distance (AGD), which is a sensitive and non-invasive measure of potential androgen deficiency during foetal development in rodents and humans, other abnormalities include hypospadias, cryptorchidism and malformation of the epididymus, vas deferens, seminal vesicles and prostate; together they comprise the 'phthalate syndrome'…" J.D. Meeker, et al. (2009)

10.1 Introduction

10.1.1 Everyone a bioassay baby

A bioassay is a test to determine the *"measurement of the concentration or potency of a substance by its effect on living cells or tissues"* or organisms (Pearsall, 1998). We might have imagined that one of the safest and purest places to ever have been during our lives was inside our mother's womb. Today, that is absolutely not true. Today, every baby is bioassay test which is (perhaps unwittingly) being conducted by a variety of chemical and other industries. In addition to the magic of creating an organism, the womb has also become a sampling flask of mankind's chemically modified environment – the Earth.

Several investigations have been conducted in both the USA and in Europe revealing the extent of chemical pollution. In 2005 a study by the University Hospital in Groningen, Holland, was commissioned by the World Wildlife Fund and Greenpeace to analyze the blood of pregnant women. Their research revealed that *"More chemicals from everyday household products cross the placenta from mother to baby than we ever imagined"* (Anon. Up Front, 2005). The hazardous chemicals found were from 8 chemical groups: artificial musks, alkyphenols, bisphenol-A, brominated flame retardants, perflourinated compounds, phthalates (found in ink, paint and cosmetics), organochlorine pesticides and triclosan (Schuiling, van der Naald, 2005). A spokesman for the investigating team, Pieter Sauer, concluded that *"Apparently, every chemical that is introduced into the environment can enter the unborn child. What we don't know is what the long-term effects of these substances are"* (Anon. a. Up Front, 2005).

Four years later the Environmental Working Group (EWG) and Rachel's Network commissioned the testing of blood samples from 10 umbilical cords from babies in U.S. and found that 9 of the 10 samples had bisphenol-A (BPA) (EWG, 2009). A further 10 blood samples tested by laboratories in Europe, Canada and the USA contained up to 232 toxic chemicals including: the toxic flame retardant tetrabromobisphenol A (TBBPA), synthetic fragrances (Galaxolide and Tonalide), perfluorobutanoic acid (PFBA, or C_4), solid rocket fuel component perchlorate. This bio-monitoring investigation was the 11th conducted by EWG *"employing leading bio-monitoring labs around the world, have together identified up to 493 chemicals, pollutants and pesticides in people, from newborns to grandparents. Each study contributes new pieces to a mosaic of the "human toxome," as EWG analysts call pollution in people."*

10.1.2 Carcinogens and toxins automatically added to the recipe

The aim of war is usually to kill the enemy and it was during WWII that chemists on both sides of the conflict developed various chemical weapons, such as nerve gases. One weapon sought after was a water poison that would be undetectable and have some delay before killing. The compound discovered which appeared to be most efficacious as a water poison was methyl flouroacetate or MFA which is *"one of the most toxic classes of non-protein substances known"* (Gribble, 1973).

Non-stick teflon coated cooking pots and pans release six toxins within minutes of heating: these include two carcinogens and unbelievably MFA. The chemicals are released into the food when the pan is heated to high temperatures or/and when the Teflon surface becomes scratched and damaged (Adams, 2008). Teflon was discovered accidentally by a DuPont scientist. The American Environmental Protection Agency maintains that DuPont deliberately withheld information about Teflon's toxicity and health hazards. As a consequence DuPont was fined $300m by the US Environmental Protection Agency (Posch, 2004). Another chemical, perfluorooctanoic acid (PFOA) is used in the synthesis of Teflon and has been found in peoples' blood worldwide. Furthermore, women employed by DuPont who were exposed to PFOA during their work bear children with an increased rate of birth defects. Furthermore, PFOA remains in the body for many years and is associated with bladder, kidney and testicular cancer. PFOA is used in a range of products including ski wax, fabrics, eyeglasses and carpeting.

One of the conclusions of the First Annual Conference for the Consortium for fire safety, health and the environment which took place in 2003, was that *"No one is at liberty to produce products or materials that place humans – especially children – at risk. The Precautionary Principle … must be used to help industry do what is right."* (Schuiling, van der Naald, 2005). This "precautionary principle" is regarded as a handicap to private enterprise and is largely ignored by the chemical industries who vehemently lobby against policies which would safeguard consumers and the environment. Sure enough, they do what is right – for themselves, the chemical industries, and their profits.

10.1.3 Need designers study toxicity and pollution?

Why should design students now study pollution and toxicity? There are several important reasons and not least because of what has already been described. The introductory accounts revealing that 232 chemicals were found in babies' umbilical cord blood and that people around the world have been found to be contaminated with any number of nearly 493 pollutants (EWG, 2009) is certainly reason enough to know the composition of materials selected by designers. Toxicity is not on the traditional design curriculum and the reason for that is quite simple – the design curriculum is out of date. Design courses have traditionally taught materials technology primarily to inform students about which materials are suitable for specific design problems, functions and contexts together with their physical properties. Clearly, this is no longer adequate because "*... the exact number of chemicals marketed globally is unknown ... One guide is the number registered with the EU which stands at around 144,000. Of these, roughly a third are thought to be harmful ... but "the vast majority have not been assessed for human or environmental safety""* Cribb warns (Cribb, 2014; Davies & Sanderson, 2014). The problem is not only that we do not know which chemicals are toxic but, for example, in addition, chemicals offgassing from products can combine with others in unexpected ways and some, counterintuitively, are toxic in low doses as opposed to high doses. Yes, designers definitely need to know about toxicity because it is not ethical to design and choose materials for products etc. without the knowledge of their chemical composition and propertiers and expect other people to live in close proximity with them. Teflon's does not provide a model for design!

The EU legislation, REACH, is supposed to protect the public from toxic products but was very strongly amended by heavy industrial lobbying so that *"The result has been a severe watering down of the legislation which has created loopholes and concessions to industry. At an estimated cost of €3-5 billion to industry over 11 years to adopt the requirements of the legislation, the motivations behind their lobbying are clear. However, NGOs are keen to point out that savings in health costs from removal of these substances from EU markets could amount to €54 billion over the next 30 years"* (Client Earth, 2013). Meanwhile, the EU vice-president, Frans Timmermans wants to cancel *"EU plans to tackle air pollution that causes tens of thousands of premature deaths and make countries recycle more of their rubbish"* (Neslen, 2014).

In the USA the situation is worse; *"There is increasing evidence that we must test and regulate potentially toxic substances that wind up in our bodies," said Sen. Frank R. Lautenberg. "America's system for regulating toxic chemicals is broken. The legislation I am currently drafting will strengthen chemical safety laws and give Americans confidence that products they use are safe"* (EWG, 2009). Sen. Lautenberg's proposed legislation was heavily lobbied and delayed by industry and sadly he died before the legislation could complete its passage through the Senate and so it did not become law.

The Lautenberg case and the lax US laws regarding toxic chemicals illustrates one of the dangers with the Transatlantic Trade & Investment Partnership (TTIP) agreement between the USA and Europe. The corporate control of US government and its intensive lobbying is to ensure that regulations are not made that would control chemicals in products and foodstuffs. For example, animals treated with the hormone and anabolic steroid trenbolone gain up to 20% more weight than they would without the hormone treatment. However, the US cattle industry *"enjoys an estimated $1 billion annual benefit from trenbolone alone."* Apparently, *"Only trace amounts of the added hormones remain in the beef after slaughter"* (Stokstad, 2013). The European Community introduced a prohibition of trenbolone and other bovine growth promoters in 1988 due to health concerns and the *"risk to consumers, i.e. possible endocrine, developmental, immunological, neurobiological, immuno-toxic, genotoxic and carcinogenic effects, has been identified with differing levels of conclusive evidence"* (health consumer, no date).

The western life style creates and inhabits a chemical environment which increasingly taxes the population with many illnesses, including: asthma and other respiratory diseases, neurological impairments, allergies, declining sperm counts, a range of cancers, immune system malfunction, developmental disorders in the young, etc. (Wargo, 2009). Furthermore, we do not know the long term effects of our close association with our chemical environment or of their effects when they combine in unknown ways with other chemicals.

Consequently, as designers we need to be as well informed as possible about the materials we specify for design products since we contribute to the distribution, growth and the '*chemicalization*' of our environment. This is not specifically a product design problem. Textiles for fashion design, furnishings and interiors are treated with fire-retardants and antimicro-bialcides (such as silver), and packaging and graphic products contain chemicals in inks and papers are treated with plastic coatings etc.

The western life-style is carcinogenic and many regions around the world are projected to experience an increase in cancers as they adopt the western life style with its associated chemical environment. In 1989 it was estimated that for those living a western life-style one person in five would die of cancer (Alberts, et al. 1989) but by 2013 the statistic was one person in four (American Cancer Society, 2013). Cancer is caused by a variety of factors which result in a single cell abnormality (a change in a cell's DNA sequence) which on further division outgrows neighbouring cells and causes a tumour. The factors which cause cancers include: viruses, ionizing radiation e.g. x-rays and chemical carcinogens. Generally, cancers arise when a chance combination of "*several independent rare accidents occur together in one cell*" resulting in a cumulative effect. *"Many quite disparate chemicals have been shown to be likewise carcinogenic when they are fed to experimental animals or repeatedly painted on their skin … Although the known chemical carcinogens are very diverse, most of them have at least one property in common: they cause mutations"* (Alberts, et al. 1989).

It is estimated that between 2002 to 2020 cancers will increase by 95% in southeast Asia and by more than 70% in North Africa and West Asia, the Caribbean, Central and South America (Gorman, C., 2010). The poor legislation and regulation means that chemicals are not tested rigorously enough and the chain of cause and effect is often sufficiently distant so that the specific cause of a cancer or allergy is at best difficult or at worst impossible to prove. Indeed, the cigarette industry exploited the situation that whilst statistically smoking increased the incidence of lung cancer it could not be proved that smoking was the cause of lung cancer in any particular individual (Oreskes & Conway, 2010).

Nonetheless, here we hope to create an awareness as to why the design curriculum must significantly change. The circular economy, life-cycle analysis, WEEE, recycling, down-cycling, up-cycling, cradle to cradle, etc. are familiar to most design students but less practiced in the profession. Design for disassembly features seldom in the curriculum and toxicity barely ever. Designing without a knowledge of toxicity will mean that design contributes to both ill health and pollution.

10.1.4 We must work towards adopting Nature's strategy. Nature never pollutes.

What is the answer? There is only one logic to follow; the Earth is finite, our resources are finite, our environment is finite and so is the space for polluting and throwing things away also finite. Pollution makes the land and freshwaters we have unusable. In a spherical world, 'There is no away.' Our only choice is to stop producing and throwing out toxic stuff which pollutes the environment and poisons us. It has recently been reported that abandoned landfills for waste are now polluting rivers in the UK, for example, *"more than 27 tonnes of ammonium leaches from an Oxford wetland into the River Thames every year, reports the Natural Environment Research Council … The researchers say it could be happening at thousands of sites around the UK"* (Peel, 2014). The question also arises what else is leaching out of landfill waste pits? We should make every effort to adopt two strategies immediately and which Nature, the mother of recycling, has always demonstrated for us. In other words, we must adopt Nature's biological production cycles (Lovins, Lovins & Hawken, 1999; Stahel, 1982; Stahel, 2010).

1. Design with organic materials and avoid all synthetic chemical compounds that are incompatible with the biosphere, organic life and its metabolic processes and physiologies. In short, mimic and work compatibly with nature's circular economy.
2. Since we appear to need a technical economy then it too must be a circular economy. This requires design for modular disassembly, repair, re-use, recondition, recycling, re-manufacturing and closed loop production systems. We must implement a circular economy for our technologies which are incompatible with nature (Stahel, 1982; Stahel, 2010), a concept that has more recently been popularized as 'cradle to cradle' (McDonough & Braungart, 2002). The only possible conclusions to the problems of toxicity and pollution within the new design paradigm are irrefutably logical and simple.

› the western consumer life style is toxic (old paradigm)
› design can make it less so.
› we need to design avoiding synthetic materials with unknown chemical compounds (new paradigm).

The challenge is in designing the transition from the status quo to a non-toxic world.

10.1.5 Material choice is an ethical choice

The unknown toxicities of many synthetic materials makes the designer's choice of materials a difficult ethical question. How can a designer morally justify choosing a synthetic material for a design without knowing about its toxicity and expect others to live in close proximity to it? Furthermore, since designers have no control over their design once it has been manufactured and has entered the market place then the question is; whose ethical responsibility is it to ensure a design's safe disposal due to the toxins it may contain? Clearly, the problems are best solved at the earliest phase in the design process. Tischner (2000) writes that *"More than 80% of all product related costs and environmental impacts of a product during its manufacture, use and disposal are determined during the product-planning phase." i.e. the design phase. Meanwhile, "Our global economy concentrates raw chemicals, mixes them in millions of products that are distributed through markets, and re-concentrates remaining wastes in landfills or incinerators, where once again they are dispersed unpredictably into the air, soil, and water"* (Wargo, 2009). Designers are participants in these processes and consequently we must acknowledge our responsibility. Victor Papanek (1971) did not mince words in his famous accusation "*… creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breath, designers have become a dangerous breed.*" Today we can recognize that design has significantly contributed to a problem of global magnitude, for example micro-plastic particles (<1mm) can now be found on shorelines all around the world. Worse: chemicals from plastic pollution are found in the feathers of sea birds (ANSTO, 2014). It is pointless here to reprimand, as Papanek does, but rather to recognize that the old paradigm of design knowledge is inadequate in a globalized world. The globalization of raw materials and the world trade in products has substantially changed the design curriculum.

Therefore the design curriculum must address the upstream and downstream costs and dangers of pollution and toxicity? For example:

- the distance the raw material's were transported from source to the manufacturer of the design. Transport by sea and land. (Could a local alternative be more sustainable?)
- the "ecological rucksack" of materials' extraction and processing. Does the extraction process cause externalities? If so then on which groups do the externalities impact?
- will the design, when thrown away, return to the 'grave,' possibly causing pollution in a land fill or can it be recycled and returned to the 'cradle' so that its materials can 'nourish' the manufacture of another design in a circular technological economy?

10.2 What is pollution?

In the natural world one organism's waste is another's necessity.

All organisms are participants in the flows of metabolites and energy circulating throughout the Earth-system. Just one species perturbs this golden principle of nature – *Homo sapiens*. Out of the millions of species inhabiting the Earth only Homo sapiens creates pollution. We do this by releasing either something in unnatural quantities (e.g. CO_2) or a harmful/ toxic substance (e.g. DDT) into the environment. The conditions of life "*are never such that more of something is always better than less of something. Rather … there is a quantity that has an optimum value. Above that quantity, the variable becomes toxic. To fall below that value is to be deprived.*" Although Gregory Bateson (1980)t was writing about desired substances the concept is equally appropriate for the environment and pollutants and toxins.

Pollution may be defined as *"the introduction by man into the environment of substances or energy liable to cause hazard to human health, harm to living resources and ecological systems, damage to structure or amenity, or interference with legitimate uses of the environment"* (Byrne, 1997). For example, if sewage is released into a stream, it can be sustainable so long as the rate of emission is not greater than the rate at which the sewage can be naturally broken down by organisms, dissipated, absorbed, or rendered harmless by the environment (Meadows, et al 1992). In 1858, in Victorian London the sewage system failed and untreated sewage flowed into the River Thames causing the infamous 'Great Stink'– probably one of the best examples of sewage emissions exceeding the rate at which it could be absorbed and rendered harmless by the environment.

10.3 Four kinds of Pollutants.

There are four kinds of pollution:

1. Thermal energy in the form of heated water discharged into rivers and estuaries by many industries.
2. Substances which occur naturally but as a consequence of human activity are produced in extraordinarily large quantities. Probably the best example is CO_2, the greenhouse gas which is causing global warming. An organic example is caused by nitrogen fertilizers washing off the land and causing algal blooms and eutrophication in both fresh waters and coastal areas.
3. The third type of pollutant are those which do not naturally occur in nature such as synthetic chemical compounds and pesticides which were first drawn attention to by Rachel Carson in her classic work Silent Spring first published in 1962.
4. Finally there are pollutants which, whilst not being toxic themselves, when released into the environment, nonetheless interact with other substances (chloroflourocarbons and the ozone layer) or even combine with other pollutants to act synergetically together with unforeseen circumstances (Chapman & Reiss, 1994). The danger of a toxic synergy between two compounds can easily occur in the domestic context where hundreds of compounds used in cosmetics, fire retardants, domestic cleaners, furniture and textile adhesives, etc. can interact with one another to form an unanticipated toxic compound. In addition to the compounds themselves some people maybe genetically pre-disposed or allergic to react to compounds which are not toxic to others due to an individual's unique genetic constitution and immune system.

10.4 Their Biological effects and some key characteristics

The biological effects on humans of most toxins and pollutants are thought to be mostly sub-lethal, aggravating existing health problems. Their biological effects can be:

1. **toxic:** disturbing the body's physiology or nervous system.
2. **carcinogenic:** causing cancer.
3. **mutagenic:** causing alterations to the chromosomes.
4. **teratogenic:** causing malformation of the embryo.

(Byrne, 1997).

Toxins interact with organisms in complicated ways so, for example, *"Pollutants that have been considered safe when tested at medium doses could have damaging effects at lower doses"* (Coghlan, 2004). Pollutants have variable life-spans except for the elements such as the heavy metals, e.g. arsenic and cadmium etc.

In the EU about 144,000 chemicals are marketed of which about a third are thought to be harmful and many are used in the manufacture of products. Consequently, designers must be aware of some of the characteristics of toxins and their pervasiveness due to their weak regulation:

1. Thousands of new synthetic compounds and materials are being produced and becoming available every year. In fact the Worldwatch Institute estimates that a new chemical compound is developed every 27 seconds. Fortunately, few of them reach commercial production *"But every year another 1,000 or so new compounds enter the chemical economy,"* (McGinn, 2000).
2. Synthetic organic compounds ('Synthetic' refers to 'man-made' compounds which do not occur in the natural world. 'Organic' refers here to carbon chemistry, 'the chemistry of life') such as halogenated hydrocarbons, which include DDT and although banned in Europe & USA, are still widely used in manufacturing plastics, solvents and other products. Examples of these compounds include: benzene, chloroform, polychlorinated biphenols, carbon tetrachloride, toluene, xylene, etc. The first three are mutagenic, carcinogenic and teratogenic. Carbon tetrachloride is mutagenic and teratogenic whilst toluene and xylene are mutagenic and teratogenic respectively. Synthetic organic compounds do not occur in nature so it is little wonder that they are harmful at the cellular level because cells have not evolved the physiological mechanisms to cope with them. Consequently, we are running a massive chemical experiment

on a global scale with minimal control and little chance of reversal.

3. Chemicals off-gas, that is chemicals slowly leave the material in which they are a constituent and evaporate into the air. One can often experience off-gassing when a plastic food container with a well fitting lid is opened and releases a plastic smell. The smell is due to our noses detecting the released molecules which can enter our bodies through breathing or food (such containers should not be used for consumables). Often, however, off-gassing from plastics, fittings, fire-retardants, industrial glues and adhesives etc. is not always detectable especially when molecules evaporate into larger spaces such as rooms and offices. Once in the air the off-gassed chemicals can be inhaled and can cause a range of health problems from allergies to cancers.
4. Marine chemical 'merry-go-round'. This term refers to the capability of plastics to act as a chemical 'merry-go-round,' by absorbing pollutant chemicals from seawater (Teuten, et al. 2009) and 'delivering' the chemicals to animals.
   The dilemma of the plastic waste floating in the oceans and gathered into massive carpets by the ocean gyres is now well known. It is now estimated that there are over five trillion pieces of plastic floating in the world's oceans weighing nearly 269,000 tonnes damaging the marine food chains (Milman, 2014; Eriksen, et al. 2014). The chemical merry-go-round enables filter feeding animals to ingest toxic plastic particles along with their normal food, plankton. Larger pieces of plastic are also mistaken for prey and consumed by predators and altogether 180 species of animals have been recorded to have ingested plastic debris (Teuten, et al. 2009). Research has already shown that mussels retain plastic particles for more than 48 days (Thompson, 2009). Furthermore, *"evidence is emerging that plastics with environmental contaminants can transport these compounds to organisms at various trophic levels"* in the food chain (Teuten, et al. 2009).
5. Toxins can accumulate in organisms at the top of the food-chain so that, for example, the non-biodegradable pollutant, the heavy metal mercury, may be taken up by plankton, at the lowest trophic level of a food chain, (at a concentration of 15 parts per million-ppm). Fish then consume the plankton and accumulating the mercury in their bodies, which themselves maybe eaten by larger fish or mammals, causing the top predators to accumulate mercury at far greater concentrations, e.g. 2,512-13,635 ppm than may have been originally released into the environment. This process is known as bio-magnification (Byrne, 1997) or bioaccumulation (Lamborg, 2014). (The burning of coal has contributed significantly to the mercury pollution of the seas, see section below "*10.8.1Toxins: Mercury*".)
6. Off-gassed chemicals can combine with one another creating unanticipated compounds which can also be inhaled and cause health problems.
7. It has been found that organisms (i.e. including humans) can be more sensitive to low doses than higher doses of a toxin. When toxicity tests are conducted on animals, usually large doses are given in order to discover how an animal's physiology reacts. However, it has now been found that large doses of a chemical can produce no apparent effects so that the chemical is then believed to be safe whilst masking the toxic effect at low doses. Some of the chemicals with a low dose toxicity are the endocrine disruptors which include heavy metals, polychlorinated biphenyls (PCBs) and plastic additives such as bisphenol-A (Coghlan, A., 2004). Behaviour patterns which are disturbed by low dose toxicity include: balance, foraging, mating and parenting, predator avoidance and learning. Recent research indicates that pregnant women exposed to high levels of phthalates (used in the manufacture of plastics) have children with lower IQs. Women are advised *"to avoid the use of plastics that are labeled 3, 6, or 7,* [in a triangle] *because of the chemicals they contain … The number of studies showing that these substances can cause harm is growing, but*

efforts by Denmark to try and get EU action on some phthalates had run into difficulties, largely because of concerns about the costs to industry" (Warhurst, 2014). Another illustration of the EU's ineffectiveness to protect the electorate and the lack of concern by the chemical industry about the welfare of consumers in order to protect its profits.

8. Unfortunately, the testing for toxicity of synthetic compounds used in the manufacture of materials is not thorough and in the USA a manufacturer need only to confirm that a new compound is not toxic; hardly a rigorous procedure! Extraordinarily, many body care and cosmetic products contain toxic substances (St-Onge, 2012) for example, talc (Dillner, 2013) used in body powders, is carcinogenic, while parabens are hormone disruptors. Although the risks from an individual synthetic compound may not be great, however, their regular use and application to the same body area can be toxic in the long term. Consequently, consumers play 'russian roulette' with their health, courtesy of ...!
9. Furthermore, as the western-consumer lifestyle spreads around the world so markets grow for products with synthetic materials. Epidemiologists have predicted substantial increases in cancer cases from 14 million in 2012 to 22 million within the next two decades (Gorman, 2010)(WHO, 2014).
10. It is thoroughly well documented that industry, their lobbyists and some politicians are more concerned to protect their own interests and profits at the expense of consumer welfare (Carson, 2000; Markowitz & Rosner, 2002; Oreskes & Conway, 2010; Lerner, 2010; Colborn, Myers & Dumanoski, 1996). This is especially the case in the USA due to its long opposition to communism during the cold war. Consequently, there is marked paranoia in business about any restrictions that would inhibit private enterprise and profitability. However, around the world neo-liberal capitalism means that many large corporations are unconcerned to curtail their business merely because they are responsible for creating either human or environmental hazards. This is illustrated by Syngenta and Beyer, the producers of neonicotinoid insecticides which are contributing to the demise of pollinating insects.

These ten points make it clear why designers should study pollution, its causes and toxicity, so as to avoid creating further pollution and poisoning.

There can be no doubt that pollution now affects us all. The joke is now that we are sufficiently full of chemicals that we ourselves are not fit for human consumption! Furthermore, the increase in human numbers and the growth of human activity means that pollution and its consequences will be more serious in the years to come. *"The chemicals industry is set to triple in size by 2050, with manufacturing shifting from North America and Europe to nations in Asia and South America. Many of these places currently lack robust safety regulations"* (Davies & Sanderson, 2014). Since we know that the existing regulations are neither rigorous in the USA nor the EU then prospects for 2050 are a cause for serious concern. *"In 2004 4.8 million deaths were attributable to exposure to selected chemicals"* (Davies & Sanderson, 2014). In the EU it is estimated that chemicals which have so far yet to be tested will take around 50,000 years to test for their toxicity and safety at the current rate of testing. It is questionable why the EU does not increase the laboratories to evaluate the safety of industrial chemicals in order to protect its citizens?

Maybe this problem has been partially recognized because in 1972 when the Conference on the Environment was held in Stockholm there were no more than ten nations with government departments responsible for the environment. Twenty years later Meadows et al. (1992) reported that there were well over a hundred nations with ministries or agencies responsible for the environment and there are many more now in 2013.

However, politicians, lobbied by industries do not always act to protect the electorate from the ruthlessness of big corporations. This has been most recently illustrated by the neonicotinoid pesticides which are decimating not only the bee populations but also the bird populations in Europe and other locations around the world. The European Union has implemented a 2 year moratorium on the use of the insecticides to provide time for a scientific assessment of the environmental impact of these chemicals. However, despite the moratorium, the Bayer company is suing the EU because of its loss of sales. This illustrates the power that corporations now possess against the democratic process despite the scientific evidence of the damage neonicotinoids are doing to ecosystems and wildlife. We will consider this dilemma more closely because sustainability is a much bigger issue than merely recycling paper and glass. Commercial interests and corporate threats challenge not only democracy but also threaten achieving a sustainable future.

10.5 The big bad wolf: Industry

A basic problem with commercial pollution and environmental damage is that it is not something that the majority of companies have traditionally considered outside their immediate infrastructure (Jowit, 2010). Resources, such as the atmosphere and the oceans, are not officially owned by anyone – they are a 'commons' which belong to us all (q.v. Glossary: Tragedy of the Commons (Hardin, 1968)). Consequently, no one has a bad conscience about polluting the commons and when they are polluted the cost does not appear on any company's balance sheet. In 2010 this headline appeared ...

10.5.1 "Cost of pollution by top 3000 companies in 2008 was $2.2 trillion"

In 2010, the United Nations Environment Program (UNEP) commissioned the London based consultancy Trucost to conduct a study into the activities of the world's 3,000 largest publicly quoted companies for the year 2008. Trucost calculated that should these companies be required to pay for their pollution and their environmental damage it would cost them $2.2 trillion, about a third of their profits! (Jowit, 2010).

The problem is the year on year drive for short term gain required for the companies' annual balance sheets. However, if companies were to extend their perception and concern of what constitutes their capital beyond their factories, laboratories and offices to the natural capital from which they draw their primary resources then the world could be in a much better state. As Pavan Sukhdev states: to annually loose 7% of your industrial capital is suicide but that is what is happening with our natural capital due to the damage by commercial pollution and environmental destruction! The analysis by the Trucost Agency revealed that the sources of pollution and environmental damage caused by the top 3,000 firms during 2008, which cost £1,46 tn or $2.2 tn, breaks down as follows:

- › Utilities £420 billion
- › Basic materials £312 bn
- › Consumer goods £281 bn
- › Industrials £201 bn
- › Oil and gas £175 bn
- › Consumer services £73.7bn
- › Total: £1,462,700,000 or $2.2 tn

Meanwhile, our loss of natural capital continues and now *"The Economics of Ecosystems and Biodiversity (TEEB) estimates that the costs for losses in biodiversity are around US$ 4.7 trillion per year – quantified in terms of the environmental and social costs of lost ecosystem services and pollution"* (TRUCOST, 2013).

10.5.2 Pricing Nature

Can we imagine the cost of this pollution in more tangible terms? The Chadwick Arboretum at the Ohio State University has provided labels by many of the trees on the University's central campus. The labels provide a balance sheet of the annual benefits or ecosystem services (see Chapter 5) provided by each tree so that, for example:
an Overcup oak *(Quercus lyrata)* with a crown diameter of 39 feet annually provides ecological benefits with an estimated total value of $504.33:

- › Storm water mitigation $173.76
- › Reduced atmospheric carbon $25.90
- › Energy (heating/cooling) $87.97
- › Air quality value $10.96
- › Aesthetic / History $205.74

If we can understand the ecological value of how one tree can benefit our existence, then it is possible to understand how we can place a fiscal value on an ecosystem and what the rest of Nature does for us. The New Scientist (Pearce, 2012) published the value per hectare of some different biomes.

- › Rainforest $23,000
- › Coral reef $1,195,000
- › Mangroves $18,000
- › Savannah $31,000

The financial value we attribute Nature is naturally an anthropocentric perception because we know that money is what many people value. We also know that Nature has an ethical, aesthetic and spiritual value for us too.

10.5.3 Corporate accomplices: politicians

Many politicians now follow neo-liberal capitalism and have promoted the interests of the big corporations at the cost of both the welfare of the electorate and of the environment. One of the best or saddest illustrations of political ineffectiveness has been the response to limit CO_2 emissions. *"Professor Bob Watson, former IPCC chair and UK government chief scientific adviser, said: "Passing 400ppm of carbon dioxide in the atmosphere is indeed a landmark and the rate of increase is faster than ever and shows no sign of abating due to a lack of political commitment to address the urgent issue of climate change – the world is now most likely committed to an increase in surface temperature of 3C-5C compared to pre-industrial times""* (Carrington, 2013).

Here are some milestones of the climate change history confirming political ineffectiveness in limiting CO_2 pollution and summarized by *The Guardian and in Landmarks for Sustainability* (Visser & van Heel, 2009):

- **In 1975** the journal Science published Wallace Broecker's famous paper entitled: *"Climatic Change: Are We on the Brink of a Pronounced Global Warming?"* in which he impressively extrapolated the atmospheric CO_2 ppm content based on 3% annual growth.
  In 1960 the value recorded by Charles Keeling on Hawaii was 314 ppm CO_2.
- **In 1970** the recorded value was 322 ppm CO_2. Broecker extrapolated that for 1980 CO_2 would climb to 335ppm and in 1990 351ppm, 2000 373ppm and by 2010 403ppm.
  Broecker was not far out in his scientific prediction because by 1988 (13 years after he published his paper) CO_2 emissions had reached 350 ppm and by 2013 400ppm!
- **1979:** First World Climate Conference.
- **1988:** Intergovermental Panel for Climate Change (IPCC) established.
- **1990:** the first Intergovermental Panel for Climate Change report appeared warning of the risks of global warming and finds 0.5°C warming (Broecker (1975) had predicted 0.58 by 1990!).
- **1992:** UN Framework Convention on Climate Change (UNFCCC) signed and Nations pledge to avoid "dangerous interference" with the climate.
- **1995:** 2nd IPCC report predicts significant socio-economic impacts.
- **1997:** Kyoto Protocol sets targets for 34 major economies.
- **2001:** 3rd IPCC report shows rising temperatures and sea levels.
- **2005:** Kyoto Protocol comes into effect seven years after being agreed.
- **2005:** EU GHG Emission Trading Scheme begins trading.
- **2006:** The Stern Review on *The Economics of Climate Change* is published.
- **2007:** 4th IPCC report shows 90% certainty of human cause of climate change.
- **2008** Poznan Communiqué issued, with 140 global business leaders uniting behind the key elements of an international deal on climate change.
- **2009:** UNFCCC Conference in Copenhagen. *"The 15th session of the Conference of the Parties to the UNFCCC and the 5th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol ... and was hosted by the Government of Denmark"* (http://unfccc.int/meetings/copenhagen_dec_2009/meeting/6295.php)
- **2009:** Nations agree to limit global warming to 2°C.
- **2010:** UNFCCC Conference in Cancún, Mexico. *"The Cancún Agreements are a set of significant decisions by the international community to address the long-term challenge of climate change collectively and comprehensively over time and to take concrete action now to speed up the global response"* (http://cancun.unfccc.int/).
- **2012:** *"The 18th session of the Conference of the Parties to the UNFCCC and the 8th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol opened on Monday, 26 November and continued until Saturday, 8 December 2012 at the Qatar National Convention Centre in Doha, Qatar."* (http://unfccc.int/meetings/doha_nov_2012/meeting/6815.php)
- **2013:** CO_2 hits 400ppm, the highest value for 4.5 million of years

(Visser & van Heel, 2009; Clark, 2013).

The indictment of politicians (together with many corporations) is confirmed by the inexorable climb of the Keeling curve, which despite the many (CO_2 emitting) conferences, 'political' agreements and other measures, smoothly continues on its exponential way without so much as a concessionary irregularity!

10.6 The Systemic Pollution of the World and ourselves

This brief and incomplete survey is intended to illustrate how ubiquitous pollution and toxins are in the environment and how we are dangerously changing our world. We will consider four environments: the atmosphere, the oceans, the land and ourselves and in each environment only consider two major problems, there are more of course. The aim is not so much to comprehensively describe the pollution in each major environment but rather to illustrate the ubiquity and impact of our actions in our biosphere where everything is connected. The environments are listed here together with the problems we shall explore. Once again some of the schesiological connections between actions and consequences will be emphasized:

The Atmosphere

- CO_2 emissions
- Black soot

The Oceans

- Toxins: Mercury
- Acidity and Warming

The Land

- Agricultural chemicals
- Fracking

Freshwaters

- Hormone disruptors
- Eutrophication

Ourselves and the man-made chemosphere

10.7 The Atmosphere

10.7.1 CO_2 emissions

Global warming is not difficult to understand. It works like this. The greenhouse gas carbon dioxide (CO_2), which we breath out, is a naturally occurring component of the atmosphere. Since the last ice age CO_2 together with the other greenhouse gases, methane and water vapour have maintained a nicely warm ('greenhouse') world. Sunlight entering the atmosphere warms the ground which reflects the sun's energy back into the atmosphere as infra-red radiation (like other warm bodies, we too emit infra-red radiation). If all the infra-red radiation actually escaped back into space then the average global temperature would be a freezing minus 15°C, but the Earth is warmer because of the 'greenhouse effect.' This is because the infra-red radiation from the Earth's surface does not all escape into space but is partially blocked and retained by the greenhouse gases (GHGs): CO_2, methane and water vapour which are warmed and warm the atmosphere as if a blanket had been thrown around the Earth. Consequently, the greenhouse effect is a perfectly benign state creating a snug atmosphere for the Earth's inhabitants. However, when the industrial revolution began, mankind started to burn the fossil fuel coal (which has locked up carbon) and release large quantities of CO_2 into the atmosphere in addition to the CO_2 which was naturally cycling in the Earth's system. Prior to industrial times there were about 280 parts per million of CO_2 in the atmosphere. Not a lot, you might think, however, *"a little greenhouse gas goes a long way"* (Walker & King, 2008) due to its efficiency at trapping infra-red radiation. The global warming potential (GWP) value which has been attributed to CO_2 is 1, and it is the GHG with the lowest impact value, however, it is the most prevalent and is measured in parts per million (ppm). Today, levels have reached about 400ppm and continue to climb. Furthermore, water vapour and methane are even better at trapping infra-red radiation than CO_2! Methane, is a smaller constituent of the atmosphere and is measured in parts per billion and during the past inter-glacials its abundance reached highs of about 700ppb (IPCC, 2007). In 2005 methane levels were recorded at 1,774 ppb. Methane (CH_4), which is the primary constituent of natural gas (currently being extracted by the 'fracking' process) has a 'greenhouse' effect or GWP of 79 (times that of CO_2). However, the effect of methane is magnified to a GWP of 105 (times that of CO_2) over 20 years due to all the aerosols (i.e. such as pollution and water droplets) in the air (Shindell, et al, 2009; Shindell, n.d.).

"Climate change is likely to be the predominant scientific, economic, political and moral issue of the 21st century. The fate of humanity and nature may depend upon early

recognition and understanding of human-made effects on Earth's climate (Hansen, 2009)" (Hansen & Sato, 2011). Pollution by CO_2 emissions are one of the nine planetary boundaries (Rockström, J., et al, 2009;) identified by Rockström and his team which should not be transgressed if we want to remain in the benign environment of the last 10,000 years (see Chapter 4 on Planetary Boundaries by Johan Rockström). The proposed safe boundary which they identified was CO_2 levels of 350 parts per million (ppm) however, in 2012, for the first time the level of CO_2 recorded touched 400ppm above the Arctic. Then in 2013 the Mauna Loa monitoring station on Hawaii recorded the new level of 400 ppm again. *"Every year in the last few decades, CO_2 concentrations have been going up by about 2 ppm per year"* Ralph Keeling, the atmospheric scientist, told Catherine Brahic. Brahic was interviewing the son of Charles Keeling who first began recording CO_2 levels on Mauna Loa in 1958 (Brahic, 2013). Keeling produced the now famous serrated 'hockey stick' curve of CO_2 emissions. Furthermore, *"We think the last time concentrations were as high as 400 ppm was between 3 and 5 million years ago, when the world was much warmer." added Ralph Keeling* (Brahic, 2013). During more recent times *"Antarctic and Greenland ice core data show atmospheric CO_2 fluctuations between 180 to 300 parts per million (ppm) over the glacial-interglacial cycles during the past 650,000 years"* (Lacis, et al. 2010). It is only within this shorter time span that our species has actually evolved (we only stopped interbreeding with Neanderthals less than 100,000 years ago (Gibbons, 2011)). It is now well established from the fossil record that temperature, CO_2, methane and sea levels all closely co-vary with temperature lagging rising levels of CO_2 (Shakun, et al., 2012; Hansen & Sato, 2011). The extra 100ppm of CO_2 emissions will create climate conditions not experienced during our species' evolution and therefore will demand innovations for circumstances beyond anything we have so far experienced as a species.

In 2011 the chance of limiting climate change to within 2°C was still believed to be *"technically and economically feasible, but politically impossible"* (Marshall & Brahic, 2011). The World Bank released a report (18 November 2012) before the Doha meeting predicting that global warming is now on course for 4°C rise by the end of the century (Anon. c, 2012).

The cause of CO_2 emissions is now virtually universally accepted by the scientific body (97% of all climatologists and scientists) to be the result of human activities primarily associated with the burning of fossil fuels. It should be noted that the climate change deniers, have neither in a single peer reviewed scientific paper nor any other publication (otherwise it would be well known and much cited) identified an alternative source for the rise in CO_2 emissions which has now reached 400ppm. The climate change counter-movement (Brulle, 2013), has created a hoax literature denying and doubting climate change to deliberately create public confusion. This movement has been financed (with circa $900million per year from 2003-2010) by more than 100 US industrialists and business foundations employing 'think tanks' to promote doubt and denial and involving similar strategies used to promote the harmlessness of smoking and cigarettes (Monbiot, 2007; Oreskes & Conway, 2010).

The emissions from the different fossil fuels are:

- 2.7 kg of CO_2 per kg of hard or black coal.
- 3.1 kg of CO_2 per kg of brown coal.
- 2.3 - 2.7 of CO_2 per kg per liter of oil, *"depending on whether it is crude oil, diesel, gasoline, fuel oil"* (Wagner, 2007).
- 1.8 kg of CO_2 per cubic meter of natural gas.
- 1 kWh of electric power: average value for Germany is 0.65 kg of CO_2 per kWh and from black coal power stations 0.82 kg of CO_2 per kWh (Wagner, 2007).

Apart from fossil fuels there are other causes of CO_2 pollution, for example, urbanization (concrete emits CO_2) and the change of land use (Karl & Trenberth, 2003). In 2008 Rosenzweig and colleagues (Rosenzweig, C., et al., 2008) reported on significant changes occurring in natural and physical systems on all continents and most oceans as a result of temperature increases which could not be explained by natural variation and therefore resulting from anthropogenic climate change as the cause.

Concern for the Consequences

Unfortunately, the consequences of global warming are not an imagined benign rise of 2°C that will make our lives sunnier and pleasanter. Firstly, the temperature will not rise everywhere by 2°C but unevenly, indeed, it may come as a surprise to know that in 2008 temperatures in the Arctic and far north were already more than 2°C above the average for the 30 years from 1951 to 1980 (Pearce, 2009). There will be a range of consequences or externalities, some of which many have already experienced, these impacts include:

- *"In many regions, changing precipitation or melting snow and ice are altering hydrological systems, affecting water resources in terms of quantity and quality.*
- *Many terrestrial, freshwater, and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances, and species interactions in response to ongoing climate change.*
- *Based on many studies covering a wide range of regions and crops, negative impacts of climate change on crop yields have been more common than positive impacts.*
- *At present the world-wide burden of human ill-health from climate change is relatively small compared with effects of other stressors and is not well quantified. However, there has been increased heat-related mortality and decreased cold-related mortality in some regions as a result of warming.*
- *Impacts from recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability.*
- *Climate-related hazards exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty.*
- *Violent conflict increases vulnerability to climate change"*
  (IPCC WGII AR5 Summary for Policymakers, 2014).

More specifically, *"China and India have experienced their coldest winter in decades and Australia has seen a four-month heat-wave with 123 weather records broken during what scientists are calling its 'angry summer'." "When you get records being broken at that scale, you can start to see a shifting from one climate system to another," said Tim Flannery, head of the Australian government's climate change commission, … "So the climate has in one sense actually changed and we are now entering a new series of climatic conditions that we just haven't seen before"* (Vidal, 2013).

Consequently, the concept of climate 'stationarity' is now obsolete due to climate change. Stationarity is the concept that meteorological systems fluctuate within an unchanging envelope of variable but predictable parameters. *"Stationarity is dead because substantial anthropogenic change of the Earth's climate is altering the means and extremes of precipitation, evapo-transpiration … Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system"* (Milly, et al. 2008).

Sea level rise and more hurricanes

Another indicator of global warming is that the oceans have significantly warmed by an average of 0.64 watts per square meter and there is even warming at levels below 700m (Trenberth, 2010). Some *"Observations have shown that 84% of the total heating of the Earth system since the 1950s is in the oceans."* This warming has led to thermal expansion and contributed 25% to the observed (Hegerl & Bindoff, 2005) mean sea-level rise of 1.6±0.2mm per year (Domingues, et al., 2008). Sea level rise is going to be enormously costly and the problem is already becoming apparent all around the world from Belgium and Bangladesh which have fragile coastlines to Tuvalu and New York. The problem will become extremely serious when sea-level rise combines with storm surges. The two hurricanes Rita and Katrina produced storm surges of 6 meters high (Marks, 2005) while Sandy drove a surge of salt water 4 meters high into Manhatten in October 2012 (Tollefson, 2012) causing an estimated $10 billion worth of damage.

In addition to causing sea-level rise, warm surface sea temperatures generate and increase the force of hurricanes. Satellite images of the Gulf of Mexico show that the surface temperatures were 28°C in the northern half of the Gulf and ideal for generating hurricanes (Anon. b, 2005). In fact both hurricanes Rita and Katrina passed over very warm water which boosts evaporation, fuels a hurricane's convection and increases its power (Marks, 2005). Sandy passed over water about 3°C above average of which 0.6°C could be attributed to global warming (Tollefson, 2012).

Carbon emissions from thawing permafrost

The global warming resulting from anthropogenic green house gas emissions (GHGs) is not only an immediate cause of concern for those living in the permafrost regions of the far north around the Arctic Circle but the rest of us too. *"In 2008, temperatures across much of the far north were more than 2°C higher than the 1951-1980 av-*

erage" (Pearce, 2009) and as a consequence two things are already happening:

1. The permafrost (a layer off soil that remains frozen throughout the summer and winter) is melting causing buildings and roads to collapse and trees to slant drunkenly that were previously supported by the underlying frozen ground.
2. In the permafrost regions plants can grow during the summer but when they die and winter comes there is little time for them to rot down, consequently, over hundreds of years the organic matter gets pushed down to become frozen in "suspended animation" (Kolbert, 2006). It is estimated that there are about 10.5 million square kilometers of permafrost retaining plant material.

Now that the Arctic is warming, the permafrost is melting and microbes are starting to rot the thawed leaves, roots and mosses and other organic material laid down over thousands of years and releasing carbon dioxide and methane. Some researchers reckon that there could be 900 gigatonnes of carbon that could be released from rotting Arctic soils. (Walker & King, 2008). A computer model of a low emissions scenario predicts 60% of the permafrost melting, however, we know that during the last years we have already had year on year record of emissions. *"In most parts of Alaska, the permafrost has warmed by three degrees since the early 1980s. In some parts of the state, it has warmed by nearly six degrees"* (Kolbert, 2006). The problem is that the tipping point is unknown. Vladimir Romanovsky, a permafrost expert says that, *"It is difficult to push permafrost over the threshold of thawing ... But after tipping it will go by itself"* (Walker, 2007). Romanovsky, concludes *"I think it's a time bomb, just waiting for a little warmer conditions"* (Kolbert, 2006).

The methane menace

Global warming is not only causing the Arctic permafrost to thaw enabling it to emit methane and CO_2 from the embedded rotting vegetation but rising temperatures are also causing methane to bubble up from the organic matter in sediments from thawing Siberian lakes. (Walter, 2006).

In 2009 more than 250 plumes of methane gas have been found bubbling up from the sea bed west of the Svalbard archipelago in Norway. This is of great concern because although methane makes up an even smaller proportion of the atmosphere than carbon dioxide (which has a global warming potential of 1) methane is a much more potent greenhouse gas which, due to its interaction with aerosols has a global warming potential 105 times that of CO_2 (Shindell et al. 2009). The rising plumes are coming from methane hydrates, a solid composed of methane and ice lying within sedimentary deposits under the seabed. These deposits are normally stable due to the high pressure of the water and the low temperatures occurring at these depths. However, in the past 30 years the Spitsbergen current has warmed by 1°C allowing the methane gas to bubble up in plumes. The scientists reported, however, that the methane appeared to be dissolving into the sea before reaching the surface. This would mean that it contributes to making the seawater more acidic (Anon., 2009).

Further confirmation of methane plumes rising in fountains more than half a mile wide in the Arctic Ocean were reported by Russian scientists. Prof Igor Semiletov *"saw hundreds of such fountains but estimated there could be thousands more"* (Roberts, 2012).

In October, 2012, similar plumes were also reported off the east cost of America where at intermediate depths the temperature of the Gulf Stream has warmed causing *"rapidly destabilizing methane hydrate along a broad swathe of the North American margin. The area of active hydrate destabilization covers at least 10,000 square kilometers of the United States eastern margin, and occurs in a region prone to kilometer slope failures ... This destabilization extends along hundreds of kilometers of the margin and may continue for centuries"* (Phrampus & Hornbach, 2012). Studies have proposed that a temperature increase of 5° Celsius at these depths could release sufficient methane to cause an extreme global warming event (hypothermal) similar to the Palaeocene-Eocene Thermal Maximum (PETM) which between 52 to 55 million years ago triggered a series of massive carbon releases causing acidification of the seas and further warming (DeConto et al, 2012). In other words the Earth system enters a positive feedback in which rising temperatures caused the release of soil organic carbon from circum-Arctic and Antarctic terrestrial permafrost. At that time the release was due to orbital forcing (irregularity) causing the hypothermal. Phrampus & Hornbach (2012) estimate that the flow and temperature changes to the Gulf Stream within the past 5000 years are warming the North Atlantic waters off the east coast of America by up to 8° Celsius causing the current destabilization of an estimated 2.5 gigatonnes of methane hydrate. However, this may be only a fraction of the methane hydrate destabilizing globally.

In March 2015 a paper was published reporting the *"Recent accelerated warming of the continental shelf off New Jersey …"* (Forsyth et al 2015) is not just occurring in the surface waters but taking place throughout the water column. This development could be very significant for the stability of the methane hydrates within the sea bed in this region.

It is to be hoped that we have not yet triggered a massive carbon release, however, Skarke and his colleagues (2014) report that about 570 sea-floor methane plumes have been detected by sonar at depths between 50 and 1,700 m between Cape Hatteras and the Georges Bank along the northern US Atlantic margin (Skarke et al, 2014). The seepage may be triggered by ongoing warming of intermediate waters. The scientists suggest that there could be tens of thousands of methane seeps still to be discovered!

We can therefore learn from the Earth's geological past that raising the Earth's temperature, be it caused by either an orbital irregularity or anthropogenic CO_2 emissions, we are in danger of triggering a hypothermal like the Palaeocene-Eocene Thermal Maximum (PETM).

One might even conclude that we may have now already passed a threshold since methane gas has been reported venting from such widely distributed locations. These now include the East Siberian Arctic Shelf (Anon, a. 2010) as well as from the opposite side of the North Pole south-west of the Svalbard archipelago off Norway (Anon, 2009) and further south at latitudes 32° to 35° North along the Carolina Rise off the east coast of North America due to temperature changes in the Gulf Stream (Phrampus, Hornbach, 2012; Skarke et al, 2014).

10.7.2 Aerosols, Black soot, & particulates

Aerosols are small suspended particles in the atmosphere such as water in the form of fog, mist and clouds but aerosols can be composed of quite a diversity of substances, including: different chemical compounds of varying shapes and sizes and originating from a variety of sources. They occur ubiquitously in the Earth's atmosphere and sources include incomplete burning of diesel fuel, biomass, dung, wood and coal and occasionally volcanic eruptions. Aerosols are important pollutants affecting both the climate, human health and also causing acid rain.

Acid rain

Acid rain is a collective term caused by the emissions of carbon dioxide, nitrous oxide and sulphur dioxide gases emitted along with aerosols from vehicle exhausts and coal burning power stations. Scientists have discovered that once the sulphur dioxide is in the atmosphere and meets hydroxyl radicals it transforms into sulphur trioxide which only needs several molecules of water to complete the transformation into sulphuric acid. This means that the atmosphere can become acidic enough to cause environmental damage although there may be insufficient moisture for it to fall as rain (Coghlan, 1997). Carbon dioxide dissolves in rainwater to become carbonic acid and nitrous oxide forms nitric acid with rainwater (Byrne, 1997).

Acid rain can fall far away from the source of the emissions that caused it and it is known as a trans-boundary pollutant and consequently it is an international problem. Acid rain has extensively damaged forests in different countries and changed the pH of many lakes in Scandinavia so that crustaceans are unable to create their shells and this in turn has affected food chains and depleted fish populations. In addition, acid rain causes aluminium to leach out of the soil and enter lakes and rivers where it may kill the fish. Once again we can recognize another schesiological chain of events difficult to anticipate and which confirms the interconnectivity of our planet.

Aerosols & climate

The effect of aerosols on climate change has been difficult to understand due to the different properties aerosols possess. The principal anthropogenic scattering aerosols are sulfate, nitrate and organic carbon. They *"consist of a mixture of light-absorbing and light-scattering aerosols and therefore contribute to atmospheric solar heating and surface cooling. The sum of the two climate forcing terms – the net aerosol forcing effect – is thought to be negative and may have masked as much as half of the global warming attributed to the recent rapid rise in green-house gases"* (Ramanathan, et al. 2007). That is to say that the effect of these scattering aerosols may have masked the warming caused by CO_2 emissions and resulted in a cooling during the mid 20th century (Myhre, 2009) instead of an increased warming. Furthermore, the aerosol, black soot or black carbon, absorbs radiation. What scientists now understand is that *"the relative increase in anthropogenic black carbon (absorbing aerosols) is much larger than the overall increase in the anthropogenic abundance of aerosols"* (Myhre, 2009). Consequently, black carbon may be second to CO_2 in contributing to global warming. Unfortunately, there are different kinds of soot which make climate modeling difficult: "organic carbon" from forest fires can brighten clouds and cool the climate, while diesel engines followed by coal burnt in homes and small industries are the worst polluters and should be cleaned up to achieve the most cooling for the climate (Kerr, 2013). The balance of sulphates to soot in the atmosphere has changed in recent years. Scientists at the Goddard Space Centre have calculated that due to a decrease of light-reflecting sulphates causing a cooling and an increase of soot which absorbs solar radiation in the atmosphere; then this probably accounts for as much as 45% of the warming in the Arctic during the last 3 decades (Shindell & Faluvegi, 2009).

Black carbon is produced by burning forests and grasslands, diesel emissions and the extensive use of cooking fires and stoves burning coal or dung across China and India. The ubiquitous use of fires and the burning of biomass for cooking over extensive regions of Asia causes atmospheric brown clouds which contribute as much to global warming as anthropogenic greenhouse gases. They also increase the heating in the lower atmosphere by about 50%. Ramanathan and his colleagues (2007) propose that the combined warming may be the reason for the warming of between 0.15-0.3K per decade during recent decades and it is thought to be the major cause of the melting and the retreat of the Himalayan-Hindu-Kush glaciers. Ramanathan et al. (2007) write that *"The rapid melting of these glaciers, the third-largest ice mass on the planet, if it becomes widespread and continues for several more decades, will have unprecedented downstream effects on southern and eastern Asia."*

Soot particles circulate in the air for about a week before falling back to Earth. Consequently, reducing soot emissions could have a dramatic effect by reducing global warming, but unfortunately the diverse sources of black carbon are unlikely to make this measure possible. Furthermore, although the return to the ground of black carbon is good for the atmosphere it is having an unfortunate effect in the Himalayas where it is falling on the glaciers.

An Italian climate scientist, Angela Marinoni, has found high concentrations of black carbon above 5000 meters in the Himalayas. Analysis of the air's circulation patterns show that air currents bring soot from as far away as Europe. Unfortunately, the Himalayan valleys act like chimneys, channeling pollutants from the Indian plains and elsewhere up onto the glaciers where the soot is deposited. The black soot changes the albedo of the snow so that 2-5% of the sun's rays are now absorbed instead of being reflected by the snow. It has been calculated that this will increase the melting of the glaciers by 12-34%. This additional melting has already caused an increase of 26% of the larger and more numerous lakes thereby reducing pastures and increasing the dangers of floods. The soot has now been recognized as a significant factor in the melting of the Himalayan glaciers which have receded by 17% over the last 30 years (Anon, 2010).

The melting of the Himalayan glaciers is incredibly serious because they provide the headwaters (sources) for the Indus, Ganges, Brahmaputra, Yangtze and Yellow rivers on which an estimated 1.4 billion people depend for their regular water supply (Immerzeel, et al 2010). The glaciers provide these rivers with a seasonal supply of melt-water but in a warmer world there will be less snowfall in winter and the melting of the winter snow will occur earlier and not during the summer and autumn when there is normally a stronger demand (for growing crops etc. See Chapter 6 Water and 'artificial glaciers'). Barnett et al (2005) warn that *"With more than one sixth of the Earth's population relying on glaciers and seasonal snow packs for their water supply, the consequences of these hydrological changes for future water availability – predicted with high confidence and already diagnosed in some regions – are likely to be severe."*

Aerosols & health

Clearly, it is imperative that cooking stoves that trap soot, such as the Chulha stove designed by the Philips design team, are made available throughout these regions to restrict the "brown clouds." The original motivation for creating the Chulha stove design was to reduce the number of people dying from smoke related illnesses because every year about 1.5 million people die because of accidents and lung disease from inhaling the smoke from cooking on improvised stoves. The

Chulha design won an Index award, however, the Chulha stove has not merely the potential to reduce the 1.5 million deaths but also contribute to the water security of 1.5 billion people in Asia who every season depend on the Himalayan melt-waters.

Aerosols are a significant health hazard, particularly the smallest particulates from diesel fumes. Small particles called PM2.5s are able to enter the blood stream and impair the function of blood vessels and also cause more respiratory damage than the larger PM10 particles. In the UK these particulates are a significant risk factor for heart attacks due to exposure to traffic fumes (Boseley, 2013).

Another source of particulates are ship exhausts which annually emit between 1.2-1.6 million tonnes of carbon particles which are less than 10 micrometers together with sulphur and nitrogen oxides. These particulates can also enter the bloodstream and cause inflammations, heart or lung failure and cancers. Large ships use cheap low grade "bunker fuel" which causes 60,000 deaths a year along busy shipping routes (Vidal, 2008).

Finally, it is well known that urban air pollution is mutagenic and that airborne particles cause lung cancer. Minute inhaled particles carrying chemicals such as polycyclic aromatic hydrocarbons (PAHs) from tobacco smoke, vehicle and coal emissions cause lung tumours. However, more than that, there is evidence that urban air pollution causes heritable genetic changes. Scientists have found that the offspring of mice kept in an industrial location near Lake Ontario displayed an increased rate of mutations but these could be reduced by ~50% when the air was filtered and cleansed with a very fine particulate filter. The PAH mutagens present in the air penetrate deeply into the lungs and entering the blood circulate throughout the body. It was found that PAH's that reached the testis could cause changes to sperm DNA which can then be transmitted to the offspring. Further evidence has shown that PAHs inhaled by pregnant mothers can also interfere with human development resulting in low-birth weight babies (Samet, et al., 2004).

10.8 The Oceans

In Chapter 3 *"Why we have to design for sustainability – the new paradigm, schesiological links and externalities"* we illustrated the problem that everything must go somewhere with the example of plastic pollution in the oceans, consequently, consequently, we will address other issues here (there are enough!).

10.8.1 Toxins: Mercury

Fossil fuels are under the spotlight because they are the primary cause of CO_2 emissions, the dangers of which are already well known. However, fossil fuel combustion, and mining, but particularly the burning of coal also contribute to the mercury pollution of both the air and the oceans. Mercury occurs naturally in many rocks, including coal and so when it is burnt it readily vaporizes into the air. The *"Burning of coal is the largest single anthropogenic source of mercury air emissions, having more than tripled since 1970. Coal burning for power generation is increasing alongside economic growth. The releases from power plants and industrial boilers represent today roughly a quarter of mercury releases to the atmosphere. Household burning of coal is also a significant source of mercury emissions and a human health hazard. Although coal contains only small concentrations of mercury, it is burnt in very large volumes. Up to 95% of mercury releases from power plants can be reduced. This can be achieved by improving coal and plant performance, and optimizing control systems for other pollutants"* (Sloss, 2014). A recent study (Lamborg, 2014) reports that human activities, notably coal burning, has caused a tripling of mercury in the surface waters of the oceans! This is due to mercury vaporizing into the atmosphere where it might remain from a few months for up to a year and consequently, it can be widely dispersed. However, it is eventually rained out into the oceans where it converts to the neurotoxin methylmercury. It is calculated that the oceans are polluted with between 60,000 to 80,000 tons of mercury and two thirds of that is in water shallower than 1000 meters. Furthermore, it is in the top 100 meters that the mercury content has tripled since pre-industrial times (Yeston, 2014). The authors of the study note that "*… the impact of human Hg [mercury] emissions is not uniform within the ocean. Therefore, the extent to which methyl mercury concentrations in fish have changed since industrialization, and might change in response to further perturbation (perhaps as much as a fivefold increase over pre-industrial levels by 2050) can be determined only following studies of the vertical patterns in Hg methylation dynamics …*" and distribution in the oceans (Lamborg, 2014). We can now see that the debate about whether nuclear power or fossil fuels should provide the bridging power source to 100% renewable power is more complicated. We need to weigh the disadvantages of managing spent radio-active fuels for 1000s of years or the risk of 2-4°C of global warming likely to tip geophysical systems into positive feedback (permafrost melting, methane hydrates destabilizing) exacerbating further global warming and also the pollution of the seas and marine food-chains with mercury. The energy bridge to renewables is not a simple 'either / or' choice because different factors must be weighed against each other.

Methylmercury poisons the central nervous system. Pregnant mothers consuming fish or shellfish containing methylmercury causes a range of symptoms in newborns; these range from impaired neurological development to severe neurological handicap depending on the quantity of methylmercury consumed by the mother. The most infamous outbreak of methylmercury poisoning occurred in 1956 in the coastal town of Minamata, Japan and again in 1968 due to the pollution of coastal waters by the Chisso Co. The company produced chemical fertilizers, acetic acid, vinyl chloride, acetaldehyde, and plasticizers. *"Minamata disease"* as mercury poisoning became known *"was caused by eating fish and shellfish contaminated by chemicals in the industrial waste discharged by Chisso,"* into the Minamata Bay. The concentration of mercury built up to levels above 25 parts per million. After a period of dredging and reclamation the mercury levels dropped so that by 1994 the mercury pollution is as low as in neighbouring areas and there are no fish that average *"above the provisional national standards (0.4 ppm total mercury, 0.3 ppm methyl mercury)."* Although the Chisso company realized that it was the cause of the Minamata disease it did not suspend its operations. In 1973 the Chisso Company was tried and paid compensation to those afflicted with the Minamata disease, with a final compensation paid in 1996. The publication *"Ten things to know about Minamata disease"* produced by the Minamata Disease Municipal Museum (2001) concludes that: *"Minamata disease teaches us the importance of not destroying nature; of living with the awareness that nature gives us life; of considering food safety and the interconnectedness of people, rivers, and the sea; of reducing and recycling home and industrial waste; and of never turning our eyes away from local problems"* (Minamata Disease Municipal Museum, 2001). The Minamata case is a tragic story which should never be repeated. However, even when levels of mercury are low, mercury in a pollutant bio-accumulates throughout the foodchain concentrating in the top predators, notably mankind.

A great achievement in the US has been the finalization and implementation by the Environmental Protection Agency of *"new federal standards on toxic pollutants and mercury emissions from coal power plants"* (Mooney, 2011).

Nonetheless, the level of mercury in the oceans has tripled in the top 100 meters since pre-industrial times due to human activities including coal burning which releases the mercury into the atmosphere. The mercury falls with the rain into the oceans and converted to methylmercury enters the food chain and bio-accumulates in the fish which can be served on our plates.

10.8.2 Acidity and Warming

How can driving a car have the schesiological consequence of dissolving the shells of marine animals? Indirectly our CCO_2 pollution is impacting on the oceans in three major ways. Our CO_2 emissions are making the seas warmer, causing the water to expand and so raising sea-levels and also more acidic.

About a third of CO_2 emissions being produced by human activities such as burning fossil fuels, deforestation and cement production are being absorbed into the oceans (Siegenthaler & Sarmiento, 1993; Khatiwala, Primeau & Hall, 2009). This has the advantage of inhibiting the greenhouse effect by limiting the amounts of CO_2 from entering the atmosphere. However, the downside is the increasing amount of CO_2 being absorbed by the oceans changing the chemistry of the sea causing the pH to drop so that the seawater is becoming more acidic. This change in the seawater is impacting on many marine organisms which use calcium carbonate as a basic building material for their bodies. If you have ever used vinegar to clean a kettle which has become 'furred up' so as to dissolve the calcium carbonate then you can begin to understand what happens to the shells of marine animals in acidifying seawater. The absorbed CO_2 causes the seas to be under-saturated with calcium carbonate. As atmospheric CO_2 levels in the atmosphere rise (CO_2 level in May 2015, 403.94 ppm (Tans & Keeling, 2015) the pH will continue to drop and acidity will increase. "On the pH scale, *which runs from 0 to 14, solutions with low numbers are considered acidic and those with higher numbers are basic. Seven is neutral. Over* *the past 300 million years, ocean pH has been slightly basic, averaging about 8.2. Today, it is around 8.1, a drop of 0.1 pH units, representing a 25-percent increase in acidity over the past two centuries"* (National Geographic, 2014). Over the last 800,000 years during which time there have been 9 glacial and interglacial periods the average ocean surface water pH has ranged between about 8.1 – 8.3 (Barker & Ridgwell, 2012).

The biological impacts of increasing ocean acidity are various and will mean that all marine organisms will have to expend more energy *"maintaining a particular pH inside of their cells to ensure biochemical processes operate efficiently"* (Barker & Ridgwell, 2012). In addition, more energy will also be required for keeping the levels of calcium they require for their calcareous body structures. *"The mineral calcium carbonate ($CaCO_3$) is a fundamental building block for numerous marine organisms, from microscopic algae to reef-building corals"* (Barker & Ridgwell, 2012). Furthermore, different groups of animals will be affected differently so that corals, echinoderms and molluscs are more sensitive than are crustaceans, but *"larval fishes may be even more sensitive that the lower invertebrates."* Altogether, acidification could cause substantial change in ocean ecosystems and species composition during this century (Wittman & Pörtner, 2013). Food chains could be severely affected and at worst collapse and new ones become established, but this is uncertain. What is clear is that acidification will change life in the oceans.

Let's now consider ocean warming. We know that the global warming is occurring and that the heat dissipates into 'sinks' or is sequestered or in other words is taken up somewhere. However, scientists have been puzzled by the fact that the average global mean temperature of the planet has remained roughly constant so far during the present century. Something which *"Michael McPhaden of the National Oceanic and Atmospheric Administration in Seattle. "Climate change denialists have made hay with [the hiatus] in an attempt to discredit the science and confuse the public," he writes in an e-mail"* (Kintisch, 2014). This inconsistency from the expected increase in warming due to the inexorable rise of CO_2 emissions was baffling to climatologists. However, the 'hiatus' has now been explained, although some had suspected *"the mighty Pacific Ocean, which has been sending vast slugs of cold bottom water to the surface"* (Kintisch, 2014). It appears that the Atlantic Ocean has been storing the 'missing heat' deep within its depths and playing a key role in the warming hiatus. The scientists studied tens of millions of readings of both temperature and salinity in order to understand how the Atlantic Ocean's heat content has changed over time and it has somehow absorbed heat that otherwise would have caused the surface to warm. Although the scientists cannot agree over the details it appears that the Atlantic and Pacific Oceans interact in some way with one ocean driving the other; nonetheless, *"Over the last 14 years … water below 300 meters in the North and South Atlantic oceans has stored more energy than the rest of the global oceans combined. "We found the missing heat," Chen concludes. A key heat storage mechanism, they say, is the "conveyor belt" current that moves salty tropical water to the North Atlantic, where it sinks, carrying heat with it. Chen and Tung think that, because of a natural cycle, the conveyor sped up during the 1990s and slowed around 2006. Atlantic heat storage has meanwhile "gone straight up" by 30 zettajoules (sextillion joules) since 1999, while global air temperatures remained relatively flat, Tung says. In contrast, their data show little heat being stored in the deep Pacific. "We were surprised – especially by the difference between the two oceans," Chen says"* (Kintisch, 2014; Chen & Tung, 2014).

It does not take rocket science to realize that the thermal pollution of the oceans is an enormous danger because warming waters will destabilize the methane hydrates (Phrampus, & Hornbach, 2012). Indeed, this is already happening along with recent accelerated warming (Forsyth, et al. 2015) as has been described above.

10.9 The Land

Let us turn now from the pollution of the commons of the ocean via the atmosphere to two examples of pollution occurring on land.

10.9.1 Agricultural chemicals

Insecticides & Bees

The first book to raise the alarm about the danger of pesticides was Rachel Carson's classic book *'Silent Spring'* published in 1962. *Silent Spring* has been recognized as one of the most influential books of the twentieth century because for the first time it gave large numbers of people an environmental awareness. Indeed, it justly deserves the accolade of having 'kick-started' the environmental movement. Carson's book brought about a change in the US policy on the use of pesticides and a ban on the use of DDT (dichloro-diphenyl-trichloro-ethane) and other pesticides. She demonstrated that commercial scientists *"at best they had not done their homework, and at worst they had withheld the truth."* Carson's book ultimately resulted in the formation of the US Environmental Protection Agency (Visser, 2009). In a counter measure to Carson's claims the chemical lobby first attempted to sue the publisher of *Silent Spring* and also persuade the public that pesticides such as the now banned DDT were essential to US agriculture, harmless and beneficial. However, when their efforts failed, the agro-chemical industry then spent a quarter of a million dollars attacking her science and finally denigrating Carson herself (Lear, in Carson, 2000). A similar story is now being repeated with the neonicotinoid insecticides and pollinating insects.

Few can fail to have heard about how honey bee colonies are suffering from colony collapse disorder (CCD), which is now pervasive around the northern hemisphere (Henry, et al. 2012). In the United States CCD began in 2006 and since then an estimated three million colonies have died. A number of agencies were suspected of being the cause for CCD including parasitic mites, and viral and bacterial infections. However, in the USA scientists analysing samples of wax and pollen found 121 different pesticides in the combs. Indeed, the bees were able to recognize that some of the pollen they were collecting was toxic because they sealed it up so that it would not be used by the colony. This 'entombed' pollen was found to contain very high levels of chemicals compared with pollen in adjacent cells (Anon, 2011, Dispatches, Guardian Weekly).

Clear evidence has now accumulated that at least one of the causes of CCD are the neonicotinoid systemic pesticides. 'Systemic' means that the insecticide permeates the plant's entire system during its growth and persist throughout the plant's life. Furthermore, the pesticide is applied to the seeds before sowing. Experiments by scientists using tiny radio tags on forager honey bees have confirmed that sub-lethal doses of neonicotinoid insecticides affect the homing ability of honey bees due to impairing their orientation abilities (Henry, et al. 2012). Honeybees that are unable to find their way home are as good as dead. Similar research into bumblebees in which the effects of an insecticide combining both neonicotinoid and a pyrethroid compounds, provides further confirmation of the disturbing effects on the bumblebees' behaviour with 50-55% workers failing to return to their nests compared with the workers of the control colonies (Gill, et al, 2012). In another experiment on bumblebees it was found that the neonicotinoid insecticide imidacloprid caused an 85% reduction in the production of new queens compared with control colonies (Whitehorn, 2012) thereby threatening the longer term existence of the species.

The science that insecticides and neonicotinoids are causing the demise of bees has been confirmed (Henry, et al. 2012; Gill et al. 2012; Osborne, 2012) The fact that the neonicotinoid insecticide is not lethal to bees, i.e. it does not directly poison and kill them dead and therefore, so goes the reasoning of the manufacturers, there should be no ban. However, bees are social animals and neonicotinoids, a neural poison, are lethal to their behaviours on which their survival depends.

"Three quarters of global food crops depend at least partly on pollination by animals, usually insects. These crops form an increasing fraction of global food demand" (Tylianakis, 2013). Bees contribute about 80% of insect pollination (Gill, 2012). In February 2013 an expert commission of the European Union met to consider a proposed two-year ban on the use of neonicotinoids following the European Food Safety Authority recommendation which deemed that the use of these pesticides is an unacceptable risk to pollinating insects? The ban failed because Germany and the UK did not give their vote to support the ban due to lobbying from the chemical industry. The companies which dominate the neonicotinoid market are Syngenta and Bayer. In the USA 59 million hectares of crops are protected by systemic insecticides, the most commonly used is imidacloprid, a neonicotinoid pesticide. It is therefore not surprising when the chief operating officer of Syngenta, John Atkin said after the ban's failure *"We are pleased member states did not support the EC's shamefully political proposal. Restricting the use of this vital crop protection technology will do nothing to help improve bee health"* (Carrington, 2013). Atkin's statement is flawed since how does he know that the ban will do nothing to help improve bee health, not forgetting that neonicotinoids are insect nerve toxins? The agro-chemical industry's response to Rachel Carson's work, fifty years ago, was similar to Mr Atkins, namely, that pesticides are essential and harmless (in this case to bees). The fact is that neonicotinoids disturb the workings of the

excitatory neurotransmitter receptors in insects and bees are insects (Henry, 2012). Syngenta and Bayer CropScience make money. Syngenta and Bayer CropScience *"have claimed again and again that they are safe"* (Editorial 2013, New York Times). Claiming that neonicotinoids are harmless is the start of what Oreskes and Conway (2010) call the *"Tobacco strategy"*. One group of scientists (working for the companies) creates doubt and attempts to undermine the work of another group of scientists working for the truth and health of the environment and the public. The same strategy has been used by others wanting to protect and increase their profits concerning issues such as: global warming, smoking, passive smoking, lead, acid rain, asbestos, CFCs and the ozone hole, the European bio-fuels fiasco etc. Lynn Dicks writing in Nature (2013) concluded that *"… we can be fairly sure that the decision to restrict neonicotinoid use in Europe will not be made on the basis of avoiding 20% yield losses in crops, or saving the world's bees from extinction."*

The argument of the agro-chemicals industry is that the world cannot be fed without these chemicals, however, what is more sure is that the world cannot be fed without pollinating insects.

If nothing else, we can learn from this that it is humans that make achieving a sustainable future difficult. As much as we might acquire environmental literacy, it is of little use without an understanding of human psychology and the profit motive driving corporations.

10.9.2 Fracking

There are enormous deposits of natural gas, which is composed mostly of methane, on the Earth both under the sea and in deep strata on land. During the past decade the technique has been developed to extract the gas from the shale by a method known as *"high-volume, slick-water hydraulic fracturing"* or fracking. The process involves the precise drilling into shale strata, sometimes more than 2 kilometers below the surface and then drilling horizontally to follow the strata for more than 3 kilometers. The process then involves forcing into the well (the bore) about 20 million liters of water under great pressure together with large volumes of sand and a toxic cocktail of 200,000 liters of acids, biocides, scale inhibitors, friction reducers and surfactants. *"Many of the fracking additives are toxic, carcinogenic or mutagenic. Many are kept secret."* (Howarth, Ingraffea, Engelder, 2011). About one fifth of the fracking fluid returns to the surface within the first fortnight of operation and throughout the well's life more fluid continues to flow out of the well. In addition to the chemicals used in the fracking process other chemicals extracted from the shale also are brought to the surface in the returning fracking fluid. These include: *"natural salts, heavy metals, hydrocarbons and radioactive materials from the shale, posing risks to ecosystems and public health when these return to the surface. This flowback is collected in open pits or large tanks until treated, recycled or disposed of"* somehow (Howarth, Ingraffea, Engelder, b. 2011). The treatment of this fluid is just one problem.

The problems of fracking have been hotly debated. On the one side local residents campaign to protect their environment and water from the risk of pollution against large energy companies and multinationals who maintain that the resource is too valuable not to extract. The film *Gasland* (Fox, 2011) has illustrated the problems of pollution with some homeowners either being unable to drink the water from their own wells or being able to light the methane gas coming out of their water taps due to fracking chemicals or methane gas polluting the water table. Although experts claim that there are risks due to human error and in the case of the Deepwater Horizon catastrophe criminal negligence, can these risks be taken which might pollute a resource more essential than gas: water. A resource which *"in 2010 the United Nations declared it a fundamental human right"* (Lubick, 2014).

Many geologists, especially those in the gas industry, claim that fracking is geologically safe. However, Prof Ingraffea, an expert on fracking technology, claims that geologists cannot guarantee what happens 2km below the earth's surface. Afterall, geological uncertainties make difficult the decisions concerning the burying of nuclear waste. However, these uncertainties do not appear to be a consideration with regard to the promoted safety of fracking and not to forget the future water security. Some of the dangers for pollution are:

› Fractures can link up in the strata between wells or fracks so that a disused and sealed well can blow out fracking fluid from a well in use due to the enormous pressures used in fracking. The blowout being caused by the fissures of one frack joining up with the fissures of another frack.

- The concrete used to seal wells can eventually decay enabling the movement of fracking chemicals under the earth.
- Small earthquakes can occur which create fissures which can facilitate the unintended movement of fracking fluids through strata.
- *"Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the life-time of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas."* (Howarth, Santoro, Ingraffea, a. 2011).
- An issue hotly promoted by the shale gas industry and politicians is that shale gas is claimed to be a clean fossil fuel. Unfortunately, this does not appear to be the case because Howarth et al. (a. 2011) in a study published in the journal Climatic Change say that *"Compared to coal, the footprint of shale gas is at least 20 percent greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years,"*... In response to criticism Howarth replied that *"In fact, we came up with two things that surprised me. First, I expected the indirect CO_2 emissions from trucks moving frac water, the compressors, the drills, etc., to be greater than we found. They are actually pretty small, when you add up all the numbers. And second, the influence of methane is greater than I expected"* (Soraghan, 2011).
- Therefore shale gas does not provide a clean "bridge" to reach renewable energy generation. McJeon and his team of colleagues (2014). *"show that market-driven increases in global supplies of unconventional natural gas do not discernibly reduce the trajectory of greenhouse gas emissions or climate forcing."* Furthermore, there is a danger that the abundant use of natural gas may actually contribute to greenhouse gas climate forcing in a range from –0.3 per cent to +7 per cent.
- Finally, we should remember that the global warming potential of methane is enhanced by the aerosols in the atmosphere to about 105 times the global warming potential of CO_2 (Shindell et al (2009).

10.10 Freshwaters

10.10.1 Hormone disruptors

A weakness of a large part of humanity's perception about itself is that it is above nature and separate from it, this is not so. People are an integral part of Nature and intimately interwoven with each another as the cycles of water, air and nutrients flowing through us confirm. The active ingredient of the contraceptive pill, ethynyl-oestradiol (EE2) is a chemical which is subsequently excreted and eventually escapes through the treatment of sewage at waste-water management plants and finds its way into the environment, lakes and rivers. Today many of Europe's rivers are polluted with this particular endocrine-disrupting chemical EE2 along with others (Gilbert, 2012).

Endocrine-disrupting chemicals may be simply defined as chemicals or chemical compounds which interfere with the functioning of the body's normal hormone activities. Endocrine-disrupting chemicals (EDCs) are found in various man-made products including: pesticides, metals, additives or contaminants in food and personal care products (Bergman et al, 2014). The US National Institute of Environmental Health Sciences writes on its web page that *"A wide range of substances, both natural and man-made, are thought to cause endocrine disruption, including pharmaceuticals, dioxin and dioxin-like compounds, polychlorinated biphenyls, DDT and other pesticides, and plasticizers such as bisphenol-A. Endocrine disruptors may be found in many everyday products – including plastic bottles, metal food cans, detergents, flame retardants, food, toys, cosmetics, and pesticides"* (NIEHS, 2014). Not very cheering.

Through the process of evolution, various chemicals have evolved to perform physiological functions in animal bodies and due to their success in performing signaling functions hormones have not significantly changed throughout evolution as much as animals' anatomies have done. Consequently, while ethynyl-oestradiol (EE2) not only has a contraceptive effect in humans by disrupting the female body's normal reproductive cycle it also disturbs the sexual physiology of other organisms including fishes. The EE2 escaping into waterways from sewage treatment plants has had the effect that *"Many of Europe's rivers are home to male fish that are 'intersex' and so display female sexual characteristics, including female reproductive anatomy. Some males also produce vitellogenin, a protein normally found in eggs that can be induced in males by hormone exposure. In one of the largest studies of the problem, the UK government's Environment Agency found in 2004 that 86% of male fish sampled at 51 sites around the country were intersex ... The feminization affects fish health and lowers the sperm count in males, raising the risk of a population crash"* (Gilbert, 2012).

Another chemical, diclofenac, which is used as an anti-infammatory drug is renown for having decimated the vulture populations in Asia, and is also affecting European fishes by disrupting cell function in their livers, kidneys and gills (Gilbert, 2012).

In 2012 a landmark regulation was proposed by the EU aimed at cleaning Europe's waterways of pollution by pharmaceuticals and limiting the concentrations of these widely used drugs. Once again this has resulted in intense lobbying by two big stakeholders, in this case the water and pharmaceutical industries *"which say that the science is uncertain [a standard corporate rebuttal] and the costs too high. European Union (EU) member states, alarmed by cost estimates of tens of bil¬lions of euros, seem to agree. Researchers and environmentalists question those estimates, and argue that the proposal should be judged principally on what they say is strong scientific evidence, rather than on financial concerns"* (Gilbert, 2012). The result of the vote on 28 November 2012, by the EU parliament was that due to the unacceptable costs of "end-of-pipe" purification, action would be delayed on the issue for a decade (Carr & Moroz, 2012). *"Environmental scientists say that the case for action will only get stronger. Fish populations may be stable now, but a study of fathead min¬nows (Pimephales promelas) in an experimen¬tal lake in Canada has shown that exposure to high levels of EE2 triggered a population crash. And researchers think that the EU is missing a chance to set a global precedent. "It's a test case for regulating pharmaceuticals in the water," says Jobling. "If they don't regulate on EE2, they won't regulate anything"* (Gilbert, 2012).

A year later in July 2013 the ClientEarth group of lawyers who work to protect the environment *"released a report [Hiester, et al. 2013] indicating that manufacturers are ignoring, misrepresenting or disregarding the potential of certain chemicals to disrupt hormonal systems (EDCs)... The five substances investigated in the report are diethyl phthalate, bisphenol-A, tetrabromobisphenol A, triclosan and octyl-methoxycinnamate"* (Leigh, 2013).

Once again we see how politics, lobbied by industry in the end does industry's bidding and in this case, demonstrates how prepared it is to let big industry pollute the environment in order to protect its profits.

10.10.2 Eutrophication

A larger and significant political issue envelopes sustainability which is the de-funding of science by politicians because of the truths it reveals which demand political action; actions frequently inconsistent with party policies and corporate enterprise. George Bush was heavily criticized by the US scientific establishment during his presidency for cutting the funding to science. Currently, the Australian prime minister, Tony Abbott is defunding Australian climate science and implementing a range of unsustainable policies. In Canada the defunding of science was to have included cuts to a series of freshwater lakes, known as the Canadian Experimental Lakes Area (ELA) consisting of 56 small lakes which *"were set aside for experimental studies of the causes and control of eutrophication and other types of water pollution"* (Vallentyne, 2000). Since the 1970s the ELA has provided invaluable scientific evidence of how pollution causes eutrophication. However, following a strong protest campaign, the politicians repealed their decision to close the ELA and happily *"on April 1, 2014, the International Institute for Sustainable Development, the Government of Ontario and the Government of Canada signed three agreements to ensure the long-term operation of the Experimental Lakes Area (ELA), a world-renowned freshwater science research facility in northwestern Ontario, Canada"* (http://www.iisd.org/ela/).

In the -60s algal blooms were plaguing Lake Eerie and the Canadian government set up the Freshwater Institute to investigate the problem. The new director, Waldo Johnson, had the idea to conduct research by using a series of small lakes in a remote area of Canada, near Winnipeg for experiments. Once the lakes had been selected the experiments went ahead and the lakes were used in the same way that medical researchers use white mice!. *"ELA's original mission was to examine the problem of eutrophication. The pressing question in the late 1960s was which nutrient triggers excessive algal growth. Studies in small tanks done elsewhere had yielded conflicting data. Some scientists thought the culprit was* *phosphorus, principally in detergents and sewage; others thought it might be nitrogen from fertilizer and sewage, or carbon, or perhaps even trace metals. In a now-famous experiment ([Schindler, 1974] Science, 24 May 1974, p. 89), the team divided Lake 226 with a plastic curtain and added phosphorus to one half. When it turned a distinctive murky green, they had their answer. It was an aerial photograph from this experiment that largely persuaded policymakers to phase out phosphorus from detergents. "I think that's the single most powerful image in the history of limnology," Elser says"* one of the ELA scientists (Stokstad, 2008).

Today the use of phosphorus and nitrogen fertilizers by the agro-industry has caused serious problems throughout the world due to their repeated, heavy and extensive application on farmland. Rains wash the fertilizers off the land into lakes and rivers and eventually these chemicals reach the sea. The excess nitrogen enriches the water causing algal blooms and an increase of the plant biomass. Subsequently, as the plankton and plants die off and rot they reduce and exhaust the oxygen in the water killing off nearly all the other organisms. This causes deoxgenated dead zones in both bodies of fresh- and seawater; this process is known as eutrophication (Harper, 1992). Eutrophication can also be caused by the release of sewage into water so that it is over-enriched.

Although, we are concerned with freshwater pollution and the eutrophication of ponds, lakes and rivers – but rivers also flow to the coast transporting our pollution to the seas. Our world is intimately interlinked in many ways and eutrophication also occurs very seriously around our coasts due to the runoff of fertilizers and sewage. There are now extensive 'dead' areas along the coasts of all continents close to city seaboards. *"The Gulf of Mexico's dead zone, averaging more than 17,000 square kilometers in recent years, was forecast to reach record dimensions this year before a tropical storm stirred the waters"* (Elser & Bennett, 2011). In 2008 it was reported that *"In many coastal regions of the world during the past 60 years, the concentration of dissolved oxygen has declined to levels anathema to life and the number and extent of listed hypoxic* [= absent or reduced oxygen content] *areas has increased from 46 in 1995 to more than 400. Loss of dissolved oxygen is linked to the release of nutrients when organic waste or fertilizer runs off into river outflows. Hypoxia poses a grave threat to the viability of coastal marine and estuarine ecosystems and can quickly lead to the elimination of the sea bed organisms and fish. Diaz and Rosenberg … review how the issue of dissolved oxygen may become the most important factor controlling man's use of the sea"* (Hurtley, 2008; Diaz and Rosenberg, 2008).

The issue of eutrophication is a deeply interconnected sustainability issue, because it is intimately associated with water which cycles through the ecosphere. Legislation forced the removal of phosphates from detergents to counter eutrophication (Stokstad, 2008), however, the situation with agriculture or rather the agro-industry remains. Does the world need to use so much chemical fertilizer which in the last fifty years has more than quadrupled to a 142 million tons per year (Pretty, 2007)? Scientists have already shown that simply adding more fertilizer year after year does not increase soil fertility. *"All else being equal, the highest efficiency of nitrogen fertilizer is achieved with the first increments of added nitrogen; efficiency declines at higher levels of addition. Today, only 30–50% of applied nitrogen fertilizer and ~45% of phosphorus fertilizer is taken up by crops. A significant amount of the applied nitrogen and a smaller portion of the applied phosphorus is lost from agricultural fields … Such non-point nutrient losses harm off-site ecosystems, water quality and aquatic ecosystems, and contribute to changes in atmospheric composition. Nitrogen loading to estuaries and coastal waters and phosphorus loading to lakes, rivers and streams are responsible for over-enrichment, eutrophication and low-oxygen conditions that endanger fisheries"* (Tilman, et al. 2002). On balance the stakeholder who benefits most from the greater use of fertilizer is neither the hungry nor the farmers but the chemical industry giants. It is an example of diminishing returns; the more fertilizer used then the less the increase of productivity and the greater the variety of externalities but more profits for the agro-chemical industry. *"More and more evidence shows that organic farming, even on a large scale, can ensure roughly the same amount of nutrients in crop production as does conventional agriculture using chemical fertilizers"* (Wijkman & Rockstöm, 2012). It is increasingly clear that the agro-chemical industry is superfluous except to itself because organic farming can achieve similar productivity without chemicals (Wijkman & Rockström, 2012).

If we just consider the fertilizer element phosphorus, which is essential for all life, it is forecast that the *"easily mineable deposits of phosphate rock are limited"* and maximum production will peak around 2030 (Elser,

& Bennett, 2011). So we need to use phosporus much more strategically. In 2005 17.5 million tons was mined, about 14 million tonnes was used as fertilizer but then 8 million tonnes of that fertilizer was lost through soil leaching and erosion from farms (Elser, & Bennett, 2011) leading to pollution and eutrophication. The 30-50% of food that goes to waste takes with it an estimated 1 million tonnes of phosphorus. Each one of us excretes about 1.2 grams of phosphorus daily, which, were it collected, could produce about 3 million tonnes per year. In moving towards the circular economy rather than wasting phosphorus NoMix toilets provide one answer and Peepoo biodegradable bags which capture human excrement provide another (Elser, & Bennett, 2011).

There are many interconnected issues here associated with our use of phosphorus contributing on the one hand to soil fertility and on the other to pollution, while other aspects are concerned with the recycling of human excrement, the peak supply of mineral phosphates and food wastage. In the nexus of all these chains design has the potential to create both the awareness and facilitate change in many niches within this network.

10.11 Ourselves and our "chemosphere"

10.11.1 Lead in paint and petrol. A behaviour changer?

Lead is a toxin which affects the body's *"circulatory, neurological, hematological, gastrointestinal, reproductive and immunological" systems … The primary target of lead toxicity is the central nervous system"* (Nemsadze, et al 2009). Lead is a dangerous toxin and poisoning, amongst other symptoms, can cause: aggression, antisocial behaviour, sub-fertility, headaches, learning disorders, cognitive dysfunction, mental retardation, developmental delay, etc.

In America *"As children were identified as suffering from lead poisoning, industry sought to forestall a threat to its product's popularity"* (Markowitz & Rosner, 2003). Consequently, for many years industries deceitfully concealed the danger of lead in paint applied to interiors, fittings and toys etc. in order to retain sales. One way in which this was done was by a fifty year marketing campaign which was aimed at children and designed to convince the public that lead was safe! The Lead Industries Association (LIA) was set up in 1928 to protect the lead industries who feared that other metals might take lead's place in the market. *"The LIA did everything in its power to obscure the health dangers associated with lead … Not until 1971 would action finally be taken by the federal government to prevent the use of lead paint on interior surfaces"* (Markowitz & Rosner, 2003).

In 1922 Thomas Midgley ("the Father of Ethyl Gas") working at General Motors created tetraethyl lead or leaded gas/petrol which protected the motor from "engine knock," however, scientists both within and outside the government warned of the health dangers. Several cases of lead poisoning even occurred during the initial production of leaded gas with some workers dying. One incident even became known as the "looney gas poisoning" case. Nonetheless, *"Many public health leaders and scientists saw the federal government as colluding with GM, DuPont, Standard Oil, and Ethyl to certify the safety of tetraethyl lead"* (Markowitz & Rosner, 2003).

In 2007 a study revealed that there is a remarkably close correlation between the use of leaded petrol (or tetraethyl lead) and violent crime (Nevin, 2007; Casciani, 2014). The graph shows that from 1941 to 1957 the gasoline lead increased from 0.4 tonnes per 1,000 of the population to 1.1 tonnes per 1,000 of the population. Then between 1957 to 1967 the graph shows a saddle shaped drop falling to 0.9 tonnes before rising again towards a higher peak at over 1.2 tonnes per 1,000 of the population. Around 1970 the lead content of the petrol peaks at about 1.3 tonnes per 1,000 of the population and then drops off to 0.1 tonnes per 1,000 of the population by about 1985. A graph of violent crimes per 100,000 of the population occurring 23 years later very closely matches the graph of the use of lead in the petrol including the saddle and its subsequent reduction in the use of lead. The hypothesis from the closely correlating graphs is that the neuro-behavioural effects of lead exposure in infancy are the cause of violent crime 23 years later in the adult.

In 2011 a brain damaged child, Delila Gray, 11 years old, was awarded $4.8 million in damages due to suffering brain damage when she was 2 and 3 years old. The apartment in which she lived had peeling and chipped lead paint. When Delila was diagnosed with lead poisoning the local authorities ordered the owners of the building to remove the lead based paint hazard and redecorate the apartment within 5 days, however, the owners failed to comply with the order until 5 months later. As a consequence Delila continued to suffer lead poisoning during intervening months from the paint. The poisoning caused brain damage and impaired her ability to concentrate and learn and caused other behavioural problems (Konigsberg, 2011).

10.11.2 The manmade chemosphere

Electrical components, plastics, perfumes, mobile phones, textiles, toys, trainers, furniture and floor coverings, food packaging, clothes, cosmetics, carpets, chopping boards, printed circuit boards, paper coatings, body care products, house care products, are examples of (design) articles (the list is incomplete) which contain at least one of the toxins listed below and some more (Price, 2004):

- polychlorinated biphenyls (PCBs): which can affect thyroid hormone function and mental development.
- phthalates (plasticizers): which can cause womb abnormalities, lowers sperm count and quality, and may cause liver, kidney and testicular damage.
- polybrominated diphenyl ethers (PBDEs or fire retardants): may cause thyroid disfunction. Deca-BDE is a possible human carcinogen and may interfere with brain development.
- perflourooctane sulfonate/ perflourooctanoate (PFOS/PFOA): possibly toxic to the liver and may also cause thyroid dysfunction and possibly foetal development problems and bladder cancer.
- HBCD or TBBP-A flame retardants: are thought to be potentially genotoxic, immunotoxic and neurotoxic with the latter possibly capable of disrupting thyroid functioning.
- Artificial musks: may cause liver damage and may stimulate cancers as well as disturbing brain messages.
- Organotins: cause damage to the immune system, as well as being an endocrine disruptor, carcinogenic and teratogenic.
- Tributyltin: is an endocrine disruptor and possibly carcinogenic.
- Bisphenol-A: exposure to BPA may result in genetically abnormal children.
- Alkylphenols: can cause endocrine disruption and affect the sexual development in animals as well as reduce sperm production and also damage lymphocytes – the cells in the blood which produce antibodies to attack germs.

(Price, 2004).

So much for domestic products. What about food? In 2011 a study was published by a partnership of European environmental groups: Générations Futures, the Health and Environment Alliance (Heal), Réseau Environnement Santé and WWF-France. The authors of the study purchased non-organic foods in supermarkets *"to give a typical 10-year old three meals a day and a snack"* and *"was consistent with a balanced diet"* (Santi, 2010). Several independent laboratories were asked to analyze the food and requested to check for *"possible residues of pesticides, dioxins, heavy metals, plasticizers (phthalates, bisphenol-A or perflourinated compounds [PFC]) and food additives.*

Their findings were instructive: 34 chemical substances were found in the fresh salmon, more than half of which are either carcinogens or EDs [endocrine disruptors]; the processed cheese contained six substances, all of which are carcinogens and EDs. The unsalted butter, served at breakfast, contained 15 residues, the beef-burger (15% fat) contained 10, all of them carcinogens and EDS. Overall 128 chemical residues would have been consumed in a single day. Worse still, substances banned in France were found in a tin of green beans from Kenya and one forbidden substance in rice from Asia.

Admittedly in almost all cases products complied with the legal limit for each substance" (Santi, 2010).

Why do we do it? Why are so many everyday objects, such as those listed above, together with the foods we consume made with chemicals which can make us ill and unhealthy in so many ways ranging from terminal cancers to behaviour changes or simply mood changes? Here are two answers; *"Chemicals have contributed to the safety and affordability of products."* (Girling, 2004), however, how does one define safety? Thirdly, big business and big corporations know that, should we consumers become ill, it will be far too difficult for us to prove the precise cause and even if we knew the cause, it will still be too costly for a consumer to sue them.

Corporations have made a *'chemosphere'* of our biosphere and we consumers have gone along with it for the sake of cheap, convenient and safe products (safe in the short-term maybe, but dangerous for our health in the long term). *"There are currently more than 80,000 chemicals in consumer goods, with little or no safety in-*

formation about their impact on human health" (Environmental Working Group, 2009).

Furthermore, as more synthetic chemicals, improperly regulated, enter the market place, the effect is to obfuscate which chemicals might be affecting us, since, as was said above, *"leading bio-monitoring labs around the world, have together identified up to 493 chemicals, pollutants and pesticides in people, from newborns to grandparents"* (Environmental Working Group, 2009).

10.12 Conclusion

Chemicals, that is synthetic, man made chemicals which do not occur in nature, are potentially dangerous because living systems have not evolved to cope with them. Chemical compounds are now used in a wide range of products in domestic and other enclosed environments into which they off-gas. As a consequence these chemicals can unexpectedly combine or interact with other synthetic compounds to create unknown chemicals with unknown properties. Furthermore, the synergetic interaction of the cocktail of contaminating chemicals within our bodies is unknown (Santi, 2010) regardless of whether they enter the human toxome through respiration or within the foods we eat, the fluids we drink, or the preparations we rub onto our skins.

Chemicals are dangerous because "*"What is harmful is not the intensity of the dose but the repetition of small doses, and consequently the period of exposure," explains Professor Dominique Belpomme of Paris University*" (Santi, 2010). This brings into question the concept of "legal limits" and on what tests these are decided. In a review of endocrine disrupting chemicals (EDCs) by Zala and Penn (2004), they write in their abstract that *"EDCs also have adverse effects on a wide range of behaviours, including sexual and other reproductive behaviours, activity, motivation, communication, aggression, dominance and other social behaviours, and learning and other cognitive abilities. We also reviewed recent findings that challenge common assumptions in toxicology. For example, EDCs have several unanticipated properties, such as nonmonotonic dose effects and synergy. Furthermore, harmful effects of EDCs sometimes become apparent only when tested in natural ecological conditions, such as social stress and infection. These findings raise questions about the practicality and feasibility of testing chemical pollutants adequately."*

Chemicals are dangerous because they can change in unexpected ways, for example by photo-transformation. Trebolone, the anabolic steroid already mentioned, breaks down into its metabolites in sunlight and can leach from urine and manure and enter ponds and streams. However, surprisingly about 15% of the metabolites can reform into the trenbolone parent molecule in darkness and disrupt the endocrine systems of aquatic organisms at concentrations as low as 10 parts per trillion (Stokstad, 2013). The androgenic trenbolone can cause irreversible masculinization of fish populations (Morthorst, Holbech & Bjerregaard, 2010) reducing fecundity.

Chemicals are dangerous because they can change our behaviour, possibly making us violent as the lead in petrol may have done. We know that lead retards mental development. It is also possible that endocrine disrupting chemicals may have re-gendered our natural behaviour. "*This decline in basic maleness coincided with increasing rates of testicular cancer (a doubling since the 1970s), undescended testicles and deformities of the penis, leading Dr Sharpe and a Danish colleague, Professor Nilsw Skakkeback, to group all these effects together under the single heading, "testicular dysgenesis syndrome." The hypothesis, supported by rodent tests, is that the development of the male foetus is affected in the womb by its mother's exposure to endocrine disrupters*" (Girling, 2004). We should now recall the quote from Meeker, and colleagues (2009), cited above "*In addition to shortened anogenital distance (AGD), which is a sensitive and non-invasive measure of potential androgen deficiency during foetal development in rodents and humans, other abnormalities include hypospadias, cryptorchidism and malformation of the epididymus, vas deferens, seminal vesicles and prostate; together they comprise the 'phthalate syndrome'…*" A more difficult question to answer is to what extent these chemicals are affecting or changing human behaviour? We know that lead is a neurotoxin, but what about the many other chemicals which share our environment? Are we who we think we are?

As never before design has become an ethical activity. We must design with not only the health of the environment in mind but also the human psychological and the internal environment or "*"human toxome," as EWG analysts call pollution in people*" (Environmental Working Group, 2009). Consequently, it is an ethical responsibility for designers to know what chemicals compose the materials they select for a design and are employed in the processes of a design's manufacture; be it inks, card, coated paper, packaging, plastic, or other synthetic materials for products.

As we noted earlier "*... the exact number of chemicals marketed globally is unknown ... One guide is the number registered with the EU which stands at around 144,000. Of these, roughly a third are thought to be harmful ... but "the vast majority have not been assessed for human or environmental safety.""* Cribb warns (Cribb, 2014; Davies & Sanderson, 2014).

Throughout this chapter we have seen that there are politicians and large corporations that are not to be trusted, neither with our welfare nor that of the environment. Regulating bodies are insufficiently funded and incapable of controlling, enforcing or ensuring that the chemicals that come onto the market are safe for either the consumer or the environment. Even politicians in the EU are more concerned to ease restrictions on corporations than they are concerned about protecting the health and welfare of citizens and the environment. The *"EU plans to tackle air pollution that causes tens of thousands of premature deaths and make countries recycle more of their rubbish are to be scrapped, according to leaked documents.*

At risk are a clean air directive designed to reduce the health impacts from air pollution caused by vehicles, industry and power plants, and a waste directive that would set states the target of recycling 70% of waste by 2030." It is incomprehensible that the "EU vice-president Frans Timmermans gave paper copies of the proposal to ditch clean air and recycling laws to commissioners" (Neslen, 2014).

One of the proposals *"to be withdrawn is an ambitious circular economy directive which would phase out landfill dumping by 2025 and, by 2030, oblige EU states to recycle or reuse 70% of their waste, 80% of their product packaging, 90% of their paper (by 2025), with similar goals for plastics, wood, glass and metals. The package would be withdrawn because the commission sees "no foreseeable agreement" with EU states that have poor recycling records and would need financial assistance to meet targets" (Neslen, 2014). All of which, if one thinks democratically, makes one wonder what politicians are for, despite the fact that earlier in the same month it was reported that "Ministers from 11 EU member states, including France and Germany, have written to the European Commission calling on it to press ahead with a tougher air quality law and new rules on cutting waste, according to a letter seen by Reuters"* (Lewis. 2014).

This lack of political regulation of industry and corporations was what was wanted by the European Round Table (ERT) of industrialists back in 1983. Wisse Dekker, the then chairman of the ERT wrote to the European heads of state and bribed them, that if they did not provide what industry and commerce wanted in Europe then they would go elsewhere. One of the ERT's requirements was: "deregulation and minimal government control." (See Chapter 14, section 14.2.5).

The EU is making dangerous concessions in order to come to an agreement with the United States over Transatlantic Trade and Investment Partnership. *"The US trade representatives insisted that a risk based approach be taken to regulation ..."* The risk of course is to the individual European citizen getting cancer or becoming infertile from US products. Nonetheless, *"The EU moves to regulate hormone damaging chemicals linked to cancer and male infertility were shelved following pressure from US trade officials over the Transatlantic Trade and Investment Partnership (TTIP) free trade deal ... Draft EU criteria could have banned 31 pesticides containing endocrine-disrupting chemicals (EDCs). But these were dumped amid fears of a trade backlash stoked by an aggressive US lobby push, access to information documents obtained by Pesticides Action Network (PAN) Europe show"* (World Roundup, 2015; Neslen, 2015). This example clearly shows that there are politicians who place trade and profits before peoples' welfare, even that of their own electorate.

It may now be becoming clearer why the 'grass roots' has a key role to play in creating a sustainable future when those in powerful and leading positions in both politics, industry and commerce are firmly and inflexibly stuck in the old profit paradigm (see Chapter 2).

We hold individual freedom to be an unassailable right. However, is that right infringed when products, purporting to be safe, contain chemicals which may change or damage our health, and behaviour including perhaps our sexual orientation? And for what reason? Profit?

Who then remains to care for the welfare of the consumer and the environment who might have some influence? Whoever else there maybe then it is certainly the designer!

10.13 References and further reading

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Vandana Shiva

11 Growth = Poverty

> *"The wealth of the 1% richest people in the world amounts to $110tn (£60.88tn), or 65 times as much as the poorest half of the world, added the development charity [Oxfam], which fears this concentration of economic resources is threatening political stability and driving up social tensions."* (Graeme Wearden, 2014)

> *"… on current trends – by next year, 1% of the world's population will own more wealth than the other 99%."* (Elliott & Pilkington, 2015)

(Dr Shiva's contribution is an edited transcript of her talk presented at the Festival of Dangerous Ideas (November, 2013) held at the Sydney Opera House (the original speech can be seen at: https://www.youtube.com/watch?v=7M3WJQbillionHKc and we are grateful to Dr Vandana Shiva for permission to publish this transcript)

Abstract
When natural resources like timber, water and mineral deposits can be extracted from ecosystems, they become assets with dollar values that can be bought and sold internationally and enable developing countries to grow and participate in the global economy. If growth is the key to emerging from poverty, then this might seem like a good thing. But what if these same resources being sold to richer nations come from an ecosystem that people depend on for their livelihood? What if new growth is actually proportional to the creation of new poverty? The cult of 'growth' has dictated policy for decades. But if well-being, not growth, is our goal, selling resources that bring long term wellbeing to communities for short term gain is a very bad deal. Hard as it may be for the West to understand, protecting the ecological resources of communities might be more important than GDP figures.

11.1 Introduction

We are repeatedly being told by every politician, in every country, that we have got to have more growth to remove poverty. The metaphor used to explain this is that; the cake must get bigger for people to have a bigger share, especially the poorest. I am not an economist and so that is why I can look at Gross Domestic Product (GDP) and growth from the outside, from where it hurts. Where it hurts nature, ecosystems, and local communities. It is at these levels that our models for growth, which are driving not just our economic paradigm but also the paradigm of how society should be; are creating poverty at so many different levels.

11.2 Poverties of the mind

The first poverty I feel, is at the level of the mind. Humanity has shrunk its mind so deeply and reduced the amazing pluralism of options we had for governing our affairs, of how to produce and how to consume and reduce it all to just one number – the GDP. The Gross Domestic Product !

Secondly, there is also a poverty of the mind because it allows an abstract number to have the power to destroy everything that is real, that sustains us, that sustains our ecological life, life in nature, and our social life as well.

There is a problem with abstract numbers, and I was among those who, as a physicist, really believed that the abstract is beautiful. This is because the abstract as abstract enables you to play mind games as I used to with quantum theory which is fine. However, when the abstract starts to become the measure for the real world and for life itself; then that is when the destructiveness starts. This is because every abstract that relates to living systems must have a feedback. We must check, how is this measure working? Is it delivering as I said it would happen or is it failing?

11.3 The Problems of GDP

Now the problem with GDP as an abstract number is that it insulates itself from feedback. Consequently, no matter what the scale of destruction that takes place there is no way to feed it back into the GDP. For example, I know there are some rough calculations that if you take China's growth and India's growth and then add the cost of the destruction and pollution of our rivers, and water-bodies, we would have a negative growth, but the pollution is not included in the costs. How is it that we have reached the point that we can sacrifice our world and our knowledge for a flawed abstraction?

Even the economist who celebrated GDP in a debate in 2010 had to conclude that GDP is a poor measure for the improvement of our living standards and they are still talking of living standards? I don't think there is anything such as a 'living standard;' there is not a standard which you can say everyone can and should reach. However, there is well being, and there are ways of life and GDP has definitely not improved wellbeing.

GDP is not just a number, it is not even a number for measuring economic growth. It has become a model for society. It is a model that justifies the destruction of all social cohesion, all social justice and every aspect of our lives that makes for liveable lives. GDP does this all in the name of this very gross number. Gross in the sense of the truly gross. Gross because it has generated more 'bads' than it has generated 'goods'. It has perpetuated a model of generating non-sustainability, inequality and a deep violence within society and within the self.

11.3.1 The origins of GDP

GDP has its roots in war, something we forget. We think it has always been around because economies as systems of production have always been around too. GDP as a measure of the economy was created during the war. It is part of the war machine. It is what helped America to win the war and at least as much as the development of the nuclear bomb which was carried out by the Manhatten project. GDP has even been called the Manhatten project of economics. The way in which this was done was by creating a very artificial boundary for production. This production boundary, totally imaginary, effectively said that: *if you produce what you consume you don't produce.*

Interesting isn't it. This means that the amazing hydrological cycle of nature doesn't produce any water. However, water gets produced the day 'Coca-cola' arrives and starts drilling for 1.5 million liters of water and miraculously there is growth. Water in plastic bottles cost 12 rupees in India. However, my experiences have taught me that the ordinary women from villages now have to start walking 10 miles for the water they need. Consequently, they wanted to shut down these Coca-cola plants. That is when I realized what that bottled drinking water meant. I never liked the brown liquid anyway because to me the taste was foul and that was long before I even knew what they put into it !

For every liter of water in a bottle there is 10 liters of destruction. The damage from the mining for ground water is amazing and what is left behind in the ground are high concentrations of the heavy metals of lead and arsenic. We have done studies of the ground water from around every plant in India comparing it with normal ground water. The ground water around the Coca-cola plants will have these heavy metals but the normal ground water will not. Of course everything about Coca-cola's production is a trade secret and so they do not tell you how these heavy metals are getting into the water or the ground. Consequently, the combination of the water level sinking because of heavy extraction and what remains becoming polluted with heavy metals there is no drinking water left in regions which previously had an abundance. Today, there is a water famine.

11.3.2 The Plachimada protest that stopped Coca-cola

The most important case in this conflict with Coca-cola occurred in 2002. I received an invitation from a small community that I did know, from the village of Plachimada, in Kerala. They invited me to come and celebrate one year of fighting Coca-cola with them and I attended out of sheer inquisitiveness. How could Coca-cola be damaging the environment? I learnt everything that was going on and when I was leaving, I asked Mayilamma who was leading the campaign. *"Mayilamma, what do you want me to tell them when I get back to Delhi?"* and she just said. *"Tell them when they drink coke they drink the blood of my people."* I can tell you that I haven't been able to touch a bottle of coke even if I'm dying of thirst, or a Kinley or a Dasani, they have different names in different parts of the world.

11.3.3 Nature's 'non-productive' cycles

Everything that generates growth is creating poverty in ecosystems because of that strange definition that *if you produce what you consume you don't produce*. Now Nature produces and consumes in amazing cycles of nutrients, the carbon cycle, the nitrogen cycle, the cycles that keep this Earth alive. However, this regeneration is treated as non-production because the idea of GDP is how to extract the wealth from nature and society because of the need during the war to mobilize funds to buy and produce all the armaments and to finance all the war research.

More importantly GDP was needed to deploy all the military all around the world. Sadly, that war machine continues to be the model for our economy. The idea that *if you produce what you consume you don't produce* and therefore nature doesn't produce and people don't produce if they produce for themselves. So, for example, if you cook a wonderful meal at home you do not produce because it does not contribute to the GDP. However, if you go out to eat a Macdonald hamburger then you contribute to the GDP. Then if you get obesity you contribute extra because then you get all the health problems that come with eating lots of hamburgers and it's a perpetual growth economy.

11.3.4 Bobby Kennedy had already identified the problem of GNP

Bobby Kennedy in his 1968 campaign, this was around the time of the Vietnam war, very powerfully started to criticize the measurement of economic growth. At that time it used to be called Gross National Product (GNP) now it is called GDP. This was because they used to measure what a country produces no matter where. Now, because we are in a period of globalization, they measure what is produced in a country no matter by whom. So, for example, no matter who the investor is in Australia, what is produced will count towards Australia's GDP even though all the returns might leave the country.

Bobby Kennedy said: *"Too much and for too long, we seemed to have surrendered personal excellence and community values in the mere accumulation of material things. … Gross National Product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage.*
It counts special locks for our doors and the jails for the people who break them. It counts the destruction of the redwood and the loss of our natural wonder in chaotic sprawl.
It counts napalm and counts nuclear warheads and armored cars for the police to fight the riots in our cities. …
Yet the gross national product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials.
It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country, it measures everything in short, except that which makes life worthwhile." (source: http://www.theguardian.com/news/datablog/2012/may/24/robert-kennedy-gdp)

Now if you look at different countries, for example the US in the time when they were really having growth; especially the period from the 1960s to the 1970s, their GDP tripled. Yet during the same 30 years there was a 560% increase in violent crime, a 419% rise in illegitimate births, a quadrupling of diverse traits, a tripling of the percentage of children living in single parent homes and a 200% increase in teenage suicide.

In India, which for the last decade has been called emerging, now obviously an ancient civilization like ours cannot emerge, however, what was emerging was the GDP. Suddenly we found that GDP was guiding not only how our economic policy was shaped but also how our society was being shaped. Then we had started to hit 9% growth and everyone was saying 'oh, we're going for the double digit.' Now growth has collapsed to 3.8% which was actually the rate before all this effort to destroy the economy was made.

11.3.5 From 'heritage' organisms to stolen organisms: GMOs

Consequently, in this period of globalization, while chasing the illusion of growth, we have managed to push every 4^{th} Indian into hunger and every second child is so malnourished that they are wasted and stunted. The malnutrition indicator of stunting means that a person's height is too short so that practically they remain dwarfs.

Furthermore, they are also wasted, which means that there body weight is so low that they will neither grow up fully physically nor psychologically. Now it was also during the same period that our seed sector was liberalized, as it was so-called, and started to become monopolized by a handful of companies, including my 'favourite' one, Monsanto, and at that time it was for cotton. Up to that time, no profits were made because the seed was renewable, and was in the hands of the farmer who could save seed for growing in the following season. It was a zero cost economy and it was a huge growth in terms of the replenishment of life. However, the monopolization of the seed by these companies meant that the farmers got into debt because they had to buy seed because growth measures how much profits get made in the seed sector.

The family of crops that are called millets have their name millet from a million because each seed gives rise to a million seeds. Now what can compare in abundance with the multiplication factor of a million with each generation of planting? You can save a quarter, eat 50% and still have enough to sell in order to pay for your education, your health, and your clothing.

The entire effort of the seed industry began by joining the World Trade Organization and following their rules for intellectual property effectively prevented seed from reproducing itself. *If you consume what you produce you don't produce*. So seed becomes a raw material and the amazing legal language meant that *'seed'* just disappeared from the discussion. The new legal language talks of *'plant propagating material'*. It talks of the seeds of the farmers, heritage seeds, as pre-basic! Imagine: 10,000 years of evolution is kindergarten, its pre-basic!

What is basic is when the corporations took the seed; shoot a gene, a toxic gene usually, *roundup ready*, or *Bt*, and then patenting the seed thereby appropriate it for themselves. What the property rights of WTO were about and Monsanto is also on record as saying that when they wrote the agreement that *'we were the patient, the diagnostician and the physician all in one, we defined a problem'*. Actually the problem for Monsanto was because the farmers saved their own seeds and Monsanto offered a solution which suited Monsanto. This should now be treated as an intellectual property crime.

I could give you example after example of what this has lead to, but one consequence is that farmers are getting into debt because the seed costs jumped 8000% and half of that is royalty that goes straight to the Monsanto headquarters. Every seed company today is licensed with Monsanto. There is no independent seed supply. So the only seed on the market is the patented one, the genetically modified one, and farmers can only get it through getting into debt and debt is what is pushing them to suicide.

11.3.6 The final analysis, the ultimate cost of GDP: life itself

This is, in the final analysis, the most extreme level in which the annihilation of life itself due to the creation of poverty becomes a consequence of chasing growth. The abstract number is abstract only at one level. However, it has around it all kinds of privileges, all kinds of groups that benefit hugely from keeping the mentality of war alive. It enables them to privatize and appropriate the resources that are shared by all life on Earth and all communities for their welfare and their wellbeing. This privatization of resources leads to growth.

11.3.7 The chipko movement

Lets consider another example; if a forest is renewing itself, if a forest is managing the water catchments there is no growth. You chop it down and turn it into timber you get growth, but that growth creates the 'bads', the 'bads' of the landslides, of the droughts, of the floods. In the 1970s ordinary illiterate women of my region started to say we have got to stop the destruction of our forests. They were laughed at and I remember a particular action of the chipko movement.

Chipko means to hug, to embrace, and so the women decided to hug the trees so that the authorities would have to kill them in order to fell the trees. This protest action went on in village after village and the loggers would arrive in one village and because they could not cut down the trees they would have to move onto the next village and the next. It was amazing because there were no cell phones nor mobiles, there were not even video cameras in those days. I remember I gave the first camera to the movement so that they could start recording some of their actions. Despite this lack of technology, the messages spread through the communities reaching them through beautiful folk songs that were created at that time. In 1977 there was a particular action when the women came out with lanterns although it was day-time. The police were there to arrest the women because they were interfering with the revenue collection in growth. The police laughed and asked *'Why are you carrying lanterns, don't you see the sun is out?' And the women replied: 'We are not carrying the lanterns for the sun, we are carrying them for you because you don't seem to realize that the first product of* *the forest is not timber, or revenue, or resin …'* That is resin from the pine trees which is used in all kinds of industrial products. They said that '*… the real products of the forest are soil, water and pure air.*'

11.3.8 The costs of GDP

In 1978 we had a massive devastation, an entire mountain slipped into the Ganges River above Uttarkashi and created a four mile long lake which when it burst created floods all the way to Calcutta. That's when the government paying for flood relief realized that what the women had been saying about the tree felling had something to do with the land slides. Furthermore, the revenues which the government was collecting from killing the trees and generating growth was nothing compared to the costs they had to pay for in terms of the destruction by the floods. We still have a government department that is responsible for flood relief and drought relief.

Another example is a horrible cyclone that we have had just now in Orissa. The last time we had a super cyclone was in -99 when 30,000 people died. This time only a 1000 died because the government was prepared and evacuated the people. Unfortunately, they were not able to avoid the destruction of the rice fields and the coastal areas and the death of their animals but at least the loss of human lives was largely avoided.

I come from the central Himalayas where the Ganges starts and that's where I have learnt all my ecology; that's where I have learnt all my lessons from nature and from the local communities.

Now cyclones like the cyclone Phailin in 2013 or the disaster in my region that we have had this year have caused devastation of the kind I have never seen before. There were two days of intensive rain, the melting of a glacier and the bursting of a glacier lake which led to the death of 20,000 people and in certain areas the destruction has not stopped. The mountains are still slipping because in our parts of the world a flood is not just a flood on level ground, a flood is taking the mountains down with it. This is an externality, a 'bad' of all the growth that is coming from your mining coal, from Canada having the tar sands, etc. This is huge growth. For instance, the two Koch brothers, just through financing one pipeline are going to make $100 billion. These same brothers are the ones who financed the Tea party and the stand off in the US congress so that nothing worked for a while.

Again, I remember in 2009 we had a very severe drought in northern India although in southern India in the arid areas we had severe flooding. Just in that one year the losses were about $40 billion. Now $40 billion is the entire commitment for a decade made by the historic polluters, the rich countries of the world, who through their growth based on fossil fuels have left us with the legacy of climate instability. Climate instability is contributing to the intensive floods, intensive droughts and more frequent and more intensive cyclones. The destruction that we are witnessing is growing by the day. Growth does not take that into account and it cannot and if it did it would have to stop. It would have to turn its attention to reducing emissions. Our priority would become creating resilience. Our priority would become shifting to activities that mitigate these problems.

Now growth fundamentalists mix up two things; very conveniently, they mix up the growth of money and the growth of life. Trees growing, children growing healthily, societies thriving and enriching culture, that is the growth of life. However, the original intention of GDP which was for growth by the multiplication of money for the mobilization of war has unfortunately left us with two additional problems.

11.3.9 The two underlying failures of GDP

The first big problem is now you can make money out of nothing. Just gamble on the casino, in fact the global economy has become a global casino. The 2008 collapse was a result of that gambling. We have $3 trillion of finances moving around the world. 70 times more than all the goods and services available on the planet. Now that is very hungry money, that's the money that has to invest in real things. It has to invest in land and if not by ethical means then by unethical means through the land grab. It has to invest in water and that is why we see the privatization of water. It has to invest in all our public services, the commons, the health systems, and our education systems. That's why you see at both the levels of domestic macro-economic policy as well as international free trade policy the heart of economic growth today is the privatization of public systems. It is a modern enclosure of the commons. The commons that ensures that everyone has access to health, to education, to homes, to shelter, to citizenship, to food, and to water.

Now I have spent a lot of time looking at agriculture and agriculture is very interesting in the way this growth idea has transformed it into a non-food system. We really have a poverty in food now. How does that poverty in food work? If GDP was one legacy of the war, chemicals for warfare were the second legacy of the war. These chemicals were then brought into agriculture as agro-chemicals. Fertilizers and pesticides, of course, have led to huge amounts of growth in terms of sales and the wonderful thing is they are what I call ecological narcotics: the more you use them the more you must use them. So the more you spray a pesticide or use a chemical fertilizer the more you have got to spray pesticides and use fertilizers. Consequently, you have got a perpetual growth model built into the failure of the technology as a fertilizer to create soil fertility or as pesticides to deal with controlling pests.

The criteria that was evolved to measure growth in agriculture is something called the *high yielding variety*, which only measures what leaves the farm. It does not measure the health of the soil, the health of the pollinators, the health of the plants, the health of the animals or the health of the farming family. It just measures how much soya left the farm, how much canola left, how much rice left and how much wheat left but impoverishing the soils. You also get impoverished farming families because they have borrowed more to produce than what they can earn from the production itself. Costs of production have gone up 10 times while usually in agriculture the price of what a farmer produces has actually dropped since globalization. If you do an analysis for Australia for example, you will find that it is the same for most agricultural crops which is also the case for India. The result is indebted farmers and farmers leaving the land. 15 million farmers have been forced out of agriculture in India during this period as the neo-liberal economies have taken over. It also means more hunger. Now growth in agriculture is constantly talked about as if could solve the problem of hunger and that is why we are supposed to have GMOs, and that is why we must have seed monopolies because after all these corporations bring us food.

Now we have been accused of killing people by questioning the inadequacy of the genetically engineered golden rice which has 80 patents associated with it, including solving the problem of vitamin A deficiency which leads to blindness. Now the reason we think it is inadequate is because it is 7000% less efficient in giving you vitamin A than the hundreds of alternatives we already have including our coriander and curry and all the greens and all the yellows and all the carrots and all the pumpkins that are already available. 7000% more available in biodiversity and yet that shrunken mind wants to focus on rice, a genetically modified patent rice which is supposed to provide more vitamin A.

11.4 Solutions to the GDP problem

Let us consider for a moment the data on agriculture statistics. Today 72% of the food comes from the small farms and not from the large industrial farms. 72%! So what should we be doing? Growing small farms and growing more on small farms. The Navdanya movement, which I started in 1987 to save seeds, promote organic farming and fair trade, did a study last year on the ecological farms which protect biodiversity. Our study measured nutrition which is what we should be measuring when we are considering food.

It is called health per acre and it shows that we can feed two Indias by conserving biodiversity. We are always made to believe in the growth fundamentalism that you have got to wipe out other species so that humanity can have more food. The reality is that the more we leave for other species the more we have for ourselves. The more pollinators there are the more food they give us, the more soil organisms there are the more food they give us, the more biodiversity intensive our agriculture is and our gardens are the more food we get per acre. This is growth in life, in nutrition, in livelihoods and in creativity. This is the contest that we have right now; the contest between a killing GDP, an anti-life-GDP an indicators that could nourish life for all species and humanity.

11.4.1 Gross National Happiness

I am very privileged not just to be part of this amazing movement of ecological agriculture and biodiversity conservation. I am very privileged to be part of the movement to go beyond GDP. About 30 years ago, the King of Bhutan said they would not follow the growth model. They would not chase GDP, but they would create gross national happiness. Furthermore, creating the happiness of the citizens of Bhutan would be the first objective and so they created parameters. Their planning commission is called the happiness commission.

Two years ago the then prime master said: *'I cannot see any other way of growing happiness than by growing organic'* and so he invited me and Vandanya to help them to make a transition to make Bhutan 100% organic. Twice a year the farmers from India go to Bhutan and the farmers from Bhutan come to us, to our farm where we have a training centre.

We offer courses and a wonderful month long course called A-Z agro-ecology and organic farming. We also offer a course on Gandhi and Gandhi's ideas of swadeshi – self making because another aspect of the GDP and the definition of *if you consume what you produce you don't produce* means that all of us are expected to be consumers. Consumerism as the current cult has become the way in which this growth machinery has kept going since the war. If once in the earlier days young men were mobilized through GDP to march to the wars now today they are marching to the shopping malls. They and young women are marching to shop and it has become the biggest past time and it is that which is consuming the world.

In the middle ages the word consumption was the word for TB and you died of it. If we do not go beyond consumption then for sure humanity is not going to do too well. This is because we have a rogue concept called GDP, creating rogue economies, and they and it need to be brought back under control, under social control and under the control of ecological limits. In questioning GDP we create alternatives that might have a lower generation of financial wealth for a few but a lot of abundance for all of life in its diversity and a lot of well being for people. Furthermore, we are taking on the challenge of going beyond money making as the measure of wealth making.

11.4.2 Earth Democracy

Aristotle had a very clear definition concerning money making which he called chrematistics – the art of making money. Öconomia for him was the art of living and in today's context the art of living has to be the art of living on a planet with limits. It is a hugely sophisticated art, a very creative art. Now the transition that we must make is from the dumb implementation of a dumb number that is destroying life to the creative search for creating living economies, living democracies and living cultures. I call this Earth Democracy, I believe that it is the project we cannot afford to postpone for too long. Thank you.

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F.J. Radermacher

12 Double Factor 10 – Responsibility and Growth in the 21st Century

"We must also account for the depreciation of natural capital in appraising wealth. This is the value of net losses to natural resources such as minerals, fossil fuels, forests and similar sources of material and energy inputs into our economy. If we use up more natural capital to produce economic output today, then we have less for production tomorrow. ... our economies have been trading one form of capital, Earth's riches, for another – human riches. Without accounting accurately for this trade-off, we will continue to have a false impression of economic progress and growth. That is as dangerous as flying an aeroplane into the night without navigation tools or instruments." Edward Barbier (2014)

12.1 Introduction

Abstract
At the latest since the world conference of Rio in 1992 the world is facing the challenge of consciously organizing sustainable development. The goal is no less than the organization of growth compatible with sustainability, together with the creation of a global social balance and the preservation of ecological systems. In this context, the demands of a **global ethic** and of **intercultural humanism** must be effectively implemented in terms of a global domestic policy. Furthermore, adequate regulations must be set in such a way as to make systematic practices that run counter to sensible rules and to the fair interests of others economically unprofitable.

The chances of attaining this ambitious goal of balance are limited. The alternatives are a **collapse** or a **resource-dictatorship / brazilianization**, probably connected with terror and civil war. Both alternatives are so disastrous that the countries of the world, facing the global financial crisis, the threat of a climate catastrophe and an aggravating division between rich and poor, might still come together in order to implement a better designed global order: **ecosocial instead of market-radical**.

12.1 Global problems

As a consequence of economic globalization, the global economic system is undergoing a process in which it is increasingly ridding itself of fetters and constraints within the context of the **mega-trend of "explosive acceleration"**, which is taking place under partly inadequate conditions set by the global framework. A painful consequence of these inadequate conditions is the current **global financial and economic crisis** which, because of the resulting massive debts incurred by countries, poses a substantial threat to sustainability.

But also the international **transfer of labour** has brought about negative effects: gains for a few to the detriment of many people who suffer heavy losses. The consequence has been a partial deconstruction of the welfare systems in the rich countries, a **decline of the situation of the middle-income stratum** and important losses of states' tax revenues. On the whole, this is a development which threatens (long-term) stability through an increasingly short-term orientation, also to the detriment of the future.

The cause of the global regulation deficit is the **loss of the primacy of politics** in the context of globalization, because core political structures – in contrast with economic processes – have retained a national or to some extent continental orientation, but not yet attained a global one. Because of insufficient international agreements on regulations and the resulting wrong orientation of the global market, the developments described **run counter to the goal of sustainable development in a massive way**. Where do the really important challenges lie here?

12.2 The de-restriction of the financial sector as an instructive example

Currently the most important problem on a global scale is the derestriction of the financial sector as a consequence of globalization in the form of **digital capitalism**. Capital is roaming around the globe in an uncontrolled manner, always in pursuit of ever higher investment returns, and is putting governments under pressure, while arising from almost nothing. The **avoidance of tax payments** is becoming the most important segment for value creation for certain key-players. This is done by taking advantage of complex international legal situations and the special possibility of **off-shore financial centres** on the one hand, and by **creation of new monetary value** or borrowing through premium-debitors on the other.

The modifications of regulations for financial markets in the last few years have enabled small groups of premium-agents to generate capital **virtually from nothing** through new forms of **monetary value creation** using novel types of financing instruments. An example worth mentioning is the "innovation" of the securitization, on a vast scale, of loans, made (politically) appealing with the argument of (a better) distribution of risks. However, these securitizations also make a massive extension of the granting of loans possible while capital contributions remain equal, which has led to a massive increase in risks. However, these securitizations also make a massive extension of the granting of loans possible while capital contributions remain equal, which has led to a massive increase in risks. And this all the more, since the disposition of loans has led to significant lowering of (the necessary) care in the granting of loans, because the risks are now born by others (e.g. in the US subprime market). Loans were bundled together in great number, taken apart, bundled up again, (only to be once again) taken apart and re-bundled, and in such a way were rearranged to less and less understandable constructs. Imagine sausages on a funfair being made into new sausages: their quality standard in comparison to the original piece of meat is probably still more transparent than the reciprocal effect between the third securitization and the original risk in the financial sector. Even being able to sell such a thing necessitates an **excellent rating**, which has been ultimately made possible through Credit Default Swaps, which in turn have turned out to be **bluff packages** (the charges taken in annually were higher than the financial security deposited for an emergency). Problems in the US subprime market (less than 1% of the collateralized volume) (then) brought the complex house of cards to a collapse. Large fees were cashed in and rebates distributed for the fabrication of illusions **(voodoo economy)**. And the governments of the United States and the United Kingdom have refused to even address this issue as late as the G8-summit 2007 at Heiligendamm (Germany). For these countries had benefited too much. Here lies the ultimate cause of the mentioned problems.

Although in the current crisis, the international community has once again managed to save the system, this has been at the cost of **exorbitantly increased debts**. The situation includes the socialization of the losses after having privatized the gains beforehand. How are debts ever to be written off in this way?

12.3 The question of the environment and resources

However, the financial and economic crisis is not the only area which causes problems. For against the backdrop of an extremely rapid growth of the global population, the global **state of the environment and of resources** is exacerbating significantly within very short periods of time. Humanity is moving towards the mark of **ten billion** people. In addition, hundreds of millions of people are becoming accommodated to lifestyles marked by high resource consumption. Can this work out well by any means, and is there any sort of prospect for the future?

Firstly it holds true that, as a consequence of the growth processes described, **access to resources** and the **strain on the environment** thus brought about are increasing dramatically. There is no prosperity without the availability of resources! However, overuse leads to collapse. Who should be able to, and who should be allowed to access a given resource, and to what extent? War or peace can depend on the answer to this question. A bottleneck for the **feeding of the global population** may therefore ensue in the next few decades, despite a massive increase in food production. The prospects for the field of energy and climate look equally dismal. There is a threat of gravely problematic situations and conflicts. In a historical perspective – compare the example of **Easter Island** – there is a threat of a collapse of entire societies. And a large part of the elites all the world over are still used to thinking in terms of **competition of nations** rather than in terms of **international cooperation**. What is called for, instead, is a way of thinking committed to a universal principle of sustainability and marked by a supranational, intercultural and inter-generational orientation. **Global leadership** is what is called for here!

12.4 Technological progress and the boomerang-effect

The question of the **limitation of the usage of non-renewable resources** and of the **limitation of the strain on the environment on a global scale** while at the same time enabling a **high growth rate** occupies, before the background described, the centre stage among all attempts to arrive at sustainable solutions. Technological progress is of key relevance in this context. The goal is a factor 10, i.e. the reduction of the strain on the environment per unit of value creation produced to one-tenth of today's values (**de-materialisation, increase in ecoefficiency**). This is being discussed and implemented in many fields today – in real estate, e.g. with **green buildings**, passive houses and even positive-energy houses.

However, it must be cautioned that technology alone does not solve the problems – neither today nor in the past. Technological progress, unless accompanied by the setting of adequate rules rather leads to more, not less, overall strain on the environmental systems because of the so-called **boomerang-effect** (an example is the supposedly "paper-free office" – the place with the highest consumption in paper in the history of mankind.) However, each demand for limitations, e.g. of CO_2-emissions, immediately poses the global and to this day unanswered **problem of distribution of emission rights** in its full urgency. This is an issue of **global governance**. And this is why we need innovation in technology and governance simultaneously, in order to attain a **double factor of 10**.

12.5 Double factor of 10

The challenge which the world is facing today may be sketched out as follows: starting from the current global finance and global economic crisis, and while facing the threat of climate and resource collapse, the task is to create a **future worth living for 10 billion people** over the next 70 years. If high global prosperity together with a high level of social adjustment and balance, also between countries, is achieved, then global population can be expected to drop rapidly from about 2050 onwards. The question is, however, whether a high level of prosperity for ten billion people is even thinkable? Can we escape the current crisis without all having to tighten their belts?

At the moment there is an increasing number of people who all but despair of the current situation and demonize growth as the root of all evil. There is also the idea of completely reorganizing public finance, to the point of abolishing interest and compound interest. Such approaches underestimate the amount of vitality which the world needs in order to create sufficient wealth for 10 billion people. A "programme of going back" is not acceptable for most, especially not in democratic processes. At the most, this might be acceptable following catastrophes or lost wars, but one ought not to play with the thought of these kinds of developments.

However wrong today's ill-reflected concept of growth may be, the demonizing of growth and the **underestimation of the potential of innovation** are equally perilous. We do not find ourselves within a zero-sum game in which it is necessary to distribute scarcities. At the most, this holds true for resources, but not for what we are able to obtain from them when proceeding in an intelligent manner. A reasonable future is conceivable only if we succeed in bringing about a **substantial and continuing global growth** with significantly different respective rates of growth for the rich world and for the developing world over a long period of time, all this while maintaining **consistent protection of the environment and resources** on a global scale. **The protection of the environment and resources** come first, growth only when this condition is met. Such growth must be part of a Global New Deal and, because the environment needs to be protected, this must be a **Global Green New Deal**.

In this process, the creative power of market processes, creative destruction **in the Schumpeterian sense**, and the power of innovations need to be made use of. Simultaneous innovations in both technology and governance are called for in order to avoid the boomerang-effect, in which context the governance must of course be of a supranational character.

How is this to be envisaged? How can one imagine a double factor 10? And what needs to be done to that end? The starting point is the so-called **future formula 10 ~> 4:34** of the author. This basically says that the world, if the correct procedures are employed, can become 10 times as rich in 70 years than it is today, in which context today's rich world can become four times, and today's developing countries 34 times as rich. The size of the population in the poor countries thereby doubles. The social balance on the globe will then be roughly equivalent to that found in Europe today. The scarcity of resources is handled through appropriate assignation of rights, price developments, new technologies and alternative life-styles. **Qualitative growth** – this is the actual challenge. The (typical) life-style of the future would then be much less demanding in resources than today's, especially since resources will be more expensive. Highquality creative services in return will be much cheaper.

Many people have difficulty imagining a double factor 10. A tenfold increase in global economic performance within 70 years without additional usage of the environment, no extra consumption in resources because of an increase in ecoefficiency by a factor 10 – all this, for many, is beyond the possible. But that is exactly what is being aimed for today in the field of **Green Buildings**. And the market as a high performance innovative system is up to this task, especially when returns on financial assets are not too high. Suffice it to recall that in the seventeenth century there were only one-tenth of the number of people living today, that 90 percent of people worldwide and more than 50 percent in Europe were working in agriculture, and that nevertheless Germany as well as Europe went through recurrent famines. And now we are ten times as many people in the world, only 3 percent still work in agriculture in the rich world, and globally we are producing food for 13 billion people. Half of this, however, is being processed through livestock units (especially cattle), while 24 000 people starve every day – a regulation deficit due to the lack of a **global rule along the lines of the German Hartz IV social concept** which would at least supply everybody with the purchasing power needed to avoid starvation.

12.6 The power of innovation is the key to a good future

If we use the power of innovation and consistently implement the restrictions for the usage of resources, which presupposes global coordination and internalization of adequate prices into the global economy, then we have every chance of a global economic miracle and of prosperity all the world over. The goal of **Muhammad Yunus**, the Nobel Peace Prize laureate of the year 2006, i.e. overcoming poverty on this globe, can be attained. We can combine sustainability and wealth, but this calls for a greatly improved **global** governance and its implementation in terms of compliance and Corporate Social Responsibility in view of solving global problems. This is the most noble task of the economy and of global leadership: serving the people, solving social problems, and supplying the necessary goods and services. And all this in such a way as to consistently protect the environment, save resources for future generations, and make the dignity of every human being count.

12.7 Eco-social instead of market-radical

The programme described can be implemented. Nor is the way of getting there anything new – it is well known from the sphere of the nation state. But the issue must be put on the agenda anew, and on a global level. The answer to today's crisis and lack of direction is the eco-social and at its core ordoliberal approach of regulated markets typical of Europe (**social market economy**) and a few Asian national economies (**network economies**). For this economic ordering model on a **global** level the following equation applies:

market economy
\+ *sustainable development*
= *eco-social market economy*

This model would need to be established in the context of the global economy, and at the end of the day would translate, within the framework of a **Global Contract**, the requirements of a global ethic and of intercultural humanism into a form of **global domestic policy** of a **global democratic character**. The European Union constantly demonstrates the efficacy of this approach in its enlargement processes. The **Montreal Protocol** is also worth mentioning as a successful example of international cooperation which was agreed upon following the same logic. A contemporary approach for advancing such a pathway globally is represented by a **Global Marshall Plan**, which links the building up of structures and the implementation of standards to the co-financing of development.

12.8 Is there any hope?

In every crisis there lies an opportunity, although one usually also pays a high price during (such) a crisis. Today, this high price consists in the significantly deteriorated situation of states, which are now facing very high debts. Working off such mountains of debt is **not** going to succeed through tightening the belts in the area of social welfare – the scale of such an undertaking would demolish democracy. Instead, the practical approach is to finally **tax** the global economic processes, and especially also the value creation processes in the financial sector **adequately**. This is necessary for reasons of regulative policy and is a question of both justice and prudence, but would also slightly increase the friction in certain trading processes, which are too fast by now, thus bringing about more stability, and furthermore would improve transparency in addition to the ability to manage such processes in the widest terms. Tax harmonisation is of central importance, but so is **keeping tax havens in check**, not only through increased transparency, but also through minimum taxation levels.

Today, the considerably more difficult situation of nation states promotes considerations in the direction described. The transition from **G8 to G20** is significant. Especially questions about the global social situation, resources and climate pose themselves differently on the G20-level than on the G8-level. Twothirds of the global population and 90 percent of global economic performance are represented in the G20. This is a considerable approximation to a more democratic global situation.

There is hope that the G20 will consistently address the issue of tax havens and also that of a better governance of the financial sector. And perhaps there is hope too in the field of climate change. At least on the concrete level of facts the problems concerning the future can (in principle) be brought under control. We are in a good starting position as regards capacity, knowledge, methodology and the necessary financial, human and technical resources. We only need to realize that the **current situation calls for a broad cooperation of states**. There is only one way we can walk together now in order to attain a reasonable future: a double factor 10 made possible through an adequate global governance system – **eco-social instead of market-radical**.

12.9 References and further reading

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More information at:
www.faw-neu-ulm.de,
www.oesf.de,
www.oesfo.at,
www.senat-derwirtschaft.de or
www.globalmarshallplan.org.
It is possible to subscribe to the weekly newsletter of the Global Marshall Plan Initiative at the latter address, free of charge. Books can also be ordered there.

Translation by **Daniel Saudek**, independent scholar in science and theology.

Peter Stebbing & the Royal Society Population Working Group

13 The drivers of all Problems: Population & Consumption

"Every grain of wheat and rye, every sugar beet, every egg and piece of veal, every spoonful of olive oil and glass of wine depends on an irreducible minimum of earth to produce it. The earth is not made of rubber, it cannot be stretched, the human race, every nation, is limited to the number of acres it possesses. And as the number of human beings increases, the relative amount of productive earth decreases by that amount." (William Vogt, 1949)

The renown biologist, Paul Ehrlich states that *"We're already way past the carrying capacity of this planet by a very simple standard,"* and *"We are not living on the interest from our natural capital – we are living on the capital itself. The working parts of our life support system are going down the drain at thousands of times the rate that has been the norm over the past millions and millions of years."* Furthermore, *"In one sense, it is consumption that damages our life support system as opposed to the actual number of people expanding … What many of my colleagues share with me is the view that we would like to see a gradual decline in population, but a rapid decline in consumption habits."* (Hickman, 2011)

13.1 Introduction

The growth of our species' population is incredible. Nobody can deny that our enormous growing population is the cause of all our problems.

Unfortunately, many authors deliberately overlook population as a problem and focus instead on its derivatives or externalities such as global warming, pollution, the destruction of ecosystems, resource exhaustion, the extinction of organisms, and biodiversity loss. Malthus was the first author to address the issue of over-population in his famous essay first published in 1798. It brought him immediate fame. Population is a sensitive subject because birth control is intimately associated with fundamental ideas about individual freedom, religious affinity and other deeply held cultural and individual concepts. It is also a 'commons' which we can no longer afford. In the socially pivotal year of 1968 three authors addressed the problem of overpopulation: Garrett Hardin and Paul & Anne Ehrlich.

Garrett Hardin (1968) raised the thorny problem of overpopulation in his paper entitled *'The tragedy of the Commons.'* Having children is a 'commons', a freedom of a family to have as many children as the parents want (supported by the *Universal Declaration of Human Rights,* (Amnesty, 2008)). Hardin, questioned the right in view of the Earth's finite carrying capacity *"the commons, if justifiable at all, is justifiable only under conditions of low-population density. As the human population has increased, the commons has had to be abandoned on one aspect after another."* These included the abandoning of food-gathering, and later the abandoning of the commons for waste disposal and domestic sewage. Today we are still struggling with the commons of pollution by vehicles, factories, insecticides etc. Legislation has been introduced restricting lead in petrol. Naturally, every restriction of the commons is perceived by some to limit their freedom, but the limitation is for the benefit of the many. Hardin mistakenly attributed Hegel (actually, it was Friedrich Engels) with the quote that, *""Freedom is the recognition of necessity." The most important aspect of necessity that we must now recognize, is the necessity of abandoning the commons in breeding. No technical solution can rescue us from the misery of overpopulation. Freedom to breed will bring ruin to all."* The key, concludes Hardin, is education since it will reveal the necessities why we must somehow limit ourselves.

Furthermore, it is in this sense that we hope that those necessities are clearly presented here in *Changing Paradigms: designing for a sustainable future*.

The second publication was by Paul Ehrlich (1968) and his wife Anne (although not credited) whose best-selling book *"The population bomb"* caused a significant social stir. The book was criticized for the alarmist picture it presented and its apparently unfulfilled predictions. However, the authors maintain that their message was correct at least in principle and writing today (March, 2014) their foresight has stood the test of time. 44 years later the Ehrlichs (2012) published a paper with the disturbing title *"Can a collapse of global civilization be avoided?"* Happily, they conclude that we have the capability to avoid collapse since we have already been able to deal with the long term threat of the ozone hole. However, the odds of avoiding collapse will be greater when more people are able to recognize the classic signs because the *"diminishing returns to complexity are everywhere."* (Ehrlich & Ehrlich, 2012) That is *"Declining marginal returns, in general, can arise from any of the following conditions:*

1. *benefits constant, costs rising;*
2. *benefits rising, costs rising faster;*
3. *benefits falling, costs constant; or*
4. *benefits falling, costs rising;*

In undertaking to study the collapse of any complex society; these conditions should be looked for" (Tainter, 2009). Which of these conditions can we recognize around us today?

How many people need to die of starvation for it to become mass starvation? During the mid -80s a famine in Ethiopia reached the western consumer conscience following what *"maybe one of the most important and influential pieces of news ever broadcasted,"* reported by Michael Buerk (1984). It was a famine resulting from political circumstances and exacerbated by drought. *"No one really knows how many people died in the Ethiopian famine of the mid-1980s. Estimates run from 300,000 to as many as one million. The roots of this great hunger dated back to the 1970s. But over the course of a decade, despite warnings from aid groups about the magnitude of the disaster, Ethiopia remained a "forgotten" crisis"* (Rieff, 2005).

In 1984, Bob Geldof became committed to the Ethiopian famine cause. He organized the Band Aid release *"Do they know its Christmas"* and followed its enormous success in 1985 with the parallel Live Aid concerts held at Wembley Stadium and the JFK stadium in Philadelphia. More than 60 rock stars participated and raised more than £50m. The satellite-linked live event was watched by an estimated 1.5 million, a third of the world's population, and which in 1985 was about 4,831,000,000 people. A wonderful illustration of humanity's collective compassion. A compassion which again we need to access.

13.2 Our growing numbers

If we go back to about the time of Christ it is estimated that there were about 250,000,000 people on our planet. A thousand years later 350,000,000. In other words it took a thousand years for the population to grow by 100,000,000. In 1830 the population reached 1 billion or during 830 years it had increased 10 fold to 1,000,000,000. The next doubling of the population then took only 100 years so that in 1930 the population reached 2,000,000,000. 30 years later another billion was added so that in 1960 there were 3,000,000,000 people on the planet. 15 years later in 1975 our numbers had grown to 4,000,000,000. In 1987, 12 years later we were 5,000,000,000 and 11 years later in 1998 we reached 6,000,000,000. Then something very special happens because it now took until 2011, 13 years later, to reach 7,000,000,000. It is calculated that by 2050 our numbers will reach about 9,000,000,000 plus. So it appears that during the last 50 years when there has been the most rapid period of population growth in history that the fertility rate has fallen from 5 to 2.5 and that the average woman in the developing countries (except for China) instead of having 6 children now has 3 children (Chin, Marathe & Roberts, 2011). This is excellent news. However, can the Earth carry 9,000,000,000 in 2050 when we are already experiencing many challenges which we must surmount to ensure sustainable livelihoods for 7,000,000,000+ people?

13.3 Today

Although, *"… so far, the neo-Malthusian worries of global mass starvation and global calamitous environmental degradation and ensuing conflict have not materialized"* (Chin, Marathe & Roberts, 2011) nonetheless, 1.3 billion people, about one fifth of the world's population of 7 billion plus, live in extreme poverty and on less than $1.25 per day, a billion of whom are undernourished (von Braun, 2010).

Our needs compete for the world's limited resources, for example, agricultural land. In 2008 a confidential and internal report of the World Bank revealed that *"Bio-fuels have forced global food prices up by 75% – far more than previously estimated … Rising food prices have pushed 100 million people worldwide below the poverty line, the World Bank estimates."* (Chakrabortty, A., 2008) demonstrating the conflict between our competing needs for both food and fuel.

In September, 2010 the UN's Food and Agricultural Organization called a meeting partly in response to the destruction of the harvest by *"a heatwave and wildfires in Russia led to draconian wheat export ban and food riots broke out in Mozambique, killing 13 people. But UN experts heard that pension and hedge funds, sovereign wealth funds and large banks who speculate on commodity markets may also be responsible for global inflation of food prices …*
A near doubling of many staple food prices in 2007 and 2008 led to riots in more than 30 countries and an estimated 150 million more people going hungry" (Vidal, 2010).

13.4 Trees illustrate our conflicting material needs

The intensification of human activity and interdependence called globalisation *"… affects every aspect of life – economic, political, social, cultural and environmental"* (Moynagh & Worsley, 2008). The interconnectedness of our world and the conflicts between fulfilling our different needs: economic, cultural and environmental is well illustrated by trees. Dead trees provide economically useful materials for a variety of human needs and activities including:

- construction and building,
- furniture,
- jobs
- fuel
- chemicals
- tools,
- paper, etc.

but as living organisms trees provide essential ecosystem services, including:

- purifying polluted air and water,
- contributing to the water cycle and rainfall,
- medicines
- modifying local climate by providing shade and cooling the air
- tree roots stabilize soil against erosion
- tree roots stabilize enhance infiltration of rainwater into the soil
- reduces stormwater runoff
- sequesters carbon dioxide
- provides habitats for other species
- jobs
- if allowed to rot down wood contributes to the soil fertility

in an urban environment trees can provide:

- noise reduction
- air purification
- aesthetic enhancement
- cultural stimulation
- contribute to cooling the air
- etc.

The demand for trees illustrates the increasing competition for the needs which one resource can provide. Should we support the needs of consumerism or provide ecosystem services essential for our survival. Holistic or joined-up-thinking is profoundly required to identify the balance of needs. We have the encouragement of Easter Island to make the right choice (Diamond, 2005).

13.5 Tomorrow

It is estimated that by 2050 our current 7 billion inhabitants will have increased to ± 9 billion. The additional ± 2 billion will not merely require nourishment but have the right to material comforts and urban services now profligately enjoyed by the western consumer culture. However, it is not merely a matter of an extra ± 2 billion people because it is estimated that many people will rise out of poverty to join the middle class consumers. *"The global middle class – defined as those who spend between $10 and $100 per day – has climbed rapidly, reaching 1 billion in 2000 and doubling to 2 billion just recently. The middle class is expected to reach 4.8 billion by 2050, raising the question of whether the planet has the resources to deliver the lifestyle people will expect"* (Powell, 2013). This is the key question being posed by Sir David King, the former science adviser to the British government. More directly: *"Our most pressing environmental challenge is not how many people the planet can support, but rather how many cellphone-toting, satellite-TV-watching, gas-guzzler driving members of the middle class it can bear."* Sir David King confirms that population is the driver for all of the 21st century's interconnected challenges of climate change, ecosystem loss and destruction, health and development, energy security and supply, mineral and water resources, food production, conflicts and terrorism.

It was within the same holistic perception that the Royal Society conducted its investigation into the issue of population. I am grateful to the Royal Society for permission to republish the text of the executive summary of their report *"People and the Planet"* compiled by the Royal Society's team of experts. Their recommendations provide a framework to which design education and design must respond.

13.6 "People and the Planet"

ROYAL SOCIETY Report, April 2012 President's Forward: Sir Paul Nurse, FRS

> *"Rapid and widespread changes in the world's human population, coupled with unprecedented levels of consumption present profound challenges to human health and wellbeing, and the natural environment.*
>
> *The combination of these factors is likely to have far reaching and long-lasting consequences for our finite planet and will impact on future generations as well as our own. These impacts raise serious concerns and challenge us to consider the relationship between people and the planet. It is not surprising then, that debates about population have tended to inspire controversy.*
>
> *This report is offered, not as a definitive statement on these complex topics, but as an overview of the impacts of human population and consumption on the planet. It raises questions about how best to seize the opportunities that changes in population could bring – and how to avoid the most harmful impacts.*
>
> *We hope this report, The Royal Society's first substantive offering on this topic, will be a springboard for further discussion and action by national and international Governments, scientific bodies, non-governmental organizations, the media and many others.*
>
> *I would like to thank Sir John Suston FRS, the Working Group and the Society's staff for making sense of such a complex set of topics. I would also like to thank the many people who contributed throughout the project, including Council's Review Panel, who have all helped to bring clarity to these enduringly important issues."* Paul Nurse, President of the Royal Society, London

We and the Cumulus Association are enormously grateful to the Royal Society to have been given permission to publish The Summary and Recommendations from the full Report People and the Planet which is also available in English, Spanish and French and accessible at: http://royalsociety.org/policy/projects/people-planet/

POPULATION: People and the Planet SUMMARY & RECOMMENDATIONS

The 21st century is a critical period for people and the planet. The global population reached 7 billion during 2011 and the United Nations projections indicate that it will reach between 8 and 11 billion by 2050. Human impact on the Earth raises serious concerns, and in the richest parts of the world per capita material consumption is far above the level that can be sustained for everyone in a population of 7 billion or more. This is in stark contrast to the world's 1.3 billion poorest people, who need to consume more in order to be raised out of extreme poverty.

The highest fertility rates are now seen primarily in the least developed countries, and increasingly in Asia and Latin America. Despite a decline in fertility almost everywhere, global population is still growing at about 80 million per year, because of the demographic momentum inherent in a large cohort of young people. The global rate of population growth is already declining, but the poorest countries are neither experiencing, nor benefitting from this decline.

Population and consumption are both important: the combination of increasing global population and increasing overall material consumption has implications for a finite planet. As both continue to rise, signs of unwanted impacts and feedback (e.g. climate change reducing crop yields in some areas) and of irreversible changes (e.g. the increased rate of species extinction) are growing alarmingly. The relationship between population, consumption and the environment is not straightforward, as the natural environment and human socio-economic systems are complex in their own right. The Earth's capacity to meet human needs is finite, but how the limits are approached depends on lifestyle choices and associated consumption; these depend on what is used, and how, and what is regarded as essential for human wellbeing.

Demographic change is driven by economic development, social and cultural factors as well as environmental change. A transition from high to low birth and death rates has occurred in various cultures, in widely different socio-economic settings and at different rates. Countries such as Iran and South Korea have moved through the phases of this transition much more rapidly than Europe or North America. This has brought with it challenges different from those that were experienced by the more developed countries as they reached the late stages of the transition.

Population is not only about the growing numbers of people: changes in age structure, migration, urbanization and population decline present both opportunities and challenges to human health, wellbeing and the environment. Migrants often provide benefits to their countries of origin, through remittances, and to their host countries by helping to offset a workforce gap in ageing populations. Current and future migration will be affected by environmental change, although lack of resources may mean that the most vulnerable to these changes are the least able to migrate. Policy makers should prepare for international migration and its consequences, for integration of migrants and for protection of their human rights.

Developing countries will be building the equivalent of a city of a million people every five days from now to 2050. The continuing and rapid growth of the urban population is having a marked bearing on lifestyle and behaviour: how and what they consume, how many children they have, the type of employment they undertake. Urban planning is essential to avoid the spread of slums, which are highly deleterious to the welfare of individuals and societies.

The demographic changes and consumption patterns described above lead to three pressing challenges.

FIRST, the world's 1.3 billion poorest people need to be raised out of extreme poverty. This is critical to reducing global inequality, and to ensuring the wellbeing of all people. It will require increased per capita consumption for this group, allowing improved nutrition and healthcare, and reduction in family size in countries with high fertility rates.

SECOND, in the most developed and the emerging economies unsustainable consumption must be urgently reduced. This will entail scaling back or radical transformation of damaging material consumption and emissions and the adoption of sustainable technologies, and is critical to ensuring a sustainable future for all. At present, consumption is closely linked to economic models based on growth. Improving the wellbeing of individuals so that humanity flourishes rather than survives requires moving from current economic measures to fully valuing natural capital. Decoupling economic activity from material and environmental throughputs is needed urgently for example by reusing equipment and recycling materials, reducing waste, obtaining energy from renewable resources and by consumers paying for the wider costs of their consumption. Changes to the current socio-economic model and institutions are needed to allow both people and the planet to flourish by collaboration as well as competition during this and subsequent centuries. This requires farsighted political leadership concentrating on long term goals.

THIRD, global population growth needs to be slowed and stabilized, but this should by no means be coercive. A large unmet need for contraception remains in both developing and developed countries. Voluntary family planning is a key part of continuing the downward trajectory in fertility rates, which brings benefits to the individual wellbeing of men and women around the world. In the long term a stabilized population is an essential prerequisite for individuals to flourish. Education will play an important role: well educated people tend to live longer, healthier lives, are more able to choose the number of children they have and are more resilient to, and capable of, change. Educational goals have been repeatedly agreed by the international community but implementation is poor.

Science and technology have a crucial role to play in meeting these three challenges by improving the understanding of causes and effects (such as stratospheric ozone depletion), and in developing ways to limit the most damaging trends (such as enhancing agricultural production with reduced environment impact). However, attention must be paid to the socio-economic dimensions of technological deployment, as barriers will not be overcome solely by technology but in combination with changes in usage and governance.

Demographic changes and their associated environmental impacts will vary across the globe, meaning that regional and national policy makers will need to adopt their own range of solutions to deal with their specific issues. At an international level, this year's Rio+ 20 Conference on Sustainable Development, the discussions at the UN General Assembly revisiting the International Conference on Population and Development (ICPD+20) scheduled for 2014/2015 and the review of the Millennium Development Goals in 2015 present opportunities to reframe the relationship between people and the planet. Successfully reframing this relationship will open up a prosperous and flourishing future, for present and future generations.

13.7 Recommendations from the Royal Society Report

Recommendation 1

The international community must bring the 1.3 billion people living on less than $1.25 per day out of absolute poverty, and reduce the inequality that persists in the world today. This will require focused efforts in key policy areas including economic development, education, family planning and health.

Recommendation 2

The most developed and the emerging economies must stabilize and then reduce material consumption levels through: dramatic improvements in resource use efficiency, including: reducing waste, investment in sustainable resources, technologies and infrastructures, and systematically decoupling economic activity from environmental impact.

Recommendation 3

Reproductive health and voluntary family planning programmes urgently require political leadership and financial commitment, both nationally and internationally. This is needed to continue the downward trajectory of fertility rates, especially in countries where the unmet need for contraception is high.

Recommendation 4

Population and the environment should not be considered as two separate issues. Demographic changes, and the influences upon them, should be factored into economic and environmental debate and planning at international meetings, such as the Rio+20 Conference on Sustainable Development and subsequent meetings.

Recommendation 5

Governments should realize the potential of urbanization to reduce material consumption and environmental impact through efficiency measures. The well planned provision of water supply, waste disposal, power and other services will avoid slum conditions and increase the welfare of inhabitants.

Recommendation 6

In order to meet previously agreed goals for universal education, policy makers in countries with low school attendance need to work with international funders and organizations, such as UNESCO, UNFPA, UNICEF, IMF, World Bank and Education for All. **Financial and non-financial barriers must be overcome to achieve high-quality primary and secondary education for all the world's young, ensuring equal opportunities for girls and boys.**

Recommendation 7

Natural and social scientists need to increase their **research efforts on the interactions between consumption, demographic change and environmental impact.** They have a unique and vital role in developing a fuller picture of the problems, the uncertainties found in all such analyses, the efficacy of potential solutions, and providing an open, trusted source of information for policy makers and the public.

Recommendation 8

National Governments should accelerate the development of comprehensive wealth measures. This should include reforms to the system of national accounts, and improvement in natural asset accounting.

Recommendation 9

Collaboration between National Governments is needed to **develop socio-economic systems and institutions that are not dependent on continued material consumption growth**. This will inform the development and implementation of policies that allow both people and the planet to flourish."

If we are concerned then there is much that design can do and there is even more that education must do to educate the young to be concerned and empower them to change the causes of our concerns.

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14 Conclusion: onwards to the new paradigm

"We are made wise not by the recollection of our past, but by the responsibility for our future." George Bernard Shaw (1856–1950)

*"To live in the third millennium, ... we shall need new thinking
joined with new ways of perceiving and visioning ourselves, others,
nature and the world around us."* (Ervin Laszlo, 1997, 3rd Millennium – The Challenge and the Vision)

"The use of the world is finally a personal matter, and the world can be preserved in health only by the forbearance and care of a multitude of persons." Wendell Berry, 1977

'To know and not to act, is not to know.' Wang Yang-ming (Neo-Confucian philosopher 1472–1529)

"The essential concept of sustainability was embodied in the worldviews and traditions of many indigenous peoples, for example, it was a precept of the Gayanashagowa, or Great Law of Peace (the constitution of the Haudenosaunee or Six Nations of the Iroquois Confederacy) that chiefs consider the impact of their decisions on the seventh generation to come." the Great Law of the Iroquois Confederacy

14.1 Introduction

In Part One, *"Why we must design sustainably"*, we have examined many of the challenges which straddle our existence: overstepping planetary boundaries, ecosystems and biodiversity, water, food security, energy, resources, pollution, disasters, poverty, economics, politics, population and consumption. We have discovered that all of these challenges are inextricably interconnected with each other, often in ways that are not transparent to us. Sometimes, the interconnections only reveal themselves while fixing one problem we then cause other problems elsewhere. And yet, many of these problems have been known about and been building up for several decades and so many (design) students must be asking *'why is it so difficult for us to move forward towards creating a sustainable future? Why is there so little progress?'*

Design has a key role to play in achieving a sustainable future but we must also understand how our **un**-sustainable past permeates our present and hinders us in reaching the sustainable future we desire. Added to which are unsustainable aspects of human behaviour.

This final chapter is in three sections, we begin after part 14.1, the Introduction, by examining some of the reasons in part 14.2, why progress in achieving sustainability has been so slow. We consider the broader context within which we are trying to achieve a sustainable future. The problems of politics, finance, GDP and the neo-liberal capitalist framework that economically now dominates our world. If we do not achieve some sort of deeper comprehension of this framework, effective strategies for sustainability will be difficult to identify and implement or remain only superficial. What now seems clear and is important to recognize is that the governing political-economic establishment is not going to initiate change of any real significance corresponding to the scale of the global problems we now face. Consider, for a moment, all the conferences and actions that have taken place to limit climate change and mitigate green house gas emissions. Yet the famous 'hockey stick' graph of CO_2 emissions recorded at Mauna Loa, Hawaii, shows not a glitch in its inexorable rise to 400ppm and beyond (Tans & Keeling, 2014). Consequently, we attempt here to place sustainability within the wider context of influences which have hindered us in achieving a sustainable future.

In part 14.3 we consider some of the indications for a new and developing paradigm. As Buckminster Fuller has said *"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."* Consequently, we can optimistically observe the development of concepts illustrated by the examples of three authors. Noreena Hertz (2008, 2011) and the *"co-operative economy,"* Aaron Hurst (2014) and his *"purpose economy"* and conclude with Jeremy Rifkin's (2011) *"third industrial revolution."* One cannot categorically say that these, or any combination, or other concepts will provide the new paradigm; nonetheless, they are positive indicators of the coming change that many see as essential. These are certainly not the only authors who identify the need for change, some others to whom we have referred include Daly, & Cobb (1994), Ahmed (2010), Ostrom (2006, 2012), Norberg-Hodge (1991), and there are many more.

In the final part (14.4) we conclude by summarizing nine (clearly there are more) broadly based deeply interconnected meta-stratgies, mostly identified by experts, which could help catalyze the move towards a sustainable paradigm (already introduced in Chapter 2). The nine interconnected meta-strategies I have selected are:

- Educational Renaissance; Interconnectivity & Holistics.
- Open Source Everything.
- The necessity for Knowledge verification.
- Nature & Ecoliteracy & Earth Stewardship.
- Cooperation across all spheres; private, public & civil society.
- Grassroots.
- Culture and Community could eclipse Consumerism.
- Resilience.
- Re-orienting design.

The evidence for these meta-strategies is illustrated here by many examples which I hope will encourage students to create their own initiatives. There is already an enormous movement and awareness towards achieving a sustainable future, but unfortunately, many of these small actions by millions of people simply do not make media headlines. These 9 meta-strategies are presented only briefly since each is large enough for a book (as some are) and they are clearly interdependent and mutually supportive.

14.2 Several of the hindrances for achieving a sustainable future

14.2.1 Money is incompatible with ecosystems; and GDP is lethal.

Gregory Bateson (1980) observed, that *"Desired substances, things, patterns, or sequences of experience that are in some sense 'good' for the organism – items of diet, conditions of life, temperature, entertainment, sex, and so forth – are never such that more of something is always better than less of something. Rather, for all objects and experiences, there is a quantity that has optimum value. Above that quantity, the variable becomes toxic. To fall below that value is to be deprived."* This is a biological principle which applies to every living organism, including ourselves! However, the same principle also holds for the ecosystems and the biosphere within which we live. So for example: *"Nitrogen is crucial to the health of ecological systems, but in excess it becomes a pollutant that can lead to eutrophication of rivers and their coastal waters"* (Palmer, 2010). Eutrophication occurs when excess fertilizers used in agriculture are washed off the land into streams, rivers and lakes causing bacterial or algal blooms. When the blooms decompose they deplete the oxygen in the water causing a mass die off of other fauna: eutrophication.

Bateson (1980) continues that: *"This characteristic of biological value does not hold for money. Money is always transitively valued. More money is supposedly always better than less money. For example, $1001 is to be preferred to $1000. But this is not so for biological values. More calcium is not always better than less calcium. There is an optimum quantity of calcium that a given organism may need in its diet. Beyond this, calcium becomes toxic. Similarly, for oxygen …"* Bateson's observation that more money is always better than less is incompatible with natural systems (including our own bodies) which exist on the basis of optimum values and dynamic balances. We might reflect that it is perhaps unfortunate that more money is not toxic for human psychologies. Profit, the driver of nature's exploitation lies at the core of our unsustainable capitalism. Profit recognizes neither 'optimum values' nor 'dynamic balances.'

Further confirmation came when George Marshall (2014) asked the NASA climate expert, James Hansen, *"why people did not accept climate change, he said, "The answer is very simple – its money. The fossil fuel industry is making so much money that they control our governments, the media, and everything they tell us."* Profit also drives deforestation and in a remote part of Peru's Amazonian rainforest because *"there is not much beyond subsistence fishing and farming as a way to earn a living. Other options are mostly illegal: logging Amazonian hardwoods, growing coca, hunting and selling bushmeat … Gomez says he will earn around $825 for spending four months logging … Here the businessmen like to give money to the illegal loggers because the wood is cheaper. There's plenty of them … Three quarters of the passing timber is illegal … plundered from indigenous reserves and protected national parks." The wood will go "… to the US, Europe and, increasingly, China"* (Collyns, 2014).

Profit has become particularly lethal within the established economic system of neo-liberal capitalism and its killer concept: Gross Domestic Product (GDP). This is because GDP is an accounting system measuring profits but not the costs incurred by those profits. The World Bank (2014) defines *"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.* ***It is calculated without making deductions for*** *depreciation of fabricated assets or* ***for depletion and degradation of natural resources.****"* Consequently, by adhering to this blatant distortion of profit and GDP, the World Bank is a driver of ecosystem and environmental destruction on the planet. A fact confirmed for Herman Daly when he was employed by the World Bank as a senior economist and the 1992 World Development Report was being prepared. Daly "… *suggested we draw a big circle around the economy and label it "ecosystem". Then it would be clear that the inputs represented resources taken from the ecosystem, and the outputs represented waste returned to it as pollution. This would allow us to raise fundamental questions, such as how big the economy can get before it overwhelms the total system … In the third draft, the diagram was gone. The idea that economic growth should be constrained by the environment was too much for the World Bank in 1992, and still is today"* (Daly, 2008). One might think that it was time that the World Bank reviewed its own definition and set a lead to the World … .

The problem of how GDP creates the illusion of profit is well illustrated by the extensive use of pesticides and fertilizers by the agro-industry because the chemical pollutants, leaching from farms, subsequently have to be removed from the drinking water. The purification costs are paid for by the water consumers (Pretty, 2003) but if those costs were paid for by the polluters (the agro-industry) then this externality would reduce the agro-industry's profit margin and lower the GDP. As it is, this externality is an indirect farming subsidy or 'tax' paid for by water consumers for the water to be purified from agricultural chemicals and so does not figure in the farming balance sheet while artificially increasing profits and GDP. Furthermore, *"Big business has used its power to persuade the state to let it keep dumping its environmental costs on the rest of us"* (Monbiot, 2012). All this is consistent with contemporary neo-liberal capitalistic politics in which the environment plays only the role of providing marketable resources and a dump for waste.

Establishment (neoliberal capitalist) economists find this fundamental economic distortion acceptable and they continue to teach the economic model based on an infinite world with infinite resources (Chakrabortty, 2013; Chakrabortty, 2014) despite the 2008 economic meltdown. Why? The answer is perhaps not all that mysterious. Any revision to the economic model based on unlimited resources and the spurious concept of GDP must obviously take into account the environmental costs, the exhaustion of resources and the externalities of pollution and the destruction of ecosystems which industrial and commercial activity causes. Feeding back the costs of these externalities into the economics would significantly reduce both GDP and apparent growth. Until recently, these environmental costs were unknown. However, since they have become known (Trucost, 2012; Jowit, 2010) mainstream economists and politicians continue to blindly ignore both the anomaly and the need to develop a new economic paradigm.

The Ehrlichs (2008) write that the *"Silence on the overconsumption … is readily explained. Consumption is still viewed as an unalloyed good by many economists, along with business leaders and politicians, who tend to see increasing consumption, even among the super-rich, as a cure-all for economic ills … Most of humanity does not realize that expanding consumption among the already rich is a recipe for more environmental deterioration …"*. The economist's belief is that the free market is good for everybody as the benefits trickle down to the poorer levels of society. However, throughout the world the media confirms that the rich get richer, poverty is growing and Nature is dying. In 2010 a report commissioned by the UN and conducted by the Trucost agency investigated the world's 3,000 biggest companies and revealed that in the year 2008 they damaged and polluted the environment to the cost of $2.2 trillion. A sum equivalent to a third of their total profits for 2008. We can now all begin to understand why sustainability for the companies is "*... a new paradigm. Markets are not fully aware of these risks, and don't know how to deal with them. The report comes amid growing concern that no-one is made to pay for the disastrous pollution and the rapid loss of freshwater, fisheries and fertile soils ...*" (Jowit, 2010; Sukhdev, 2008).

More recently Trucost (2012) published their analysis for 2009 and "*... estimated the unpriced natural capital costs at US$7.3 trillion relating to land use, water consumption, GHG emissions, air pollution, land and water pollution, and waste ...*". That is quite some bill that Nature is paying with its destruction for GDP. It is part of the reason why we are overconsuming the Earth's natural capital and annual productivity by 1½ times – so as to keep the figures for GDP looking good. How does this sum compare with the total World GDP? "*WORLD GDP over the past 12 months was about $65 trillion. In the year to September 2013, global output will be about $10 trillion bigger, according to the IMF's projections*" (Economist online, 2011). Therefore paying for Nature would reduce the World's GDP by 11% for that year!

Tragically, nearly no one is made to pay for Nature, because it does not figure in our economic system and GDP, although our economic system depends on it – an unsustainably perverse situation! Few companies are prepared to reduce their profit margins. The politicians fear to regulate the companies and make them pay for the environmental damage they cause because large companies, as they do, are prepared to move to other, less regulated, countries. Furthermore, were the company to move away it would cause local unemployment making the politician unpopular! In addition, the politician would have caused a loss of GDP! Meanwhile, consumers want ever cheaper goods as the Primark store chain confirms. So everyone benefits at Nature's expense and always the corporation. I illustrate this now with just two attempts to save costs to increase profits which were happily rejected, although danger still looms in Brazil:

14.2.2 Good news for the Great Barrier Reef and Tasmanian Forest

The port at Abbot Point in Queensland, Australia, is being expanded to facilitate coal exports from Australia. The port handles a through-put often exceeding 2 million tonnes per month and sometimes totaling 50 million tonnes of coal per annum. The expansion, which has been approved, will require the dredging of 3 million cubic meters of spoil which it was planned to be dumped within the Great Barrier Reef Marine Park because of the enormous expense of dumping the spoil on land (Jabour, 2014). *("While the area to be dredged is located within the Great Barrier Reef World Heritage Area, it is in an area excluded from the marine park"* (Petersen, 2014)). "*As the world's most extensive coral reef ecosystem, the Great Barrier Reef is a globally outstanding and significant entity. Practically the entire ecosystem was inscribed as World Heritage in 1981, covering an area of 348,000 square kilometers.*" (or 34,800,000 hectares) (UNESCO, 2014). Tragically, over the last 27 years half of the initial coral cover of the Great Barrier Reef has already been lost (Kennedy, 2012). If the excavated spoil were to have been dumped within the Marine Park the ocean currents and storms would have dispersed the spoil endangering the pristine water quality on which corals depend. The financial value of the ecosystem services provided by a coral reef per hectare is estimated to be $1,195,000 per year (Pearce, 2012). (Therefore the total value of the Great Barrier Reef's ecosystem services per year originally equalled $41,586,000,000. (However, half has already gone at an estimated loss of $20,793,000,000). Happily, the plan to dump the spoil in the Great Barrier Reef Marine Park was canceled and the excavated spoil will now be dumped on land instead (Millman, 2014). This example, nonetheless, illustrates how corporations and politicians are very prepared to save costs/increase profits by making Nature pay with its destruction.

The Australian Prime Minister, Tony Abbott, who has been described as the "*the most environmentally destructive prime minister in living memory ...*" and wants to back "*... open-cut mines in the Tarkine wilderness,*" in Tasmania. In addition he also "*... wants 74,000 hectares of the world's tallest flowering forests stripped of their world heritage status so that they can be logged*" (Brown, 2014).

Fortunately, *"UNESCO world heritage committee discards Abbott administration's request to open 74,000 hectares to logging"* (Mathiesen, 2014) and the forest has been saved rather than contribute to Australia's GDP. Meanwhile, in Brazil, the politician Kátia Abreu, known as the *'chainsaw queen'* and *Miss Deforestation* is another ambitious neoliberal capitalist who *"leads the agricultural lobby in loosening controls on Amazon deforestation ... The senator and rancher from Tocantins was an influential force in the weakening of Brazil's forest code blamed by many for the recent rise in Amazon deforestation"* (Watts, 2014). It is disastrous that she has recently been appointed to the Brazilian cabinet by its new president, Dilma Rousseff (World Roundup, Guardian, 2015) causing anger amongst environmentalists.

So trashing Nature is good for GDP. Do not forget the World Bank's (2014) definition for Gross Domestic Product states that GDP ***"... is calculated without making deductions for ... depletion and degradation of natural resources."***

14.2.3 Alternatives to GDP

The good news is that alternatives to the measure of GDP as an indicator of a nation's prosperity are emerging. The Nation state of Bhutan whose previous ruler, King Jigme Singye Wangchuck wanted to make Bhutan both sustainable and economically self-sufficient. *"Among the development goals set by the king was the ideal of economic self-reliance and what he nick-named 'Gross National Happiness' (GNH). GNH is not a simple appraisal of the smiles on the faces of the populace; rather it encompasses explicit criteria to measure development projects and progress in terms of society's greater good"* (Kelly, 2012; Mayhew, Brown & Mahapatra, 2011).

On 2 April, 2012, a meeting took place at the UN convened by the Government of Bhutan entitled: *"Happiness and Well-being: Defining a New Economic Paradigm" – brought together hundreds of representatives from governments, religious organizations, academia and civil society to discuss the issue."* At the meeting the UN Secretary General Ban Ki-moon *"highlighted the need for an economic paradigm that incorporates social and environmental progress in efforts to achieve sustainable development. Gross National Product (GDP) has long been the yardstick by which economies and politicians have been measured. Yet it fails to take into account the social and environmental costs of so-called progress," Secretary-General Ban Ki-moon said at a high-level meeting at UN Headquarters in New York"* (UN News Centre, 2012).

The EU has assessed alternatives to GDP (Bergh, van den, & Antal, 2014) and the authors write that as measures of social welfare or human progress; *"Four main categories are considered, namely ISEW and GPI based on corrections of GDP, sustainable or green(ed) GDP, genuine savings/investments and composite indexes. All these alternatives turn out to suffer from various shortcomings. Nevertheless, several of them represent a considerable improvement over GDP information in approximating social welfare. This gives support to the idea that we should not wait to give less importance and attention to GDP (per capita) information in public decision-making until a perfect alternative indicator is available."* Both the Index of Sustainable Economic Welfare (ISEW), which was proposed by Daly & Cobb (1989), and the Genuine Progress Indicator (GPI) include a wider range of factors including the environmental costs that GDP ignores. Consequently, where GDP appears to be rising *"the ISEW shows a constant or even decreasing pattern after a certain time ... Both ISEW and the GPI suggest* ***that the costs of economic growth now outweigh the benefits, leading to "growth that is uneconomic""*** *(paraphrasing Herman Daly)"* (Bergh, van den, & Antal, 2014).

14.2.4 Neoliberal capitalism: the ceding of political power and democracy to giant corporations

In addition to the ecological destructiveness of GDP we live in the age of neo-liberal capitalism (see the Glossary entries on: Politics, Economics and GDP) and we need to understand what this means too. In a nutshell *"Neoliberals claim that we are best served by maximizing market freedom and minimizing the role of the state. The free market, left to its own devices, will deliver efficiency, choice and prosperity. The role of government should be confined to defence, protecting property, preventing monopolies and removing barriers to business. All other tasks would be better discharged by private enterprise. The quest for year zero market purity was dangerous enough in theory: distorted by the grubby realities of life on earth it is devastating to the welfare of both people and planet"* (Monbiot, 2012). The neo-liberal capitalist doctrine is driving *"the massive transfer of political power away from the people to unelected global capitalists, can be directly attributed to the changes which were first introduced in Chile in 1973"* under Pinochet. The destruction of Chile's post-war socialist economic system *"became a blueprint* *that was copied the world over"* (Clark, 2011). It is noteworthy that today *"only Britain and Chile have privatized water itself – having sold the resource to private companies for onward sale"* (Catley-Carlson, 2014).

The deregulation of the banks and commerce allowing market forces to grow with very limited regulation, together with the development of globalization and international trade agreements have substantially contributed to the opposite of a sustainable future. This development, which commenced under the Thatcher and Regan governments, was further aided by President Clinton who cancelled part of the 1933 Glass-Steagall Act which regulated certain banking activties. Today, this weakening of the banking regulations has matured into the neo-liberal capitalism that is the major driving force enabling corporations to destroy ecosystems and the environment (Hertz, 2008; Hedges, 2013). US imports alone threaten nearly 1,000 species worldwide with extinction (Lenzen, et al., 2012). Furthermore, it is also driving the social polarization of rich and poor. What is moral does not stand up to the drive for profit.

Politics worldwide is moving away from the democratic management of societies for the electorate to a politics run for the benefit of corporations and commercial activity (Meek, 2014) such as the TTIP agreement demonstrates (see Chapter 10). Government spending for social welfare is being cut while spending by governments to support corporations is increasing (Farnsworth, 2012; Farnsworth, a. 2012). Consequently, we now see the development of corporate-governments (Hertz, 2003; Monbiot, 2000) concerned less with the electorate and more with the wishes of corporate lobbyists and the welfare of their corporations. Lobbying now competes with, if not eclipses, voting as the policy determining activity in economically advanced nations. In the UK, for example, cabinet ministers are 'partnered' with industrial moguls for easy lobbying and direct 'consultation' (Ball & Taylor, 2013). James Hansen, previously Head of NASA's Goddard Institute for Space Studies and climate expert spoke at a UK protest against E.ON, the energy corporation, which planned to build a new coal powered electricity generating station. *"The democratic process is supposed to be one person one vote, but it turns out that money is talking louder than votes. So, I'm not surprised that people are getting frustrated. I think that peaceful demonstration is not out of order, because we are running out of time"* (Adam, 2009) for reducing emissions to limit the impact of climate change.

14.2.5 For example, is the European Union a democracy or a corporate oligarchy?

In 2014, Europe elected a new European parliament, be that as it may, lobbying by unelected lobbyists will have a major influence on the European 'democratic' process and the decisions made by the European Commission. *"Every office block within a kilometer of the European Commission, council, and parliament is peopled by Europe's biggest corporate names. Thousands of companies, banks, law firms, PR consultancies, trade associations are there to bend ears and influence the regulations and laws that shape Europe's single market, fix trade deals, and govern economic and commercial behaviour in a union of 507 million."* Altogether, it is estimated that there are 30,000 lobbyists in Brussels and that they influence 75% of European legislation (Traynor et al, 2014).

Consequently, it would be wrong to imagine that the European Parliament is primarily a democratic institution, it is not. It began life as the European Economic Community (EEC) in 1957 when it was created by the Treaty of Rome to open up a common market in Europe. The initial signatories were Belgium, Italy, France, The Netherlands, West Germany and Luxembourg. In 1973 the United Kingdom, Denmark and Ireland joined, followed by Greece, Portugal and Spain in the -80s with still more countries joining subsequently. *"The EEC was designed to create a common market among its members through the elimination of most trade barriers and the establishment of a common external trade policy ... Politically, the EEC aimed to reduce tensions in the aftermath of World War II. In particular, it was hoped that integration would promote a lasting reconciliation of France and Germany, thereby reducing the potential for war"* (Gabel, 2014).

In the early -80s when the European economy was in the doldrums, a group of CEOs from a number of European corporations sought to promote the business interests of their trans-national corporations (TNCs). Altogether, 17 industrialists and corporate leaders formed the European Round Table of Industrialists (ERT), which had its inaugural meeting in 1983 and drew together plans to "relaunch" Europe so that it would be good for all their businesses (Balanya, et al, 2003). Their wants included:

1. the adoption of a single market.
2. monetary union.
3. to be able to set up infrastructure projects.
4. flexible labour markets.

5. deregulation and minimal government control.
6. the reduction of public spending, (i.e. government spending) supporting social welfare, healthcare, pension provision, education, etc.
7. national austerity measures.

etc.

In 1983 one of these business moguls, Wisse Dekker, and the chairman of the ERT, wrote to the European heads of state explaining what the ERT wanted, adding that if the politicians did not deliver then they would move their businesses out of Europe. Dekker's political bribery was successful and neo-liberal capitalism has now become well established in Europe and elsewhere around the world (Moser, F., Dhoet, S., Lietaert, M., Hoedeman, O., 2013). The 'vision' of the ERT has been so successful that industrialists now significantly influence the European Union as politicians previously used to do in many democratic countries. In the UK, its even better than that for industrialists; the British premier, David Cameron, simply asks corporations what they want and, lo and behold, their wishes frequently become government policy! (Monbiot, 2000; Hertz, 2003; Monbiot, 2012).

One might well imagine that in a western style democracy, the tax paying electorate receive welfare benefits in the event of misfortunes such as becoming unemployed or ill health. However, in many countries, due to the economic crisis of 2008 brought about by corrupt banking activities, austerity measures (7 above) have increasingly impacted on electorates, particularly in the UK. Now, those who enjoy increasing welfare support from governments are the corporations; for example, since 2007, the Walt Disney company has received £167 million from the UK government to encourage it to make films in the UK (Sylt, 2014; Chakrabortty, a 2014). *"Direct and indirect state support to corporations – referred to … as corporate welfare is commonplace and is deeply embedded within the welfare state with various forms of assistance being delivered through social policies. In such an environment, the fact that social policy has very little to say about 'corporate welfare' is a serious omission"* (Farnsworth, 2012). Clearly, 'corporate welfare' is the lie that completely undermines the political argument for privatization, *"putting paid to the myth that capitalism and businesses could ultimately be more profitable, more efficient and more competitive without state interference and direct support"* (Farnsworth, 2012). In the USA tax payers' money was used to refloat the bankrupt car maker, General Motors, and following the 2008 financial crash billions of tax payers money was used to prop up the failing banks that were 'too big to fail.' Consequently, the political argument for privatization is groundless.

At this point it might be wondered why so much concern is given here to politics in a book about sustainability. We have to recall what Theodor Adorno (2006) wrote *"There is no right life in the wrong one."* In other words while many people and companies are trying to live and operate sustainably there are very powerful corporations, who through their actions and wealth exploit the legislation negating the sustainable actions of others.

This is well illustrated by the case of neonicotinoid pesticides on which the EU (being Europe's elected body) has placed a 2 year moratorium on their use because of the, now well established, harm that they do to pollinators and the 'high acute risk' they pose to honeybees. The large corporations, Syngenta and Bayer, (two of the manufacturers of neonicotinoids) are actually suing the European Commission because of the ban on the use of neonicotinoid pesticides (Benjamin, Holpuch & Spencer, 2013)! It is clearly unsustainable that corporations have been given so much freedom ('personhood'), empowered by deregulation given to them by politicians, and motivated solely by profit that they can threaten species on which we all depend. In the meantime they are able to sue the people's representatives who are acting democratically and making a democratic decision! We need to be aware that this is the frame within which we want to democratically persue a sustainable future.

In the USA politicians are lobbied and beholden to transnational corporations for the financial donations given to them for their electoral campaigns. An electoral system has become a buying system which consequently excludes those of the electorate who are unable to pay to enter politics. A recent paper by Gilens and Page (2014) poses the question; who governs and really rules in the United States? Their conclusion is that it is not the average citizen voter but it is the economic elite that dominates US policy. This has also been convincingly demonstrated by Brulle (2013) in describing the counter-climate-change movement in the USA. This movement was financed by over a hundred industrial "philanthropists" including; Scaife Affiliated Foundations, Koch Affiliated Foundations, ExxonMobil

Foundation, etc. who financed a variety of "think tanks" and other organizations to produce papers, articles and other publicity material deliberately doubting climate science and denying climate change. Brulle records that from 2003 to 2010 the total money donated was $7,225 million or nearly a $billion a year was spent to mislead society at large. The impact of the counter-climate-change movement stirred up sufficient debate so as to successfully paralyze (Monbiot, 2006; Monbiot, 2007) political legislation for a decade that would have limited emissions from industrial and consumer activities. It was only in 2014 that President Obama finally put forward his legislation for reducing emissions from coal by 30% (Goldenberg, 2014, a & b). What is happening in the US is also happening in Europe.

We all know that neo-liberal economics and the politics that support it, along with five core principles are fundamentally flawed and unsustainable, but let us consider what these principles are:

Firstly: economic growth is held to be paramount despite its obvious contradiction to the planet being finite. Therefore corporations are given the freedom to pursue economic advantage by whatever means possible with minimal government regulation. Following a ruling by the US Supreme Court *"corporations are considered to be persons for many purposes under the law, now including the preservation of First Amendment rights"* (McHenry, 2010).

Secondly: Free trade is believed to be good for all nations. However, international trade threatens biodiversity and species extinctions in developing nations. As has been mentioned; it is calculated that US imports threaten nearly a 1,000 species worldwide; furthermore, German imports threaten 18 species worldwide, and exports from Indonesia threatens nearly 200 of its endemic species (Lenzen, et al., 2012).

Thirdly: government spending is thought to be inefficient and wasteful and therefore spending on social welfare (health, education etc.) is to be reduced (austerity measures).

Fourthly: privatization is to replace public ownership (WHO, 2014). Ultimately, nothing underlies neo-liberal-capitalist dogma beyond Bateson's observation that $1001 is better than $1000. It is clear that the market is not for the benefit of society but that society is there for the benefit of the market and those who run it. And ecosystems …?

Fifth: As the rich get richer it was thought that their investments and spending will somehow benefit those in the poorer echelons of society by the 'trickle down effect'. However, now that the *"richest 85 people in the world have as much wealth as the poorest 3.5 billion – or half the world's entire population – put together."* Alex Andreou (2014) continues, then *"If one subscribes to the charitable view that neoliberal philosophy was simply naive or misguided in thinking that "trickle down" would work infinitely, then evidence that it doesn't, should be cause for concern."* But regrettably governments are unable to revive the economy because the only measure of human progress they have is a financial one which *"fails to take into account wealth distribution, educational achievement, innovation, or even the welfare and health of the population they claim to represent"* (Andreou, 2014). In 1968 Bobby Kennedy made the same criticism of GDP which then was called GNP (Gross National Product in a campaign speech (see chapter 11 by Dr Vandana Shiva).

This is the era which Noreena Hertz has named *"Gucci Capitalism based on self-interest and profit maximization of the last 30 years looks set to be replaced by an open source, Co-op Capitalism based on collaborative and shared enterprise."* (Hertz, 2011) Gucci Capitalism is another term for the 'old paradigm' described in Chapter 2.

14.3 Some indications of an emerging economic paradigm in which design for sustainability can flourish

The consumer society largely continues with business as usual based on the existing political-economic system of neo-liberal capitalism and growth. However, the basic recognition of the problem is the first step in moving towards effective solutions (Daly & Cobb, 1994). Political tweaks here and there to encourage sustainability are inadequate due to the holistically interrelated dynamics of all the challenges (Ahmed, 2010). The whole system requires a radical re-configuration due to the inevitability of:

i. the end of the industrial age and its dependence on fossil energy.
ii. and the transformation to what might be called the post-carbon age (Ahmed, 2010).
iii. the *"corporate capitalist model is still driving the world economy in the wrong direction, worsening*

environmental risks and increasing ecological scarcities. The single largest sustainability challenge of our time is this: today's corporation, the main agent of today's economy, generating two-thirds of global GDP and jobs, needs to be redesigned. Without corporate redesign, we are unlikely to see any progress towards a "green economy"." So wrote Pavan Sukhdev, a career banker on the Board of Deutsche Bank's Global Markets Centre and leader of the Report commissioned by G8+5 on *The Economics of Ecosystems and Biodiversity* (TEEB) (Sukhdev, 2014).

iv. Furthermore, the Council of Scientific Society Presidents supported the US Environment Secretary Steven Chu's testimony to a Senate Sub-committee about the necessity for change. On May 4, 2010 they wrote: *"We represent the leadership of over 1.4 million scientists in over 150 scientific disciplines.*

The acceleration of greenhouse gas (GHG) emissions from human activity is increasingly leading to harmful climate change and ocean acidification. Societies must act urgently to reduce these emissions to protect the life-sustaining biophysical systems of the Earth. As noted by DoE Secretary Steven Chu in his April 28, 2010 testimony to the Senate Subcommittee on Energy and Water Development, the necessary transition: "will require nothing short of a new industrial revolution." We agree with this assessment of the scale of the response needed. We need to work aggressively to conserve energy and increase the efficiency of energy use, and we do need rapidly to develop less polluting energy systems. Objective science has a critical role to play, and we urge that the nation fully use and incorporate the best available science in designing and implementing the energy and environmental policies necessary to guide this revolution" (Apple, 2010).

This call for fundamental change is supported by authors who also recognize the urgent need for a new economic paradigm of a kind already proposed in Chapter 2. as an alternative to the environmentally catastrophic neo-liberal capitalism (Ahmed, 2010). The ideas of Hertz's co-op capitalism, share much in common with the *'purpose economy'* (Hurst, 2014) and 'the third revolution' (Rifkin, 2011).

The Cambridge University economist Noreena Hertz (2011) has created the concept of *co-op capitalism*. Aaron Hurst (2014) has identified what he describes as the *'fourth economy – the purpose economy'*. (The previous three economies being: the agrarian economy, the industrial economy. the information economy). Jeremy Rifkin (2011), using a different nomenclature proposes that we are entering the *"third industrial revolution"*. These overlapping concepts described by the authors Hertz, Hurst and Rifkin include:

1. The extensive use of the information and communication technology media.
2. Connections enable achievements which would otherwise be impossible and so the network has social value.
3. Collaboration and sharing play a key role in market relationships, providing fairness and access to all.
4. Concern for communities, a social mission and social entrepreneurship in which profit is not the sole driver.
5. The new economy is characterized by peer-to-peer or lateral relationships rather than the corporate hierarchical structure.

Cooperation is particularly important, not merely because it is common to co-op capitalism, the purpose economy or the 3rd industrial revolution but it is also a common human behavioural trait which all of us share and therefore deserves closer examination and encouragement.

14.3.1 Co-op Capitalism

Noreena Hertz believes that in the current economic climate the conditions are "*... in place for a new form of capitalism, a form that I have named Co-op Capitalism with values of co-operation, collaboration, coordination, community and communication at its heart, to emerge in its stead?*" Hertz (2011) believes that what she calls *"Gucci Capitalism"* (corresponding to the "old paradigm" of Chapter 2) is ending (Hertz, 2008) because:

› Firstly, the financial crisis is prompting new thinking in economics. Economics students worldwide are demanding a complete overhaul of what is taught in economics (ISIPE, 2014; Chakrabortty, 2014; Chakrabortty, 2015);
› Secondly, there is a greater emphasis on the integration of economics, environmental issues and social justice in economic thinking (see Chapter 6) together with a critical analysis of Gucci capitalism. Furthermore, *"Intervention is back in vogue"* and many be-

lieve *"that the free market should not be allowed to function independently"* (Hertz, 2011) and so we will see less de-regulation and perhaps even re-regulation. Intervention may also take a new form in that some of the big corporations are forced by governments to act for the public good such as the pharmaceutical industries and to provide affordable medicines. However, public pressure for sustainability is having an impact, for example, the supermarket chain Walmart, claim that *"Last year, Walmart doubled the amount of local produce sold in stores nationwide. That number will continue to grow …"* (Walmart, 2014).

› Thirdly, Hertz suggests that other countries with different mindsets to Gucci capitalism are in their ascendancy, for example, *"In the four BRIC countries (Brazil, Russia, India, and China), fifteen per cent of their population are member-owners of co-operative enterprises …"* (Hertz, 2011).

Co-op capitalism is defined by a number of characteristics, which include:

1. *The "Community is valuable of itself … Co-op capitalism sees value in the collective"* in contrast to Gucci capitalism which primarily values the selfish individual consumer. In contrast, Co-op capitalism believes that public goods must be managed in ways to ensure fair access and use by all. Consequently, the UK government's plan to sell off the public space forests to private corporations caused an outcry and was seen as detrimental to the public good and consequently the decision was reversed (due largely to the potential damage to the government's image).
2. *"Co-op capitalism values processes, not just outcomes"* so that *"how we interact matters … how an exchange takes place, the relative power on each side – also matters of itself and because this will impact or distort the outcome."* Again, this contrasts with Gucci capitalism which *"is concerned with the outcome of transactions but neither their nature nor the process."* Furthermore, Co-op capitalism must redefine GDP to include the environmental impacts and the externalities of commercial activity.
3. *"The network has worth … because connections often allow us to achieve things that we either could not achieve by ourselves, or … with great difficulty."* Gucci Capitalism meanwhile focuses on individual success. *"Recognizing that connections have both an economic and a social value means that enabling connectivity becomes of itself a social, political and economic goal."* In addition we must connect to the biosphere to swap the unsustainable connections of the old paradigm for the sustainable connections of the new paradigm (see Chapter 2).
4. *"Collaboration can trump competition"* whereas *"For Gucci Capitalists competition is the only modus operandi." Finally, "Co-op Capitalism explicitly values collaboration, explicitly sees the value in sharing ideas, pulling together in common cause …"* (Hertz, 2011)

These four characteristics illustrate how of co-op capitalism, can provide an alternative model to the neo-liberal capitalism brought about by Thatcher and Reagan, or "corporate fascism" defined as *"the merger of corporate power and state power, such that corporate power dominates"* (Jaeger, 2011) the economic and political landscape.

So could co-op capitalism work? The good news is that sustainable co-operative capitalism is already becoming established in the commercial sphere. It is easy to find examples which illustrate the principles of co-op capitalism, and here are just two:

Community

Olam is a leading agri-business company which markets the produce of 3.9m small-holder farmers around the world. However, the Olam company is not just a marketing 'middle man,' selling produce to make a profit. Rather, it recognizes that the farmers on whom it depends operate on a narrow margin and need security which Olam is concerned to provide (thereby also co-operatively protecting its own interests). Consequently, *"in 2012 Olam invested $2.2m in social infrastructure, rural health and education,"* rural electrification and water facilities. Furthermore, in order to staff the infrastructure facilities such as schools and hospitals which it has built, Olam also collaborates *"with a wide range of private and public organizations and NGOs, such as USAID."* Olam has also introduced a private charter to help keep small holders in business so that supply chains can be created and maintained that are sustainable from seed to shelf in 65 countries around the world (Guardian, 2014). "73% of Olam Livelihood Charter farmers own mobile phones enabling direct payment, market pricing and information" (Olam Annual Report, 2013). Olam's strategy is transparently concerned with the communities of its small-holder farmers and their longterm welfare since Olam understands that its own welfare depends on the farmers' welfare.

We can see that within Olam the four principles of co-op capitalism cited above are all at work within this company: the communities of the smallholding farmers are valued. Processes are valued *"not just outcomes"* and that interaction also matters. The network as a whole is valued "*... because connections often allow us to achieve things that we either could not achieve by ourselves, or ... with great difficulty.*" Furthermore, the connections are valued because connectivity supports environmental, *"social, political and economic goals."* Finally, *"Collaboration can trump competition" since it values sharing ideas and working for a common cause* (Hertz, 2011). Mankind's greatest achievements were only possible because of cooperation: Stonehenge, the pyramids, the Taj Mahal, Machu Pichu, Notre Dame, the Great Wall of China, and 'putting a man on the moon.' Today we need massive cooperation to bring about sustainable change.

Network

The second example is from the media. Media and social networks reporting on the latest developments, businesses, and projects continually provide access to new knowledge and sources for updating the design curriculum. Dr Hans Peter Meinzer (Meinzer, 2007), in a Cumulus keynote presentation said that "*... if I were ill then I would like to be treated to the full extent of the available knowledge.*" Design is no different and an effective design process requires access to the most upto date available knowledge. In addition it is also essential to know who to contact as a potential expert, adviser, collaborator, consequently networks of all kinds have a key role to play.

One excellent sustainable business internet network is provided by the *Guardian News and Media* award winning website with its web page on sustainable business at: http://www.theguardian.com/sustainable-business.

It is *The Guardian's* stated "*... vision is to be a leader on sustainability within the media industry.*" It identifies core sustainability challenges which very much reflect Hertz's co-operative principles, notably supporting and creating networks. It aims to place itself "*at the forefront of ethical thinking in the media industry*" with goals which, amongst others, include:

- developing and mobilizing *"people to be inspirational, innovative and share skills for a sustainable future."*
- a duty to the community to protect and enhance *"the health of local environments, communities and economies."*
- *"building a trusted and engaged audience relationship?"* through openness and independence.
- meeting *"the highest environmental standards"* and using "*... technologies, products and services that protect human health, resources and natural abundance*" and to *"mitigate the potential impacts of climate change ..."*
- championing sustainability and *"provide the most comprehensive news coverage and analysis on sustainability to inspire a positive future ."*
- forming *"commercial partnerships that contribute to a sustainable future and protect business continuity."*

(TheGuardian.com, 2014: http://www.theguardian.com/sustainability/sustainability-report-2013-our-strategy)

The Guardian's strong ethical stand is confirmed by its *Keep it in the Ground* campaign concerned with leaving fossil fuels in the ground so that climate warming does not go beyond 2°C. The Guardian Media Group itself has set the example and divested itself of its £800m investments in fossil fuels. "*In March,* [2015] *the Guardian launched a campaign calling on the Gates' Foundation and the Wellcome Trust to divest from coal, oil and gas companies. More than 223,000 people have since signed up to the campaign*" (Howard, 2005). The Gates Foundation has $1.4bn invested in fossil fuel companies, including BP which was responsible for the Deepwater Horizon oil spill disaster.

The Guardian's web page enables one to easily navigate through its Business page to the Sustainable Business page which presents about 30-40 articles addressing developments, reports, conferences etc. embracing the entire sweep of sustainability business activity. In addition the web page has 14 hubs providing information on particular aspects of business and also sustainability, including: Sustainability Fashion, Children's rights and business, Circular economy, Communication, Finance, Food, Social Impact, Supply chain, Sustainable design, Sustainable living, Technology and innovation, The role of business in development, Values-led business, and Water, etc.

Meanwhile, another Guardian web page introduces the reader to a range of professional fields of activity, each with its own hub of further links. For example the Global Development Professionals Network presents a series of hubs concerned with *"promoting understanding, dialogue and debate among global development professionals"* and *"aims to link to the best content on the web and to promote the sharing of research and ideas."* (http://www.theguardian.com/global-development-professionals-network/dealing-with-risk) and again some of the issues addressed are also concerned with sustainability: Cities in Development, Communications, Dealing with Risk, Climate change, Diaspora driven development, Farming and food security, Global health innovation, Renewable energy, Tackling youth unemployment, and Transforming institutions, etc.

Each hub presents news stories and is interconnected to related themes on other hubs. The hubs are sometimes sponsored by businesses but the content and editing is independent of commercial support.

This brief and incomplete account of The Guardian Newspaper's web page illustrates several aspects of Hertz's co-op capitalism principles. Anyone visiting the site will recognize immediately a concern for the development of communities, by supporting networking, linking peoples and the encouragement of collaboration through its own media activities as well as reporting on them in business practice. The Guardian Newspaper is a rare illustration of the new economy in both its own being as an organization (and it is a subject worthy of analytical study itself) and simultaneously through its actions, campaigns and achievements. It provides the design curriculum with an example of how the media can contribute to moving society towards achieving a secure and sustainable future.

Although Olam and The Guardian are two large organizations they illustrate many of the characteristics of co-op capitalism at work with their emphasis on concern for the community, collaboration, network and process to create sustainable businesses.

14.3.2 The purpose economy: the promotion of human value

It has been claimed that British prime minister, Margaret Thatcher, *'knew the price of everything and the value of nothing.'* In the UK she led the way forward into a new *'endarkment'* (Ehrlich & Ehrlich, 2013) of neo-liberal capitalism, the privatization of public utilities, the cutting of social welfare, the empowering of corporations, and the principle that whatever could not pay its way or create a profit should close (for example the psychiatric hospitals). It is from the vacuity of profit driven politics that a phoenix of humaneness is now arising which is motivated by a concern for people's welfare and the idea that a company should have a mission beyond profit.

Aaron Hurst is the initiator of what he calls the purpose economy promoted by his company Imperative which he launched in 2014 with the aim of connecting people to purpose. The core concept is to bring a sense of meaning and purpose to the work we all do everyday and to feel that our work is meaningful and to raise our personal sense of self-value. Hurst claims that it is not about finding a cause or a mission but rather that there are three ways to acquire purpose through one's work:

- Firstly, it comes by doing something greater than oneself and not just for one's own self interest (q.v. Glossary: Happiness is ...).
- Secondly, relationships are important because working with other people or in a team generates purpose. Furthermore, it is about making an impact on one's local community.
- Thirdly, purpose develops when we personally invest in ourselves, by challenging ourselves and expressing ourselves creatively.

It maybe that from the perspective of higher education that Hurst's three strategies possess an echo of the emperor's new clothes since many who are involved in education would strongly identify with all three strategies in addition to others. Nonetheless, what is indicative is the success of Hurst's mission confirming that today's commercial zeitgeist and milieu is receptive to his message.

Hurst claims that *purpose economy* organizations are emerging with a diverse range of purposes which are illustrated by these examples:

- B Corp (https://www.bcorporation.net/what-are-b-corps) is an organization promoting and certifying corporations and businesses to meet and adhere to "*rigorous standards of* *social and environmental performance, accountability, and transparency."* So far *"there is a growing community of more than 1,000 Certified B Corps from 33 countries and over 60 industries working together toward 1 unifying goal: to redefine success in business."*

› Etsy (https://www.etsy.com/) provides a platform to buy and sell all things handmade, including art and craft, contemporary and vintage.
› Lenddo (https://www.lenddo.com/) depends on the applicants honesty and offers a loan service over the internet.
› Good Eggs (https://www.goodeggs.com/welcome) *"mission is to grow and sustain local food systems worldwide."* (Hurst, 2014).

Hurst provides substantial evidence of the change taking place throughout society and simultaneously provides examples and strategies in the spirit of design for sustainability.

14.3.3 The Third Industrial Revolution (TIR)

Rifkin (2011) observes that the conventional top-down, hierarchical organization is being replaced in society by lateral power, and distributed and collaborative relationships. The concept of the *'third industrial revolution'* (TIR) proposed by Jeremy Rifkin identifies five pillars which he claims will bring about the same significance as the two previous industrial revolutions. TIR will depend on the simultaneous implementation of the five pillars due to the interdependence of each on the others. These pillars are:

1. *"shifting to renewable energy;*
2. *transformation of the building stock of every continent into micro-power plants to collect renewable energies on site;*
3. *deploying hydrogen and other storage technologies in every building and throughout the infrastructure to store intermittent energies;*
4. *using Internet technology to transform the power grid of every continent into an energy-sharing intergrid that acts just like the Internet ...*
5. *transitioning the transport fleet to electric plug-in and fuel cell vehicles that can buy and sell electricity on a smart, continental, interactive power grid"* (Rifkin, 2011).

The intelligent energy grid

A key feature of Rifkin's revolution is to make all buildings into mini-power stations able to generate the power each house requires. As we all know, the sun is not always shining and the wind is not always blowing. Therefore, a key feature is to have an intelligent energy grid to which all buildings are linked and able to either receive or pass on excess energy to the grid for others to use. This whole re-orientation of energy management towards a lateralization rather than the top-down, centralized power provision has many advantages. Amory Lovins (2002) writes that small local power sources with shorter lead times can raise the value by a factor of 10 for renewables. The benefits include lower grid costs and losses and fault management with less likelihood of massive area blackouts of the kind that hit eastern North America and Canada in 2003 (Teather, 2003).

The symbiotic house

Rifkin's proposals for restructuring energy and making houses micro-power stations challenges the concept of a house as it has developed throughout history, namely, as a shelter. Houses need to be redefined as symbiotic living systems for their human inhabitants. Rifkin's concept of houses as micro-power stations focuses on energy. However, when considered as a symbiotic system, houses could not only generate energy from their own solar panels and hot water from solar thermal collectors etc.; but their own (or neighbourhood) ground could source heat pumps to maintain a heat supply. In addition, houses might be fitted with unobtrusive wind turbines and the roofs could collect rainwater for the grey water recycling system; the human waste system could generate methane gas (Vince, 2008) and water (BBC, 2015). This developing perception provides exciting challenges for design to help re-think how we use buildings.

Water is another utility which could be similarly managed to Rifkin's TIR and on the basis of Lovins' (1997) 'soft paths' strategy of locally distributed reservoirs, lakes and catchments rather than the top down 'hard strategy' of large central reservoirs (Gleick, 2003). In addition, local rivers can be installed with small hydro-turbines to supply micro-grids for powering several hundred homes (Cahn, 2013).

We can recognize that new attitudes create new possibilities and the spirit of TIR is not one of competition like the old paradigm and neoliberal capitalism driven by profit and self-interest. *"The new model favors lateral ventures, both in social commons and in the market place, on the assumption that mutual interest, pursued jointly, is the best route to sustainable economic development. The new era represents a democratization of entrepreneurship – everyone becomes a producer of their own energy – but also requires a collaborative approach to sharing energy across neighbourhoods, regions …"* (Rifkin, 2011).

Rifkin illustrates the social entrepreneurship of the TIR economy with the example of TOMS (www.toms.com/). TOMS manufactures shoes and operates two branches; one generating profit and the other a non-profit philanthropic subsidiary. The shoes are made from recycled, organic materials and modeled on the traditional alpargata shoe worn by Argentinian farmers. TOMS shoes are marketed in more than 500 stores throughout the USA. The non-profit branch called *Friends of Toms* donates a pair of shoes to a child in need somewhere around the world for every pair of shoes sold by the profit generating branch, TOMS. The companies were founded in 2006 and up to 2011 had already sold over a million pairs of shoes AND donated the same number of shoes to children in need! This contrasts to the western supermarket promotion strategy based on greed of *buy-one-get-one-free*. Rifkin claims that "TOMS" illustrates the new social entrepreneurial business models that are emerging in a *Third Industrial Revolution* era. Doubtless too, Noreena Hertz would claim that TOMS illustrates her concept of *co-op capitalism* and that Aaron Hurst would equally claim that it illustrates his *purpose economy*.

I have cited the example of TOMS described by Rifkin because it draws together all three concepts. Furthermore, although TOMS is concerned with shoes, a popular article of fashion designers, it might equally have been almost any kind of design article. What is important about TOMS is that it illustrates principles that are part of the growing new design paradigm.

14.4 Let's recognize nine meta-strategies for catalyzing our sustainable future.

The economic change proposed by concepts such as: co-op capitalism, the purpose economy and the third industrial revolution are now gathering momentum and contributing to the development of a new paradigm. No-one can precisely define the new paradigm, but certainly it will be a contrast to 'Gucci capitalism' and the old paradigm, described in Chapter 2.

Let us recall that the Council of Scientific Society Presidents supported the US Environment Secretary Steven Chu's testimony to a Senate Sub-committee about the necessity for change regarding energy and emissions. On May 4, 2010 they wrote: *"We represent the leadership of over 1.4 million scientists in over 150 scientific disciplines." and they demanded an energy transition which "will require nothing short of a new industrial revolution." We agree with this assessment of the scale of the response needed. We need to work aggressively to conserve energy and increase the efficiency of energy use, and we do need rapidly to develop less polluting energy systems"* (Apple, 2010). However such strong demands are not just necessary for energy and emissions they are essential for the broader sweep of sustainability.

Consequently, there are meta-strategies, independently proposed by experts which we can recognize for their catalytic potential for moving towards a sustainable future, especially when they could act synergetically. There are more, but I conclude Part One with just these nine because they are all closely interconnected with each other and mutually supportive and urgent. Furthermore, they offer the potential for design to make a valuable contribution, how it is done, who does it and for whom. The days are gone when design was seen merely as the generator and re-styler of consumer goods and a contributor to the economic welfare of companies and GDP. Design for the sustainable design paradigm is concerned with genuine human and environmental welfare. These nine meta-strategies (for want of a better word) are drawn together here because they surely could catalyse the change to the new design paradigm with their synergetic potential. They are:

1. Educational Renaissance; the integration of Holism & Interconnectivity.
2. Open Source Everything.
3. Knowledge verification.
4. Reconnection with Nature, Eco-literacy & Earth Stewardship.
5. Cooperation developed and to replace competition.
6. Grass Roots empowered for change.
7. Community & culture developed to eclipse Consumerism.
8. Resilience against the unexpected.

9. the Re-ORIENTATION of DESIGN: to embrace non-commercial need and welfare.

These nine meta-strategies are already occurring and a number of examples are included below to both illustrate the changes taking place, and to encourage further initiatives. Some of the meta-strategies or recommendations may appear impossible or too extreme to implement. However, we cannot allow 'business as usual' to predominate the economic and political stage. In the 14 chapters of Part One we have summarized many of the problems *"because the risks are clearly not obvious to most people and the classic signs of impending collapse, especially diminishing returns to complexity, are everywhere"* (Ehrlich & Ehrlich, 2013).

14.4.1 Educational Renaissance: Can we be sure that we think correctly? Interconnectivity & Holistics.

(Snow, 1993; Ehrlich & Ehrlich, 2010; Orr, 1992; Rifkin, 2011; Ahmed, 2010; Worthy, 2013; Vester, 2012)

A renaissance in education is essential and is the first meta-strategy because it is an integral component of the other eight metastrategies.

We face a world of increasing complexity and not only as a result of globalization. Science continually reveals how human activity impacts on Nature, showing us that it is all deeply interconnected in ways we were unaware of only years or so ago. The development of the world's increasing complexity was considered by Rufus Miles, who as far back as 1976, wrote that:

"The more complex and interdependent the systems and subsystems, the more vulnerable they become to design failure, since:

(a) No human designers, and this applies especially to politicians who are responsible for designing the largest human systems, can know or comprehend all the factors that need to be taken into account, and their interrelation, sufficiently to make the current set of systems work well. If complexity and interdependence increase further, the problems will be further compounded and the stability of the system further jeopardized.

(b) Those responsible for selecting the designers – the voting public in a society like the United States – are even less informed about the intricacies of the systems than the politicians who represent them [also due to the growing power of corporate lobbying, this is very questionable as recent research shows (Adam, 2009; Traynor et al, 2014; Gilens & Page, 2014)]. They cannot judge, therefore, which programs or social designers (politicians) to support, and in consequence they are highly likely to vote for the representatives who promise to support programs that benefit them directly and immediately – a fatal flaw in designing workable complex systems for interrelating enormous numbers of human beings with each other and their environments.

(4) The United States is probably nearing the point (it could even be beyond it) where the complexity of the systems of interdependence exceeds the human capacity to manage them, causing system breakdowns to occur as fast as or faster than any combination of problem-solvers can overcome them" (Miles, 1976).

Miles's concerns lead us to wonder whether we could intellectually better equip ourselves to deal with today's problems. What else could we need? It appears that the styles of Western and Eastern thought are cognitive adaptations to different lifestyles. Research (Talheim, et al, 2014) into the east-west cognitive dichotomy in China leads Talheim et al. to propose that in separate wheat and rice growing regions, peoples with a history of rice farming are more interdependent and holistic-thinking, and perceptive of connectivity. Whereas people in wheat farming cultures are more independent, and more individualistic and analytical in their thinking. The authors also discovered that wheat growing provinces in China had 30% more patents than rice growing regions. Wheat growing has also been a dominant agriculture in western cultures.

What are we to understand from this? It appears that over generations different styles of thinking develop and evolve within different cultures, which are supported by certain ways of life. Western thinking, characterized by its analytical, reductionist approach has difficulty in seeing the connectivities which permeate our world. One of the consequence of western style knowledge is that it has intellectually fragmented knowledge into isolated 'siloes' so that specialists make decisions without an awareness of the consequences beyond the 'silo.' We can now begin to realize how important new thinking strategies are for solving our global problems and why education needs to be reformed. 'Rice-thinking' (holistic, connected) or 'wheat-thinking' (analytical, specialist) alone are inadequate – we must have both and more besides! Confirmation of our meta-problem is the *"paucity of interdisciplinary analyses* *of global crises as systemic and mutually interdependent. This lacuna has undermined the ability of mainstream policy institutions to accurately predict the trajectory of these crises, and hindered the production of viable and far-reaching solutions"* (Ahmed, 2010).

Ehrlich and Ehrlich (2010) and others are greatly concerned that *"In modern societies, knowledge has become deliberately and excessively divided into even smaller units – 'siloed' and isolated from related knowledge. Knowledge and information are so compartmentalized that even brilliant leaders do not see (or choose for political reasons not to point out) obvious and crucial connections. Because of the culture gap and a public education system that fails to make important connections and draw important inferences, few people in our society are able to describe how the climate works, the significance of the second law of thermodynamics, how biodiversity is related to ecosystem services, or why population growth increases the threat of novel pandemics; all of which a responsible citizen needs to understand in a world faced with a possible collapse of civilization."*

The renown biologist, E.O. Wilson and his colleague Charles Lumsden (1981) also draw attention to the fragmentation of knowledge: *"The social sciences have been balkanized into a bewildering diversity of subdisciplines and schools of thought. If a single rationalization for this crippling state of affairs, it is the belief that human behaviour is vastly more complex and subtle than anything encountered by the natural scientists." The two authors then provide an insight into the nature of complexity itself. "The crucial property of complexity per se is compressibility. A compressible system is one that can be described or regenerated by a set of rules or instructions much shorter than the shortest direct description of the system itself. It is further possible to recover the original system in detail. Much of science consists in codes that permit the folding of complex information into economical, easily retrievable forms … Time and again the search for codes has revealed a deep structure containing new phenomena and previously unsuspected connections to other systems. Many of the greatest advances have come when one discipline was mapped onto the axiomatic structure of another." These ideas are very exciting and lead Lumsden and Wilson to suggest that "A worthy goal of the social sciences, then, is to discover the compressibility of human social phenomena."*

Intimately associated to the problem of the 'western' academic tradition of the fragmentation of knowledge, is the problem of specialization. In western developed countries the drive for children from 14 to 16 yrs old to the time they leave school is strongly oriented towards specialization for a future career and employment. This drive is politically motivated. In Germany, for example, some of the gymnasia focus on technology, others on business studies or computing and informatics. Meanwhile, in the UK, the Warwick commission (Heywood, et al., 2015) has severely criticized the substantial reduction of the arts in education (Brown, 2015). (This theme is addressed in Recommendation 7 below).

Lüdeke, Petschel-Held, & Schellnhuber, (2004) who have identified the necessity of curricula change write that:

"Traditional disciplinary approaches analyzing individual facts or processes are no longer sufficient. Two particular challenges emerge:

i. *the need for integrating knowledge from various scientific disciplines and*
ii. *the necessity for producing action-oriented knowledge to cope with, mitigate, or counteract global change and its negative effects. The first challenge can be seen as an intra-scientific problem that requires interdisciplinary approaches. The second challenge, however, pushes science beyond its traditional realm and requires that various societal actors and/or their norms and values be included in the scientific progress. This type of research is often called transdisciplinary research."*

Rifkin also considers that, *"The curriculum is out of date and out of touch with the realities of the current economic and environmental crises"* (Rifkin, 2011). Unfortunately, 'siloed' thinking permeates not only academia, but also business, politics (Rifkin, 2011) and very dangerously, banking (Moss, 2014) and economics.

Economics is an example of an academic 'silo' which has profoundly failed; a subject dominated by the narrow dogma of the neo-liberal capitalist (or neo-classical liberalism) establishment which fails to recognize on the one hand the finite character of the world and on the other its interconnectivity with natural resources, waste, climate change etc. All points which not only Herman Daly was confronted with whilst working at the World Bank in 1992 (Daly, 2008), but the rest of the world in 2008 with the financial crash (Chakrabortty, 2014; Chakrabortty, 2015) and most recently economics students (ISIPE, 2014). A crash which some academics consider was in part actually due to the myopic economic establishment.

Could it be that the (western) intellectual traditions have not only inadequately equipped us to deal with the crises now facing us but may even have "incubated them"? (Ahmed, 2010). Why are these crises all happening at the same time?

The rice-wheat thinking dichotomy provokes another question: what other ways of thinking exist in other life-styles and cultures which could also contribute to securing a sustainable future? Human cultures have survived on the Earth in a diversity of climates and environments. What can we learn from all of them? Should we be asking?

There is no culture which is so profligately wasteful with the Earth and her resources as the western consumer culture. There is much we could learn from other cultures for ours to become sustainable and as Commoner (1972) observed *"it is difficult to ignore the embarrassing fact that … the four laws of ecology – are ideas that have been widely held by many people without any scientific analysis …"* (see chapter 3). For example, respect for nature and the world because *"Still today, many traditional peoples aspire to fairly common ideals and values and follow an ageless code for living in harmony with all other beings and structures of the earth … one of the key elements of traditional ethical systems passed down through generations – respect. Respect for children, for family, for oneself, and all others; respect for the ancient lineage of grandmothers and grandfathers; respect for all living beings, for the land as a living being, for all the gifts of the land and all the beauty of the earth; respect an continuous gratitude to all spirits, to all the elements of the earth and sky, and to the web of life … Among the many contributions indigenous cultures have made to the human prospect, respect is now being recognized for its survival value in economic and social adaptation"* (Brown & Garver, 2009).

We have to understand the world in a new way, a systemic way which is compatible with the global system and which embraces nature, our dependence upon it and the global impact of our species.

An educational renaissance? Some recommendations

If we accept that a renaissance in education is long overdue, and in light of what has already been written above, then a renaissance is central to moving towards a sustainable future. What is to be done? Here we can identify only a brief list of themes without addressing them in detail. Education should teach:

A wider range of subjects

Firstly, a wider range of subjects should be taught to higher levels in both the sciences and the humanities in an integrated way concerned to obliterate their classical division (Snow, 1993) and identify underlying common principles (a knowledge of knowledge). In any case, the curriculum should be extended to include economics, finance and politics for enabling 'subsidiarity' at the 'grass roots' and the lateralization of utilities etc. (Rifkin's Third Industrial Revolution, 2011).

An integrated and holistic curriculum

Secondly, specialization in education should be delayed in order to develop an holistic and integrated perception of knowledge which emphasizes the world's interconnected (Vester, 2012) reality. In addition an understanding of systems (Meadows, 2010) to develop linking thinking (Sterling, et al. 2005) and schesiological or consequential thinking (Stebbing, 2011). This depends on a fuller range of subjects to enable the identification of interconnectivities (both interdisciplinary and transdisciplinary) between subjects so as to balance analytical thinking with a holistic perception and creativity.

Humans are an integral part of the whole system

Thirdly, the western academic 'objective' thinking style distances the student from the world as if they were mere observers rather than participants. An educational renaissance could also transmit a new ethical perception and wisdom that we are integral organic components of the Earth's natural system and Nature (see Recommendation 4). Although, this may seem esoteric, we nevertheless need additional ways of thinking about ourselves and our relationship to the Earth. This is obvious when we examine the damage wrought by the western thinking style as illustrated by the consumer society. We appear to have lost the holistic perception that Zen Buddhists (Batchelor & Brown,1992) and the Kogi people of Colombia (Ereira, 1990) have retained. The Mamas (wise men) of the Kogi teach that we do not harm our bodies and yet harming the environment on which our bodies depend is actually harming our bodies (Ereira, 2014). Furthermore, since we care for our bodies we all need to care for and restore Nature, what might be called Earth stewardship.

Community, subsidiarity and the Grass Roots

The recognition that the world is increasing in complexity and less manageable from the top (Miles, 1976) means that those at the grass roots must be better informed and prepared for more decision-making at the local level. In October, 2014, the EU recognized the unmanageability of European bureaucracy due to the complexity in which we live. Michel Lebrun, who is President of the Committee of the Regions in the EU *"favours greater autonomy for regions and results in an effective governance, improving service delivery to citizens and enhancing democratic stability"* based on Belgium's decentralized system (EurActiv, 2014). In response to the delegation of autonomy and subsidiarity, education must provide subjects such as economics (Daly & Cobb, 1989; Hertz, 2003; Hawken, Lovins & Lovins, 2004; Ahmed, 2010; Meek, 2014), finance (Yunus, 2003; Lanchester, 2014), civics (Evans & Lewis, 2013) and politics (Hedges, 2013; Meek, 2014) which are uncommon on many curricula. This development in education would better prepare young people for Jeremy Rifkin's Third Industrial Revolution and the lateralization of energy and civic organization.

Culture and the arts might eclipse consumerism

An unfounded fear is that a sustainable life style will somehow bring a reversion to a muddy Middle Ages lifestyle as we transform the consumer society to a sustainable society. On the contrary, artistic creativity and culture could significantly replace consumerism for both entertainment and identity (*'I shop therefore I am'* (Kruger, 1987); *'Buy-one-get-one-free'* (frequently used super-store promotion); *'shop 'til you drop ...'* (Confino, 2012). However, education has a key role to play in providing the opportunity for developing both creative and aesthetic skills which would greatly enhance individual development and enrichen local cultures. This will not happen when governments adhere to neo-liberal capitalism and discourage artistic activity by cutting funding to the arts. In the UK *"Not enough is being done to stimulate or realize the creative potential of individuals, or to maximize their cultural and economic value to society. Improvement requires a greater degree of investment, participation, education and digital access."* (Heywood, V., et al., Warwick Commission, 2015). (This issue is addressed in Recommendation 7 below).

As a consequence of the educational focus on early specialization, in the developed countries, there is little concern for education for personal development, recreation and for the other 8 hours, the third of our lives outside work. Therefore, with the lack of development of the creative, artistic, and individual potential then maybe it is not surprising that the *"Average daily TV viewing time per person in selected countries in 2013 (in minutes)" USA 293, Japan 265, Italy 261, Poland 247, Spain 244, Russia 239, United Kingdom 232, France 226, Germany 221, Brazil 217, Korea 217, Australia 201,Netherlands 195, China 159 and Sweden 159* (Statista, 2015). This range from a daily average of nearly 5 hrs viewing in the USA to 2 hrs 39 minutes in China and Sweden per day, also exposes viewers to an enormous amount of advertising pressure to buy stuff! However, were 'education' to be more balanced and, in addition to not only training young people for a career, but also educating them for creative expression, then many people might be diverted towards a more fulfilling creative and cultural activities in their free time.

Some of the developments proposed here are already occurring in some universities. For example, Columbia State University (Macilwain, 2007) has created an *Earth Institute*, led by the economist Professor Jeffrey Sachs to address a range of multi-disciplinary problems and their interconnections, including: water, energy, urbanization, hazards, global health, poverty, food, ecology and nutrition, ecosystems health and monitoring, climate and society.

In conclusion, education must broaden its perspective from focusing solely on specialization for employment but also for recreation, Earth Stewardship, etc.

14.4.2 Open Source Everything

(Steele & Bloom, 2012; Benson, 2014; www; see Glossary – Open Access Manifesto)

The www. and the internet provide open access to virtually all human knowledge, much of humanity's wisdom (since, regrettably not all cultures have www access) and the enormous potential for cooperation and contributing to democracy whilst also offering enormous potential for crime and confusion. The latter potential was illustrated by climate warming and the development of the counter-climate-change movement (Brulle, 2013). It also provides an enormous resource for the 'grass roots.'

It is now difficult to imagine how the world was before the World Wide Web and the Internet. Wikipedia, the free encyclopaedia is one of mankind's greatest cooperative achievements with (to date 24.6.2014, the English version) has 4,542,118 entries which would occupy more than 2,600 sized *Encyclopaedia Britannica* volumes were they to be printed. Furthermore, networks exist for sharing all media, knowledge and experiences along with films, music, videos, and information on every hobby and interest. The cyber space we now possess enables everyone with the technical access to contribute and share and thereby stimulate their own and others' creativity and innovation (Rifkin, 2011) through open source sharing.

In today's world, the open source of everything provided by the Internet offers enormous opportunities for every innovative designer wishing to contribute to a sustainable future. It is possible to find a client for the kind of design work one is ambitious to do; to find a team of those with similar aims or else set oneself up to realize a project. It is also possible to find funding and supporters through 'crowd-sourcing' etc. (http://www.innonatives.com/).

The designer's client may seem to possess the controlling hand concerning a commission but *open source everything* empowers the designer to exceed his traditional role and to educate the client towards more sustainable decisions. If one paraphrases Robert Steele's (Ahmed, 2014) words *'Open Source Everything makes truth rather than the budget the currency of power'* and decision making.

The journal *Nature*, which is one of the most widely read scientific journals became accessible without paying for a subscription in December, 2014 and furthermore, its publisher, Macmillan, will allow 49 of its other journals to also become accessible. Unfortunately, there is a small catch because would-be readers have to get a link to the journal from an existing subscriber. *"Those without a subscription will be relegated to "beggar access," as Scientific American put it, where they can read something only if they ask subscribers to share it with them"* (Benson, 2014).

An ethical issue arises because much research featured in scientific journals is already funded by public grants to the universities conducting the research and paying to access the information amounts to a second tax. Furthermore, the researchers are not paid for the articles submitted for publication and from which the publisher profits. *"The world's entire scientific and cultural heritage, published over centuries in books and journals, is increasingly being digitized and locked up by a handful of private corporations," the late Internet activist Aaron Swartz wrote in 2008 in the Guerilla Open Access Manifesto. He fought against the privatization of knowledge, becoming a warrior for the open access movement"* (Benson, 2014) (see Open Access Manifesto in the Glossary).

Benson (2014) writes that *"The corporations that ask for a toll to cross the information gap are ultimately thwarting the growth of knowledge. ... A kid living in the ghetto should have just as much opportunity to educate him- or herself as a kid in Beverly Hills, and open access to information can make that possible."* Furthermore, we might add that, knowledge to securing a sustainable future should be freely available due to its benefit to all of mankind and the planet.

How will *'open source everything'* help you to contribute to a sustainable future (... and save the world)?

14.4.3 Knowledge verification and the 'scamocracy'

(Brulle, 2013)

On the other hand, while open source everything provides enormous opportunities for those who want to create a sustainable world, it also enables those with selfish, corrupt and criminal aims many opportunities too. Consequently, one cannot automatically trust the information available on the WWW and so it is important to use reputable sites. It is now essential to learn how to verify knowledge and identify its accuracy, otherwise we can become vulnerable to manipulation, deceit and to mis-informing others.

Not all information on the World Wide Web is to be trusted and some of it is designed to deceive. Whatever else the global milieu we live in might be, it is also a 'scamocracy.' We have already seen in Chapter 10 Pollution how some big corporations have no hesitation to not only mislead the market in order to protect their profits but they also have no qualms about causing ill health, even death, to both employees and consumers (Oreskes & Conway, 2010; Markowitz & Rosner, 2002).

No-one can be unfamiliar with the debate concerning climate change. However, why should there be a debate about scientific information? Today, everyone holds an opinion about climate change based on the facts they have acquired. Whilst the Internet and

Wikipedia provides us with all manner of information, how do we know that what we read, hear or see is true? What strategies do we use to verify the facts? For more than a decade the debate has continued about whether climate change was fact, fiction or fraud. Why? Unfortunately, we must develop a curriculum that teaches strategies for verifying the authenticity of knowledge.

In 2013 a paper was published in the Journal Climate Change (and posted on line) by Prof Robert Brulle analyzing *"the funding dynamics of the organized effort to prevent the initiation of policies designed to limit the carbon emissions that are driving anthropogenic climate change."* The paper verified how 140 conservative industrial foundations (such as ExxonMobil, Koch Enterprises, Scaife Affiliated Foundations, Donors Trust/ Donors Capital Fund, etc.) donated an average exceeding $900 million annually to 91 climate change counter-movement (CCCM) organizations (including advocacy organizations, think tanks, and trade associations) over the eight years from 2003 to 2010. The task of the organizations receiving these millions of dollars was to deliberately confuse the public about climate change with literature and other media activities to deny and/ or obfuscate the science about climate change. Brulle writes that *"A number of analyses have shown that one major factor driving this misunderstanding and an overall lack of legislative action is a deliberate and organized effort to misdirect the public discussion and distort the public's understanding of climate change … This literature has revealed a great deal about the nature of efforts to deny and/or distort climate science. It clearly shows that a number of conservative think tanks, trade associations, and advocacy organizations are the key organizational components of a well-organized climate change counter-movement (CCCM) that has not only played a major role in confounding public understanding of climate science, but also successfully delayed meaningful government policy actions to address the issue."*

Some of the 'think tanks' which have received 'donations' (i.e. been paid) to create scepticism about climate change include: The Heartland Institute (which has also organized a number of conferences questioning the science of climate change), The American Enterprises Institute for Public Policy Research; The Hudson Institute, etc. The Cato Institute which incidentally was founded by Charles Koch et al. and initially called the Charles Koch Foundation. Consequently, as a 'think tank' one can imagine that it strongly supports its founders. These US 'think tanks,' conservative in their outlook, often claiming to be non-partisan are supportive of free enterprise, personal freedom and minimal government regulation (neo-liberal capitalism). However, the issue of climate change and actions to limit greenhouse gas emissions would fundamentally conflict with the perceived US freedoms of private enterprise and the aims of the fossil fuel industry. The US 'think tanks' described by Brulle are totally partisan and have received billions of dollars to confuse and create a debate about climate change and to undermine the science warning us all of the dangers of global warming.

The '*climate change counter-movement*', as it has been called by Brulle, has been enormously effective in its deception. The journalist George Monbiot (2006) writing seven years before Brulle's paper was published, reported on the action of the *"network of fake citizens' groups and bogus scientific bodies has been claiming that science of global warming is inconclusive" have "… set back action on climate change by a decade."* A number of those involved in creating the deception had previously worked to undermine the science on proving that smoking causes cancer and passive smoking causes illnesses (Oreskes & Conway, 2010). Consequently, the climate change deceivers used similar strategies as had been used to create doubt about the cancer-smoking issue.

Education now has the new responsibility to teach strategies for knowledge verification and authentification, since we could unwittingly be promoting others to act unsustainably.

In conclusion, the professor of cancer medicine and oncology at Imperial College, London, Justin Stebbing, in noting that *"There is certainly no such thing as an anti-cancer diet,"* concludes that *"We should understand that the internet is a double edged sword and if we're looking for information we should go to reputable sites"* (Mohammadi, 2015).

14.4.4 Reconnection with Nature, Eco-literacy & Earth Stewardship (Orr, 1992; Louv, 2010; Louv, 2012; Brown & Garver, 2009, Sandifer, et al, 2015)

As part of the educational renaissance we all need to understand our dependence on nature, biodiversity, ecosystems and their services. This needs to be understood through direct experience of – and connectivity with nature. We must all become Earth Stewards and act, not merely to hinder the accelerating extinction of species and the destruction of ecosystems but to actually restore them. In some way this requires social innovation in some form, for example, as a social service, people might spend time on "Nature Service" working to restore ecosystems (and perhaps their own health too). Our survival depends on the survival of biodiversity, ecosystems and species (Sandifer, et al. 2015). A recent WWF report warns that during the 40 years from 1970 to 2010 *"Populations of mammals, birds, reptiles, amphibians and fish on our planet have declined by 52 percent"* (McLellan, et al 2014).

"We are at a key juncture in history where biodiversity loss is occurring daily and accelerating in the face of population growth, climate change, and rampant development. Simultaneously, we are just beginning to appreciate the wealth of human health benefits that stem from experiencing nature and biodiversity" (Sandifer, Sutton-Grier and Ward, 2015). Although much more research is needed on exactly how biodiversity supports us Sandifer, Sutton-Grier and Ward present *"strong evidence linking biodiversity with production of ecosystem services and between nature exposure and human health."* The evidence they bring together shows how every level of our physical and psychological well-being is affected by biodiversity, including: our immune system, inflammatory and respiratory disorders, asthma, allergies, intestinal and cardiovascular disorders, stress reduction, general health and psychological welfare. Since we have such a dependency on nature and ecosystems (not to mention food, natural products and drugs) it seems enormously stupid that we do not all act to care for our Natural Capital.

Ecoliteracy (see glossary: ecoliteracy)

Today we now understand the world as an holistic system which is based on at least three fundamental principles:

1. *"life's basic pattern of organization is the network;*
2. *matter cycles continually through the web of life,*
3. *all ecological cycles are sustained by the continual flow of energy from the sun."* (Stone, Barlow, 2005).

Furthermore, Barry Commoner identified four ecological laws:

1. *"Everything is connected to everything else.*
2. *Everything must go somewhere.*
3. *Nature knows best (to which we could also add that … and everything depends on Nature)*
4. *There is no such thing as a free lunch."* (Commoner, 1972)

(These four points are elucidated in chapter 3)

Ecological literacy means that we consider the further consequences of our actions and choices and how they impact on nature. Design's demands impact on the Earth's system in diverse ways so that we must always be asking:

- … this material or another …?
- … this process or another …?
- … this much energy is required or could it be less …?

etc., *"What then?"*

The ability to pose this question, according to Garrett Hardin, is "ecological literacy" (Orr, 1992), because it leads naturally to reducing the ecological footprint and environmental impact, and recycling or reusing resources etc. Ecological literacy is therefore an attitude of respect for the natural world. It is at this point we can also talk about deep ecology (see Glossary) because an attitude leads to a philosophical approach for how we do design; an approach which is sustainable and compatible with the Earth and its natural systems. An attitude towards ecological literacy will steer us towards sustainable design without necessarily possessing exhaustive knowledge of ecology.

Biophilia hypothesis

It is difficult to respect or care for what one does not know or understand. The possible good news is that, like our innate ability to cooperate, it may be that we have an innate or *"natural affinity for life"* and living forms and it is further proposed that it *"is the very essence of our humanity and binds us to all other living species."* This hypothesis, the biophilia hypothesis, was proposed in 1984 by the world renown biologist, E.O. Wilson (1984).

Some evidence for Wilson's *'biophilia'* hypothesis was provided by a landmark study, coincidentally published in the same year, by another scientist, Ulrich (1984), who was investigating the influence of nature on the recovery of hospital patients. Ulrich conducted a carefully controlled experiment using two hospital wards where everything was the same except for the view from the windows. The windows of one ward overlooked the monotonous brick wall of a neighbouring building while the windows of the second ward overlooked green trees. The patients' recoveries were striking and scientifically significant because the patients in the ward overlooking the trees required less medication, had fewer post-operative complications and left hospital sooner than the "wall-view" patients.

It is perhaps, less well known that plants also benefit our health beyond their obvious nutritional value. Exercising or simply walking in woods and forests, also known as forest bathing or *Shinrin-yoku* in Japan, also strengthens the immune system (Phillips, 2011) by aromatherapy. It does this by increasing human natural killer T-cells activity, the expression of anti-cancer proteins and providing other benefits (Li, 2008). Furthermore, research shows that green surroundings enhance human psychological performance for activities such as reading and concentration and gardening can also improve students learning and behaviour (Louv, 2012).

Since Ulrich's (1984) work there has been confirmation from a variety of sources that we possess an intimate connection to nature, more intimate than we are normally aware of. Mankind has kept pets for millennia, probably beginning with wolves following our ancestral hunters and which developed into a symbiotic relationship (Lorenz, 1964). Today, it is well known that dogs and other pets provide health benefits to their owners of all ages. These benefits range from lowering blood pressure and contributing to their carer's physical and mental health (Olmert, 2009). Children who have pets develop stronger immune systems and horses and dolphins have been found to be beneficial in providing therapy to children with both physical and mental development problems (Haskins, 2014).

Biophilic Design

One branch of architecture is called biophilic design and follows the idea, verified by Ulrich (1984), that the ambience of nature and natural systems has a beneficial and healing effect on human wellbeing (Sternberg, 2009). Therefore, in contrast to creating 'concrete jungles,' biophilic design aims to integrate nature throughout the urban environment; concreted public spaces, ministerial buildings, hospitals, parkhouses, office blocks etc. (Kellert, 2008).

In addition, several studies indicate that the presence of trees for example, appears to reduce crime in urban areas. A study conducted by Kuo and William C. Sullivan (2001) show that *"the greener a building's surroundings were, the fewer crimes reported. Furthermore, this pattern held for both property crimes and violent crimes."* And *"researchers with the U.S. Forest Service's Pacific Northwest and Southern research stations found neighborhoods with tree-lined streets and larger yard trees have lower property and violent crime rates"* (Donovan & Prestemon, 2012).

As well as human psychological welfare we also need Nature to provide the ecosystem services for urban welfare. These services include, for example, the cooling of the urban environment and purification of the air by trees, bushes and other plants. Plants, although they need water, cool the air without warming it and require no electricity as do air conditioners! Research reveals that the heat produced by air conditioners now raises some urban temperatures by 1°C (Radford, 2014). Currently, 87% of households in the USA have air conditioning and consume more electricity to keep cool than all the other countries of the world! These examples indicate the extent to which Nature can contribute to our wellbeing when design works with Nature.

Everyone an Earth Steward

The most obvious way of acquiring ecological literacy is to work directly with nature. The vibrant city of Pinyin or Chóngqìng is the fastest growing and the largest metropolis in China with a population of about 29 million. In 2010 the city announced its plans to send urban-born students to live and work in the countryside for a month as part of a community service plan during which time they will have to plant 100 trees. A press officer stated that the community service is voluntary but the media has reported that *"all students are expected to take part"* (Branigan, 2010). This strategy might sound somewhat draconian to those living in western style consumer cultures. However, the real questions are: firstly, how are we to reconnect ourselves with Nature and to value it for what it provides to make our existence possible? Secondly, how can we restore our Natural capital?

A spate of authors (Wilson, 1984; Orr, 1992; Louv, 2010; Rifkin, 2011; Worthy, 2013; Gooley, 2014) have written about our alienation and disconnection from Nature. The fact is that the western tradition of *"Education in the modern world was designed to further the conquest of nature and the industrialization of the planet"* (Orr, 1992). Is this because the consumer 'modern world' is based on *"The rationalization of human self-interest in the maximized consumption of material goods assumes that individuals are fundamentally separate entities whose needs and desires can be primarily defined in material terms … Further, the natural world is viewed as* *a potentially limitless stockpile of material goods which can therefore be subjected to the ceaseless extraction of resources. Nature in general is perceived as a possibly hostile environment whose purely physical units are fundamentally disconnected, atomistic and thus self-interested, and it should therefore be efficiently organized according to the rationalizing imperatives of capitalism. Within this world view, ethical values, such as love, justice and compassion appear to have no real basis, precisely because they cannot be materially located in a natural world seen purely in terms of its potential for maximal exploitation in service of unlimited material consumption"?* (Ahmed, 2010). The world political economy has been operating and developing within this false ideology and consequently caused the global crises which now seriously threatens life on earth. *"These fundamentally destructive consequences of neo-liberal capitalism constitute direct empirical confirmation that its underlying ideological assumptions about human nature and the natural world are, in fact, false … Global crises are therefore symptoms of a deeper philosophical malaise, and concerted efforts are required to develop an alternative holistic way of understanding human nature and the natural world as inter-embedded"* (Ahmed, 2010). Ahmed continues by citing Noorgard who states that, *"We need richer bases for understanding how we interrelate with nature."*

"And capitalist economics have a stake in our detached egos" (Worthy, 2013) as we consumers create the image of our individual identities through what and how we consume and waste – *"conspicuous consumption"* (Veblen, 1899). Eric Fromm (2008) has also addressed the issue of consumer identity in his classic *To have or to be*. The feminist artist Barbara Kruger's (1987) work *"I shop therefore I am"* perceptively criticizes our existence and identity which is given meaning by the accessories we can afford and display. It is Noreena Hertz's *Gucci Bag* metaphor. However, Kruger's work also implies that shopping is a continual process necessitating the consumption of nature to maintain the consumer's identity which is simultaneously detached from nature. *"Eco-psychologists say our disconnected modern experiences of the world are reflected in our peculiarly detached egos … we hyper-separate ourselves from the rest of nature"* (Worthy, 2013).

Our separation from nature may have given rise to what Richard Louv (2010) has called nature-deficit-disorder, occurring in children. Children suffering from Attention-Deficit-Hyperactivity Disorder (ADHD) and certain other mental disturbances are prescribed drugs, however, Louv's researches leads him to propose that more time spent playing in fields and woods and closer contact with nature can correct such problems.

The question is how can we profoundly reconnect ourselves, with nature, trees, plants and animals such that we can all understand *"from the earliest ages, that they are an intimate part of the workings of the biosphere and that every activity they engage in – the food they eat, the clothes they wear, the car their family drives, the electricity they use – leaves an ecological footprint that affects the well-being of other human beings and other creatures on Earth"* (Rifkin, 2011).

It cannot be overstated that our survival depends on Nature and if we cannot maintain it, it will be unable to maintain us. It is imperative that we learn to care for and co-operate with *Nature-all* of us. Consequently, for us all to become Nature's stewards – Earth Stewards seems an obvious strategy. Victor Papanek (1971) proposed that designers should spend a tenth of out time working for *"the 75% of mankind in need."* However, how would it be if we could spend a portion of our time as an Earth Steward restoring ecosystems and the environment to restock our natural capital? Earth Stewardship could be integrated into study courses as examplified by the city of Pinyin in China cited earlier. Companies could send their employees to participate in short eco-reconstruction projects. There are many formats and possibilities for Earth stewardship and social design innovation. There are voluntary organizations already in existence such as The Conservation Volunteers (TCV) undertaking nature conservation work and restoring ecosystems. Some workshops are run as 'green gyms' with the concept of getting fit while doing conservation work in the countryside. This win-win situation benefiting both Nature and human welfare is a strategy which could be extended in diverse ways and designed into all our lives. *"… contact with diverse natural habitats and many different species, has important positive impacts for human health. In a seminal study Fuller et al (2007) determined that the psychological and physical benefits of contact with nature increased with species richness and habitat diversity"* (Sandifer, et al, 2015).

We need to look not inward, trying to consolidate our consumer ego identity. We need to open ourselves and look outward so that we can identify emotionally and empathize *"not only to other life forms but also to ecosystems and the biosphere itself"* (Rifkin, 2011). There are many ways which could be designed to do this but do it we must. *"When people are more connected to nature in both work and leisure, perhaps involved in farming part time or working on ecological restoration projects, they learn important lessons about nature's needs and how we can partner with rather then dominate it. New programs could educate people about the range of real-world effects of particular consumption choices … When we strive to teach children how their living in the world affects nature and other people, they can learn to make more thoughtful decisions and have greater command over their own ethical engagements"* (Worthy, 2013).

In Sept 2014 the World Wildlife Fund together with the Zoological Society of London, the Global Footprint Network and Water Footprint Network, published its 10th Living Planet Report which should have made the front page of every newspaper. Since 1970 the world has lost 52% of its vertebrate populations, that is of mammals, birds, reptiles, amphibians and fishes. *"Put another way, in less than two human generations, population sizes of vertebrate species have dropped by half. These are the living forms that constitute the fabric of the ecosystems which sustain life on Earth – and the barometer of what we are doing to our own planet, our only home. We ignore their decline at our peril"* (WWF, 2014). The study was based on an analysis of 3000 populations. *"The scale of biodiversity loss and damage to the very ecosystems that are essential to our existence is alarming," said Ken Norris, the director of science at ZSL, in a statement. "Although the report shows the situation is critical, there is still hope. Protecting nature needs focused conservation action, political will and support from businesses"* (Cressey, 2014). It is news of a gravity equivalent to each of us having a foot amputated (see Glossary: Kogi people), critical, but there is still hope! Ethically, Earth Stewardship has become a moral obligation in which we must all work towards restoring our natural capital rather than debiting it. Education and design have key roles to perform in communicating why and how we must all become active Earth-stewards and cooperate with, care for and restore Nature – our Natural Capital. Simultaneously, we can enhance our own health and knowledge too (Sandifer, 2015).

14.4.5 Cooperation: our innate co-operative nature

(Bowles, 2009; Fehr, 2004; Gaechter, 2012; Pennisi, 2009; Rand, et al. 2012; Hauser et al, 2014)

No other species cooperates as humans do, not merely to survive, but to create knowledge, culture and to change the world. Cooperation is a crucial key to our future survival and we must develop our capabilities for cooperation in every dimension. The opportunities for conflict will increase as demand for limited resources increases; competition, beloved by the market, is not the way forward, but systemic cooperation is the only way forward.

An *"… intuitive human reaction is to cooperate, whereas reasoning makes people somewhat more selfish"* (Gaechter, 2012). Research by Rand, et al (2012) and Hauser, et al (2014) contradicts the idea that humans, are basically selfish. Our style of reasoning plays a significant role and Kahneman (2011) has substantially illustrated that fast and automatic intuitions and not slow thoughtful deliberation determines much of human decision making. Rand, et al (2012) propose that co-operation is intuitive despite individuals having to make a personal cost for the benefit of others. This is because co-operation is typically advantageous in daily life and because *"intuition supports cooperation in social dilemmas, and that reflection can undermine these cooperative impulses."* Although some other species have evolved co-operative behaviours; *"No other species seems to have succeeded in establishing large-scale co-operation among genetically unrelated strangers"* (Fehr, 2004). One explanation for our cooperative behaviour is that individuals are concerned about their reputation within the group (Fehr, 2004). Furthermore, military history clearly shows that groups which are more prepared to cooperate are also more likely to be successful (Pennisi, 2009; Bowles, 2009). Cooperation is a behaviour trait which evolutionary selection might have favoured when hunter-gatherer groups had to compete for resources (Bowles, 2009). Today there is ample evidence that *"Humans working together have transformed the planet to meet the needs of billions of people"* (Pennisi, 2009).

We might consider that cooperation is a gift from evolution and since we have an innate tendency to cooperate then clearly we need to become better at it because cooperation is far more likely to achieve a sustainable future than competition in any form. In this century we are going to see many resources peak, or become scarce and perhaps even exhaust (Heinberg, 2007). It will be the wrong strategy to compete for them, rather, we must develop cooperative strategies and infrastructures to use them as sustainably as possible. In addition cooperation is crucial to resolving many of the challenges which have been described in Part One.

The unsustainability of commercial competition and the free market is well characterized by the privatization of the Dutch postal service: *"On Wednesday, we have at least six people coming to the door, all bringing some mail. First was the local paper. Then the other local paper. Then the postman comes. Three more will come later. I think that's the basic defect of post office privatization. What used to be done by one man is now done by six. They're all underpaid, and the delivery hasn't improved"* (Meek, 2014). The duplication of the service wastes valuable resources and if vans instead of bicycles are used for deliveries then the services also contribute to emissions. This example well illustrates the folly of privatization beloved of Thatcher and Regan.

Competition must be replaced by coordinated cooperation as a strategy for saving both resources and energy because the *"Overexploitation of renewable resources today has a high cost on the welfare of future generations"* write Hauser and colleagues (2014) who show how crucial cooperation is to sustainability. In an abstract to their research they write that *"the resource is almost always destroyed if extraction decisions are made individually. This failure to cooperate with the future is driven primarily by a minority of individuals who extract far more than what is sustainable. In contrast, when extractions are democratically decided by vote, the resource is consistently sustained. Voting is effective for two reasons. First, it allows a majority of cooperators to restrain defectors. Second, it reassures conditional cooperators that their efforts are not futile. Voting, however, only promotes sustainability if it is binding for all involved."* They conclude that their results *"… have implications for policy interventions designed to sustain intergenerational public goods."* (See also Glossary: Ostrom, Elinor).

This research begs the question to what extent corporations, practiced at competing with each other for resources, would be prepared to cooperate? This problem is already acute with regard to the fossil fuel industries who must mutually agree to leave two thirds of the coal reserves untouched in order to save global warming from exceeding 2°C ?

Perhaps an example of the future potential and the power of cooperation is illustrated by the Eco-Industrial Park at Kalundborg in Denmark (Hawken, 1993). In the park a number of companies are in an industrial ecological symbiosis to use each other's by products. *"In Kalundborg, a coal-fired power plant, an oil refinery, a pharmaceutical company specializing in biotechnology, a sheetrock plant, concrete producers, a producer of sulfuric acid, the municipal heating authority, a fish farm, some greenhouses, local farms and other enterprises work cooperatively together. The Asnaes Power Plant started this process off in the 1980s by recycling its waste heat in the form of steam. It formerly condensed the steam and returned it as water to a nearby fjord; now it sends the steam directly, to the Statoil refinery and the Novo Nordisk pharmaceutical company. It also provides surplus heat to greenhouses, a fish farm owned by the utility, and the residents of the local town, allowing 3,500 oil burning heating systems to be shut off. etc."* (Hawken, 1993). The whole symbiosis is enormously successful and *"In 2010, it reduced CO_2 emissions by about 265,000 tons per year and water consumption by an estimated 30 percent"* (Global Lamp Index, 2011).

Hawken (1993) quotes Hardin Tibbs: *"It is significant that none of the examples of cooperation at Kalundborg was specifically required by regulation. Some were based strictly on price, while others were based on the installation of infrastructure by one party in exchange for a good price offered by the other. In some cases mandated cleanliness levels, such as the requirement for reduced nitrogen in waste water, or the removal of sulfur from flue gas, have permitted or stimulated reuse of wastes, and have certainly contributed to a climate in which such cooperation becomes feasible. The earliest deals were purely economic, but more recent initiatives have been made for largely environmental reasons and it has been found that these can be made to pay too."* Meanwhile, *"The successes of participating companies are now such that other innovative companies want to join in order to test new technologies on a large scale"* (Global Lamp Index, 2011). In a world of exhausting physical resources then surely cooperation is one of the best resources we possess since we must learn how to maximize cooperation and mimic biological symbiosis in order to reach sustainable circular economies. The earlier cited example of the six different Dutch postal delivery services plainly illustrates the environmental stupidity of the neoliberal-capitalist market competition.

14.4.6 The Grass Roots empowered for change

The 'grass roots' may be defined as the common people, i.e. not those who are in government, an elite or in power. The grass roots includes us. It is very clear that there is an increasing counter culture reaction emerging from the grass roots to the neo-liberal capitalist consumer society. The ample evidence includes: transition towns, community supported agriculture, food boxes by subscription, restaurants using thrown away food, etc. Furthermore, the grass roots is empowered by our inherent ability for cooperation combined with the communication technologies enabling people to easily maintain contact and achieve community aims. This was well illustrated by the Occupy movement and the People's Climate March, that took place on 21 September 2014, world-wide. An estimated 547,000 people participated in the People's Climate March protest which took place around the world (Davey, Vaughan & Holpuch, 2014) in 2,646 rallies organized in 162 countries (http://peoplesclimate.org/wrap-up/). The protest included a 'mega-march' in New York City with an estimated 310,000 participants aimed at influencing the politicians participating in the UN climate summit meeting taking place over the following days in New York. The protest's appeal for political action on climate change received substantial press coverage which, hopefully, politicians will not ignore.

One of the most dispiriting responses to the question about designing and living sustainably is "well, what can I do about sustainability?" As if being one person on a planet of over 7 billion others was already a hopeless situation. In fact the very **opposite** is true, because never before have we at the grass roots had so much of four things we very much need: firstly, creative potential, secondly, cooperators and thirdly, access to information and as Erich Fromm (1960) wrote: "*... truth is one of the strongest weapons of those who have no power*" and finally the power of communication to the rest of the grass roots.

Consequently today, many of us are actually empowered as never before by open source everything (as described above) and by the digital communication media; a power which more and more of the world's citizens possess and are using. The diversity of examples of grass roots power, social action and entrepreneurship which follow are intended to provide inspiration and exemplify some of the ways design can bring us nearer to a sustainable future. Many are relatively small actions and do not make headlines whilst others are world shaking events such as the Arab "Spring" when on "*14 January 2011 – the day Zine al-Abidine Ben Ali fled Tunisia, his 23-year rule toppled by 29 days of a popular uprising. A real revolution for a change. It's the first time Arabs have toppled one of their dictators*" (Eltahawy, 2011). Another protest that occurred during 2011 was the "*Occupy ...*" movement which created a global awareness of social inequality when 750 "Occupy" protests occurred in cities all around the world. The digital communication media enabled the protesters to coordinate their actions and create greater impact of their dissatisfaction with market trading, extortionate profits, and the pay and bonuses of bankers and CEOs.

Mobile phones empower the "Grassroots" in Africa

When the poor do have access to the internet then the information communication technologies (ICT) can be a powerful tool for lifting them out of poverty. "*At the end of 2007 there were more than 280 million mobile phone subscribers in Africa, representing a penetration rate of 30.4%.*" (Smith, 2009). It is anticipated that in Africa the use of the mobile phone or 'handi' is going to increase 20-fold during the next five years. The mobile enables communication between peoples living in the remotest areas and "*in the past twelve months the digital traffic has increased over 100%.*" The cell-phone helps farmers to sell their produce at the market price and cut out the middleman enabling the farmers to obtain a larger profit margin. In addition to finance, new apps are being developed which will help farmers identify pests so they can take appropriate action at an early stage of infestation (Kathure, 2014). The information communication technologies and the design and development of apps for agricultural, medical and other uses has enormous potential for helping people to raise themselves out of poverty.

The falling cost of a mobile phone now means that vast numbers of people ranging "*from the middle class in cities to small businesses in rural areas – access to mobile broadband*" so that "*Mobile commerce can offer endless opportunities for entrepreneurs*" and "*Mobile banking has given consumers cheaper access to their finances.*" (Smith, 2014) "*Professor Jeffrey Sachs, a leading development economist and director of the Earth Institute, has said: "The cell-phone is the single most transformative technology for development"*" (Smith, 2009). Could this also apply to moving towards a sustainable future?

Kickstarter

The digital communication technologies have empowered many new opportunities for innovations to be realized through creating new channels for not only communication but also the acquisition of funding to finance innovation. The Kickstarter crowd-funding platform/website has now raised more than $1bn since it was launched in 2009 to help anyone to fund a project that would be unlikely to be either approved of- or supported by a bank. Projects have ranged from funding films (including *The Square* about the Egyptian *January 25 revolution*), a space telescope, and medical research (Mance, 2014).

Sustainability Maker / innonatives

(http://sustainabilitymaker.org, www.innontives.com)

More recently our co-editor, Ursula Tischner, following the same strategy as Kickstarter, has, with the help of funding from the EU, set up a platform called *innonatives* in the framework of the Sustainability Maker project. The raison d'etre for the *innonatives* platform is to provide anyone the opportunity to set up a project concerned with sustainability to be supported by crowd funding. *innonatives* is a vehicle for individual empowerment for those who maybe are thinking that *"I am just one person, what could I possibly do?"* This project empowers ANYONE who has an idea for a project that will contribute to achieving a sustainable future to get both funding and support.

Cooperative Consumerism – the sharing economy

(Botsman & Rogers, 2011; Harrison, 2013)

New strategies are becoming established for replacing neo-liberal capitalist consumerism with cooperative consumerism. Sharing, renting, lending, borrowing, helping and other concepts are becoming established and developing with the basic idea of replacing the concept of ownership and consumerism with non-ownership in some form. We all have personal skills and assets, which in our possession are often under-utilized and could benefit someone else were they to have access to them when not needed by ourselves. These assets are of several kinds: materialistic, knowledge, skills and talents.

Sharing Material Assets

Car sharing is one of the best known examples of asset sharing and is now decades old. The German organization Bundesverband CarSharing (bcs) has reported a significant increase in participants. "*… the annual balance of German carsharing, issued today by Bundesverband Car Sharing e.V., shows that customer numbers went up considerably: meanwhile more than 750,000 users bank on the principle "using not owning" on German streets thus continuing the trend for carsharing observed in years. By now more than 1.1 per cent of the German population aged older than 17 participate in carsharing.*

At the beginning of this year 757,000 customers had registered with one of Germanys 150 or so carsharing providers. Compared to the previous year this is an increase of 67.1 per cent. 320,000 customers had registered with providers offering station based carsharing (a plus of 50,000) while free-floating schemes counted 437,000 customers (a plus of 254,000). For the first time the quota of carsharing customers in relation to the overall population aged 18 or older exceeded the one per cent hurdle.

These customers have 7,700 cars at 3,900 pick-up stations and 6,250 cars from free-floating schemes at their disposal. With station-based carsharing an average of 42 customers share one car as do 70 customers of free-floating schemes …

Carsharing is a useful mobility service from an ecological point of view as well as from an economical one. Only by an intelligent combination of all modes of locomotion will we be able to provide mobility for everyone in the future. It will become part of many people's routine to switch daily several times between walking, biking, using public transport, carsharing and a private car" says Martin zur Nedden, head of Deutsches Institut für Urbanistik (difu)" (Loose, 2014).

The internet has also made the global sharing and renting of private rooms possible and has become enormously popular. Airbnb, a pioneer organization in this field facilitates short duration accommodation rentals in 34,000 cities in 192 countries around the world at prices cheaper than most hotels (https://www.airbnb.com/). A recent valuation of Airbnb in June 2014 stood at £5.9bn. Meanwhile, *OneFineStay*, is an alternative based on the same principle, but offering private luxury homes at prices more expensive than most hotels.

Leila

In Berlin, a shop called Leila *(leihen is the German word to lend)*, has opened as an all-sharing-platform or library of things which can be borrowed, including: tools, books, home and garden equipment, sporting equipment etc. Members do not have to buy goods because anyone can deposit goods with Leila and on becoming a member can borrow any of the 2,000 items. Borrowed items only have to be returned clean and in the condition they were lent. Their web site is at: http://www.leila-berlin.de/.

Ouishare

The Leila shop is also associated with the *Ouishare* community which was launched in the autumn of 2011. *"OuiShare is a global community empowering citizens, public institutions and companies to build a society based on collaboration, openness and sharing. Since 2012, OuiShare has organized 200+ events in 30+ cities across Europe and the Middle East ... and two OuiShareFests, the largest international Festival on the collaborative economy gathering 1000+ experts and enthusiasts from around the world."* The OuiShare web site is at: http://ouishare.net/en/about/story

Sharing knowledge, skills and talents Collaborating Centre on Sustainable Consumption and Production GmbH (CSCP)

An organization operating on a commercial scale is the Collaborating Centre on Sustainable Consumption and Production GmbH (CSCP) which works with businesses to develop sustainable strategies helping clients to provide their products and services without damaging the environment. They operate by co-creating visions of more sustainable living, exploring trends across different household segments and contexts and prototyping sustainable living experiences to test triggers for behaviour change. In addition they have a platform and network of partners for knowledge sharing and collaboration. (http://www.scp-centre.org/team/team-pages/sustainable-lifestyles.html) The CSCP began in 2005 *"was created as an international non-profit 'think tank' and 'do tank' in collaboration with the United Nations Environment Program (UNEP) and the Wuppertal Institute for Climate, Environment and Energy."* CSCP is composed of experts from more than 15 disciplines and 30 countries.

Restaurants – Combining cuisine and recycling

Some restaurants now collaborate with supermarkets and other food establishments by taking perfectly good food which has either passed its shelf-life date, was over-bought or otherwise had lost a little of its aesthetic appeal. The quantity of food that is thrown away is now estimated to be between 30 to 50% of the total world production (Institute of Mechanical Engineers, 2013). This is the same quantity of food which, it is estimated, will be needed to feed the world by 2050. The pioneering use of supermarket food waste combined with culinary knowledge to create attractive dishes is being pioneered for example at The Pay As You Feel Café in Leeds (facebook.com/PAYFcafe) and the Rub and Stub restaurant in Copenhagen.

(source for PAYFcafe: http://www.theguardian.com/lifeandstyle/video/2014/mar/27/cafe-food-past-sell-by-date-video).

(source for Rub & Stub restaurant: http://www.bbc.com/news/magazine-25449219).

Community Supported Agriculture (CSA)

Other forms of food provision have developed during the last decade including community supported agriculture (CSA, see Glossary) in which both a local farmer and his customers enter into an agreement. This may entail the regular (weekly) delivery of a box of produce for an annual flat fee paid by the customer or / and the customer may also work for a set period during the year or some other mutually beneficial (symbiotic) arrangement. Locally produced food has the advantage that consumers know that the produce is organically produced and is fresh and has not been transported thousands of kilometers creating an unnecessary ecological footprint. Furthermore, the consumer may even have worked on the farm and they will also know that they are supporting a member of the local community. In addition, CSA provides an opportunity to closely work with nature and develop 'eco-literacy' and enjoy a healthy experience working on a farm!

Out of the Dark, Furniture and hope restored; social welfare design

Some young people loose their way during their education and for a variety of reasons leave school either too early or without any qualifications. Consequently, due to their vulnerability there is a danger that they might join a gang, get into drugs and slide into a life of petty crime (Lonsdale, 2014). *"Out of the Dark is a charitable social enterprise that recycles, restores and revamps salvaged furniture as a means to train, educate and employ young people from disadvantaged backgrounds. At the heart of Out of The Dark lies the premise of creating an extended family. Not only is the enterprise run as a family business, all young people involved are welcomed into the fold and become part of the family."* Out of the Dark has not only collaborated with other charities but also worked with firms such as Heals and John Lewis and other well known furnishing store clients in the UK. In an age of political austerity and cuts to welfare services this example perfectly illustrates the transmission of knowledge and design for social innovation and welfare. (http://www.outofthedark.org.uk/).

Participle Design; social welfare design

The difficulties of youth have also been addressed in a completely different way by the Participle Design Group. Their Loops project helped youths who had fallen out of school by providing opportunities to observe professionals at work in fields that the youths themselves really wanted to work in but for which they lacked the education. The Participle Design Group then helped and advised the youths to get back on track enabling them to become more motivated, confident and resourceful (Rawsthorn, 2010). Participle's strategy was so successful that their work in design for social welfare increased enormously. In their inspiring mission statement they write that: *"We believe there needs to be a new settlement between individuals, communities and government – new ways for people to get involved in determining their lives in a meaningful way, new approaches that mean some people do not get stuck at the bottom of the heap for generations and new bonds that mean people can flourish and bring their dreams alive. We also think that what matters is not just ideas, but real change on the ground, in our communities. On an everyday level this means public service reform – this is where the opportunities lie, to build something different"*
(http://www.participle.net/).

As governments impose more stringent austerity measures and cut and cancel welfare provision for the electorate in compliance with neo-liberal capitalism, the grass roots has little option but to provide for its own care through its own initiatives.

The transition town movement

The transition town movement exemplifies how whole communities at the grass roots level are taking matters into their own hands and redesigning themselves to create resilient communities. Such communities are motivated by the end of cheap oil which they anticipate will bring radical change (Ahmed, 2010). More recently, however, despite dropping oil prices, the fossil fuels must remain underground if we are to avoid a rise of global warming beyond 2°C (see Chapter 8, Energy). The impacts of the coming changes are difficult to foresee due to our established dependence on fossil fuels for industrialized agriculture, transport, the synthetic chemicals that permeate our lives, etc. The *transition movement* is a proactive response to the future. It is proving enormously popular at bringing people together into resilient community groups. These groups are successfully *"rebuilding local agriculture and food production, rethinking healthcare, rediscovering local building materials in the context of zero energy building, rethinking how we manage waste, all build resilience and offer the potential of an extraordinary renaissance – economic, cultural and spiritual."* Rob Hopkins (2008) the initiator of the transition movement claims that this is not a dreadful future but an abundant and nourishing one.

Although Rob Hopkins only began the transition town initiative in 2006, it has become a worldwide movement starting with his home town of Totnes in the UK, there are today Transition Towns all over the world and by Sept, 2013 there were 1130 initiatives registered from 43 countries including the UK, Ireland, Canada, New Zealand, Australia, the USA, Italy and Chile.

The first meetings of the Totnes initiative in 2006 identified themes which groups wanted to concentrate on and included: *"food, transport, energy, business and livelihoods, health and wellbeing, building and housing, and inner transition"* (http://www.transitiontowntotnes.org/about/history/). The groups met regularly and subsequently, many projects have come to fruition which have increased the resilience of the Totnes community.

The promotion of the Totnes Town Transition Initiative reads: *"Transition Town Totnes (TTT) is a dynamic, community-led and run charity that exists to strengthen the local economy, reduce the cost of living and build our resilience for a future with less cheap energy and a changing climate.*

TTT is not a 'membership' organization, but a collection of mainly volunteers with a small staff team, who come together to work on projects. Anyone can be involved. Everyone has something to offer and people who get involved are from a wide range of backgrounds, ages, and experiences.

Our projects and groups are ever-changing and evolving, and we always welcome new people. Our work ranges from increasing low impact affordable housing, sharing skills, creating livelihoods, reducing energy costs and carbon emissions, growing our local food economy and working in

partnership with other projects such as ATMOS and Food in Community."
(http://www.transitiontowntotnes.org/)

Subsidiarity

An increasingly important development could be *"subsidiarity … according to which decisions are made as locally as possible (by the lowest practical authority) so they reflect the decisions of citizens and communities … However, the interdependence arising from globalization mean that a greater share of decisions require coordination"* (Goldin & Mariathasan, 2014). The significance of greater local decision making is that it is likely to be more compatible for the sustainable management of a region (even the bio-region) since local knowledge and topography can influence decisions which might otherwise be unknown or of little interest at a central government level. Furthermore, neoliberal capitalism has taken more choice away from local communities (e.g. fracking). (q.v. Glossary: Ostrom)

Governments frequently show themselves to be out of touch with local problems and sometimes attempt to implement incompetent and ridiculous legislation. Examples of poor governance are well illustrated by the EU and range from the biofuels fiasco to the ridiculous attempt to introduce a law to ensure that restaurants which provide olive oil should present unopened bottles of olive oil for each individual customer. *"As pointless – no – moronic laws go, it's a doozie, showing absolutely no understanding or consideration for how restaurants and consumers operate. It's annoying for diners, and galling for restaurateurs"* (Ramsden, 2013).

Subsidiarity could be important in the sustainable management of local resources. In this respect the work of the economist, Elinor Ostrom (2012) has confirmed that local communities do not necessarily require government legislation or privatization to manage renewable resources such as fisheries or forests. Furthermore, governments do not automatically possess competence to manage resources as the EU's fisheries policies have confirmed. Centralized distant government decision-making is more open to corruption whereas local decision making, involving fewer stakeholders, can be more transparent.

Through precise observation, Ostrom confirmed that *"the tragedy of the commons"* (Hardin, 1968) can be avoided. *"In the words of Mark Pennington: '[Professor Ostrom's] book Governing the Commons '[2006] is a superb testament to the understanding that can be gained when economists observe in close-up detail how people craft arrangements to solve problems in ways often beyond the imagination of textbook theorists … In particular, communities are often able to find stable and effective ways to define the boundaries of a common-pool resource, define the rules for its use and effectively enforce those rules … Elinor Ostrom's work in this field, for which she won the Nobel Prize in economics in 2009, was grounded in the detailed empirical study of how communities managed common-pool resources in practice." Ostrom's work revealed that "there are principles that we can draw from the detailed study of the salient features of different cases to help us understand how different common-pool resources might be best managed; which rules systems and systems of organization have the best chance of success or failure; and so on … In developing a viable approach to the management of the commons, it is important, among other things, that a resource can be clearly defined and that the rules governing the use of the resource are adapted to local conditions. This suggests that rules imposed from outside, such as by government agencies, are unlikely to be successful.*
There are important areas of natural resource management where Elinor Ostrom's ideas should be adopted to avoid environmental catastrophe. Perhaps the most obvious example relevant to the UK is in European Union fisheries policy" (Institute of Economic Affairs, 2010).

Ostrom's work confirms the value of subsidiarity as a sustainable strategy with wide applications for the ecological maintenance of our renewable resources. Consequently, instead of fishing quotas being decided by the EU; they should be managed by fishing communities responsible for the region of the sea which they fish. However, while governments offer no panacea, Ostrom recommends that each case for the management of a commons resource needs to be based on the individual case itself, because there is no best way of doing something. Ostrom emphasizes *"that government, private and community-based mechanisms all work in some settings"* (Ostrom, 2012).

Furthermore, it has been found that: *"Community cohesion founded on norms, trust, communication, and connectedness in networks and groups was also an important global attribute leading to successful fisheries co-management"* (Gutiérrez, et al. 2011). For example, indigenous groups living in rain forests in India, Indonesia and the Amazon would make better caretakers of

the forests than any others because *"Indigenous people have high stakes in protecting biodiversity because they depend on its survival for their own, hunting and gathering non-timber forest products for their daily needs, according to Nicole Girard, Asia program coordinator for Minority Rights Group International, a UK-based charity. "Once their resources are threatened by either development projects or climate change, the impact is felt more directly and more acutely than by those in cities," Girard adds.*
Over the generations they have learned to live sustainably and have a keen understanding of a forest's limitations, making them the ideal caretakers of forested land. For example, a traditional fire-prevention practice preserves eco-system functioning by creating barriers to contain flames, protecting the deepest and most essential parts of the forest, Tauli-Corpuz explains. Fonseca points out that "indigenous peoples' rights to forests have long been recognized as a crucial component to maintain the environment and address climate change" (IRIN, 2015).

As we noted earlier, Michel Lebrun, who is President of the Committee of the Regions in the European Union also *"favours greater autonomy for regions and results in an effective governance, improving service delivery to citizens and enhancing democratic stability"* based on Belgium's decentralized system (EurActiv, 2014).

A further example of subsidiarity is occurring in Paris, where the mayor, Anne Hidalgo, *"has put in place the city's very first 'participatory budget' project, setting aside €426m (£335m) – 5% of the city hall investment budget – from now until 2020. It's the largest sum of public money ever to have been allocated to such a scheme. Proclaiming she was "handing the keys of the budget to the citizens," the Socialist mayor put the question to her fellow Parisians: what would they do to improve their city?"* A number of projects were proposed for the city and Parisiens were able to vote for the ones which they most favoured.

The successful projects chosen by the Parisiens included: *"A €2m project to create vegetation walls that would "improve biodiversity" received the most votes. Second was a €1m scheme to introduce "learning gardens" in primary schools, while third most popular was a €1.5m plan to transform gritty, abandoned areas around the city's ring road into space for gigs, exhibitions and film screenings. Mobile rubbish collection points (€1m) to facilitate recycling came in fourth, and co-working spaces (€2m) for young entrepreneurs rounded out the top five."* Altogether, nine projects will be implemented commencing from January, 2015 (Plesse, 2014).

Cooperative democracy, Change.org

Change is an online platform (www.change.org/) which *"Enables anyone, anywhere to start a petition, mobilize support, and win **change** in anything from local concerns to global issues"* by simply asking people to sign a petition online. For example an online petition by Sonja Schuhmacher against fracking in Weidener Becken, Oberpfalz, in Germany successfully raised 24,700 signatories in two weeks and brought about a successful local ban on fracking (D.P.A., Mittelbayerische Zeitung, 2014).

In conclusion, the grass roots has become empowered in recent years probably because of four reasons:

1. There is broad recognition for the necessity of social change due to the end of the dependence on fossil energy, the impact of climate change and the transformation to what might be called the post-carbon age (Ahmed, 2010). However, it is not so much the exhaustion of oil and coal reserves but rather because *"at least two-thirds of these reserves will have to remain underground if the world is to meet existing internationally agreed targets to avoid the threshold of 2°C for "dangerous" climate change.""* (Carrington, 2013; Carrington, 2015). It will be a matter of serious concern whether the fossil fuel industries will leave (and financially write-off 'stranded assets' (Smith School of Enterprise and the Environment, 2015)) two thirds of the carbon resources buried or whether they will ignore global warming and attempt to extract and market those resources. It is a situation which, due to the vast sums of investment already made may require extraordinary political and/or civil action. *"Stern said that far from reducing efforts to develop fossil fuels, the top 200 companies spent $674bn (£441bn) in 2012 to find and exploit even more new resources, a sum equivalent to 1% of global GDP, which could end up as "stranded" or valueless assets"* (Carrington, 2013). However, it is to be hoped that, as Jeremy Leggett optimistically suggests *"At least one major oil company will turn its back on fossil fuels" because "The industry is facing plunging commodity prices and*

soaring costs at risky projects in the Arctic, deepwater Brazil and elsewhere. Oil companies are also realizing it is no longer morally defensible to ignore the consequences of climate change" (Macalister, 2015). International cooperation will be crucial in bringing about a worldwide moratorium on the use of fossil fuels.

2. Dissatisfaction by many with the consumer lifestyle.
3. Recognition of the inability of governments to govern due to increasing, complexity (already recognized by the EU (EurActiv, (2014)), corruption; and also the increasing welfare austerity being imposed on electorates while large corporations and trans-national corporations enjoy a welfare provision (Chakrabortty, a 2014; Farnsworth, 2012) and legalized tax evasion (Brooks, 2013).
4. The communication technologies means that as never before we are informed about the state of the world and have enormous possibility for coordinated public, grass roots, action.

Finally, these deliberately diverse examples illustrate actions by individuals and groups at the grass roots of society to demonstrate both new strategies and applications for design. Design which is less concerned with contributing to 'commercial material welfare' but rather to social and environmental welfare. It is also the kind of innovation which is needed and happily growing and supported by the DESIS Network (q.v. Glossary: DESIS). Design is a subject without a fixed career map and those who have been educated as designers can create new design careers on the cusp of change. There are an enormous number of challenges, potentials and applications for design in grass roots initiatives.

14.4.7 Community and Culture could eclipse Consumerism

Consumerism as it has become known cannot continue on our finite planet. The McKinsey thinktank estimates that there will be *"3 billion more middle-class consumers expected to be in the global economy by 2030"* (Dobbs et al. 2011). The word *"more"* should be noted. That means that altogether by about 2030 there will be nearly 5 billion middle-class consumers (Dobbs, et al. 2012). It is already difficult to imagine the continuation of "shopping-malls" which contribute to the exponential curves of consumption – the *"Great Acceleration"* of our resource use, exhaustion and destruction (Steffen et al, 2007, Steffen et al, 2015). Although, in the USA shopping online (Uberti, 2014) has been one of the contributors to the death of the shopping malls together with the demise of the middle class *("46% of Americans believe themselves to be middle class"). The diminishing middle class is not only a British phenomenon. Both America and Europe have shrinking middles. The real-terms incomes of many people on low and middle incomes have barely risen over the past 30 years. It is perhaps easier to see the downward spiral of the American middle classes as we gaze on the "ruin porn" of Detroit* [Marchand & Meffre, 2011]. *Simply put, their share in the income pie has dropped, while that of the top 7% grows"* (Moore, 2013).

The political model now embracing the developed countries is one which is little concerned with the redistribution of wealth for a fairer society, but rather in its concentration in-, for and by the wealthy, the managing elite and by those who govern. The austerity measures and financial cuts to public welfare, health and education services forces the electorate itself, instead of their political systems, to become increasingly responsible for its own welfare (Gilens, & Page, 2014). This political idea is well illustrated by the English premier, David Cameron's, *""big society" that would involve a dramatic redistribution of power from "the elite in Whitehall to the man and woman on the street"*... the concept was *"criticized by Tory candidates during the election for being too vague, was overshadowed by doubts about whether the theme was designed to help the government impose stringent spending cuts"* (Watt, 2010). Furthermore, 'power' is not being redistributed *"to the man and woman on the street"* but to the large and trans-national corporations. Since 2010 the UK national health service has suffered severe financial cuts (Campbell, 2013). In addition half a million people survive depending on food banks (Topping, 2013) due to financial cuts to welfare services. Meanwhile, in the UK those without a personal computer and internet access are further deprived with the closure of 500 of 3,100 public libraries (Guardian Editorial, 2014).

The UK is just one example of a developed country in which many people are sinking into poverty. In February, 2015, SWR2, German radio reported that 12.5 million German citizens are classified as poor despite a record number of people being in work (ksb/sms 2015). If we combine this development with the necessity to reduce consumerism due to diminishing resources then a frequently heard reaction is a desire not to return to a middle-ages life style. However, today new social models are developing which replace the superficial pleasures of consumerism as many discover greater satisfaction in many other forms of being. Some of these concepts have already been described in the Recommendation 6 which is concerned with the development of the Grassroots.

Is it possible to think of a replacement for consumerism and the globally *"skyrocketing"* phenomenon of single occupant households? These households have been *"rising from about 153 million in 1996 to 277 million in 2011 – an increase of around 80% in 15 years. In the UK, 34% of households have one person living in them and in the US it's 27%. Contemporary solo dwellers in the US are primarily women: about 18 million, compared with 14 million men. The majority, more than 16 million, are middle-aged adults between the ages of 35 and 64. The elderly account for about 11 million of the total. Young adults between 18 and 34 number more than 5 million, compared with 500,000 in 1950, making them the fastest-growing segment of the solo-dwelling population. Unlike their predecessors, people who live alone today cluster together in metropolitan areas. Sweden has more solo dwellers than anywhere else in the world, with 47% of households having one resident; followed by Norway at 40%. In Scandinavian countries their welfare states protect most citizens from the more difficult aspects of living alone"* (Klinenberg, 2012).

How could community and culture replace the dominance of consumption? There are developments already occurring such as co-housing and the re-establishment of local communities (as has already been mentioned above, the transition towns) etc.

Co-housing

"Co-housing originated in Denmark in the mid-1970s, and swiftly became established in Scandinavia, Germany and the US. A few co-housing communities have emerged in the UK over recent years, and the idea is now rapidly gaining momentum with more than 60 projects in the pipeline." A typical co-housing project consists of about "20 individual, private housing units are grouped around a communal garden and courtyard, with shared facilities such as a laundry room, workshop, allotments and bike sheds. Central is a common house where residents meet, cook and eat together twice a week, hold parties, collect their mail, host local groups and collectively govern their little community …"

"The design principles encourage social interaction, … Co-housing is attractive to single people, especially in older age groups, who want to live neither in isolation nor in conventional senior housing, and to families looking for supportive environments in which to raise children and juggle work commitments. All groups and communities have a strong desire to collectively reduce their environmental footprint" (Sherwood, 2014).

LILAC (Low Impact Living Affordable Community)

A project entitled LILAC (Low Impact Living Affordable Community) (Chatterton, 2014) exemplifies *"how a group of people got together to build one of the most pioneering ecological, affordable cohousing neighbourhoods in the world … demonstrating how ordinary people can build their own affordable, ecological community … with … clear values that motivated and guided the project's members: sustainability, co-operativism, equality, social justice and self-management … they were driven by challenges and concerns over the need to respond to climate change and energy scarcity, the limits of the 'business as usual' model of pro-growth economics, and the need to develop resources so that communities can determine and manage their own land and resources."* This extract is from the synopsis of the book written by one of the co-founders of the LILAC project, Paul Chatterton (2014). The project also includes *"several allotments, a "pocket park" and a meeting space for community groups."*

Co-housing offers enormous potential for a sustainable future since sharing facilities reduces consumption. Furthermore, co-housing opens the opportunity for the development of communities composed of mixed age groups providing greater social interaction and resilience, mutual care, even health support, and cultural creativity, and the development of music, theatre, gardening and hobby groups etc. Co-housing potentially offers an antidote to the spreading single living style which increases consumption of both resources and space. However, one interesting social design problem is how to develop and adapt the benefits of co-housing and develop communities where the building stock (e.g. tower blocks) already exists.

Could cultural activity be the sustainable replacement for consumerism?

Several factors have the potential to work together to enhance cultural activity throughout the population and create greater individual involvement in craft, art, care for nature and other cultural and sporting activities. We have been lulled into passive consumerism, watching hours of TV and advertisements encouraging us to consume more. In the UK the Warwick Commission Report (2015) reveals that *"Creativity, culture and the arts are being systematically removed from the education system, with dramatic falls in the number of pupils taking GCSEs in design, drama and other craft-related subjects, a new report has revealed … Between 2003 and 2013 there was a 50% drop in the GCSE numbers [of children] for design and technology, 23% for drama and 25% for other craft-related subjects. In 2012-13, only 8.4% of students combined arts and science at AS level. The number of arts teachers in schools has fallen by 11% since 2010 and in schools where a subject has been withdrawn, drama and performance has dropped by 23%, art by 17% and design technology by 14%. The report highlights a downward trend in participation in most cultural activities"* (Brown, 2015). Furthermore, in the UK *"One of the biggest problems for the arts is national and local funding cuts, with Arts Council England cut by 32% and local government by 40% between 2010 and 2015"* (Brown, 2015).

The encouragement of cultural activity could greatly help to replace consumerism and television induced passivity, improve health and steer all to both a more sustainable and more fulfilling lifestyle. *"In many parts of the world, cultural facilities and activities are increasingly being exploited as a 'driver', or at least an important player, in physical, economic and social regeneration. Sprinkle a little cultural fairy dust on a rundown area and its chances of revival will multiply – or so the argument goes"* (Evans, & Shaw, 2006). True enough, the encouragement of culture is not easy because all of us have experienced places which were cultural hotspots whilst others appeared to be grave yards with cultural aspirations. *"Every place is unique and there is no guarantee that what works in one setting will work in another. Solutions must grow from their own communities."* (DCMS, 2004). An observation also made by Elinor Ostrom. Nonetheless, accepting the difficulties; the question is what strategies might contribute to the development of culture throughout local communities and neighbourhoods?

- Education has a key role to play in providing a balanced curriculum between the humanities, arts and the sciences and it should not primarily be concerned with preparing the individual for work. Education must also prepare a person to become fulfilled in their leisure time through cultural and sporting activity so as to enhance their personal fulfillment and participation in a community. "Freetime" is not peripheral to human existence. In the UK for example, the governments neo-liberal capitalist policies have marginalized the arts in education so that *"The 2014 Taking Part survey found a sharp fall in the number of children doing any arts: 35 per cent fewer took part in music activities, drama, and dance than in 2010"* (Toynbees & Walker, 2015). The political marginalization of the cultural and sporting component of the curriculum narrows people's perception of their own creative potential and development. My hypothesis is that this basic political failure of education in developed countries is confirmed by the "average adult" spending daily between 2 ½ hrs to 4 hrs 50 mins watching television (see above, Statista, 2015).
- *"Françoise Choay says neighbourhood is the only antidote to cyberspace and we need it very much because there is something basically human about small spaces and proximity. Giandomenico Amendola goes even further, asserting that the urban neighbourhood is the best means of counteracting the trends towards delocalization, detemporization and virtualization that are changing our lives"* (quoted in Rellstab, 1999).
- A neighbourhood provides the opportunity for cultural development through involvement and cooperation between local residents, many of whom are known to one another. This establishes local ownership of cultural activity and enhances the identity of a neighbourhood and strengthens its resilience. It is unfortunate that the architecture of many cities no longer encourages the development of neighbourhood communities through appropriately designed social space.
- Cultural activity is more accessible in a local neighbourhood or community with fewer barriers to creativity and with less pretentious audiences. The involvement helps residents to establish ties with one another creating greater concern, care, tolerance and understanding between nationalities and age groups.

Furthermore, Franco Bianchini says *"direct participation in cultural events and activities, rather than simply consumption, is one of the essential preconditions for maximizing the contribution of culture to the development of human potential and to social cohesion in the neighbourhood"* (quotes in Rellstab, 1999). *"Why is it more exhilarating to write than to read, to make music than to listen to it, to paint than to visit an art gallery? Take the theatre … Acting a part means getting into it with one's whole body, not just one's head; as recent research has shown, it is an extremely intense experience, all the more exciting and overwhelming because it does not happen in private but in front of an audience"* (Rellstab, 1999).

Since humans are the greatest resource we have we could create for ourselves a more enriching and sustainable future if we were all more culturally interactive, performing, singing, creating, making, gardening (Leendertz, 2010) etc. in our free time. It would have many benefits including better physical and psychological health, provide an enrichment of personal experience as well as enhance community resilience. Such a future would be more fulfilling than our contemporary consumer society paralysed by the consumption of stuff. As Hopkins (2008) writes *"I am not afraid of a world with less consumerism, less stuff and no economic growth. Indeed, I am far more frightened of the opposite"* and he invites his readers to join him in *"taking the steps towards making a nourishing and abundant future a reality."*

Cultural change is not easy but Brazil has introduced a "cultural coupon" worth $20 a month. *"The money, loaded on a magnetic card, is designated for purposes broadly termed cultural – though that could include dance lessons and visits to the circus in addition to books and movie tickets. In a country still battling high levels of poverty, the initiative has won widespread praise as a worthy and yet relatively cheap project … "What we'd really like is that they try new things," culture minister Marta Suplicy said in a telephone interview. "We want people to go to the theatre they wanted to go to, to the museum they wanted to go to, to buy the book they wanted to read.*
When asked what they most like to do in their spare time, 85% of Brazilians answered "watch television".
The rechargeable coupon, known in Portuguese as a Vale Cultura, is available to workers who earn up to $300 a month, or about five times Brazil's minimum wage. So far, 356,000 people have signed up, and government officials hope as many as 42 million could eventually join, helped by firms that enrol their employees and companies who sign up to accept the card in lieu of cash. Several credit card firms are making and distributing the cards. State-run companies are obliged to participate, and ministers are encouraging unions to demand the Vale Cultura as part of their annual wage negotiations.
"This is innovative and cool, and no one in the world is doing anything like it," Suplicy said. "My hope is that it will be revolutionary for culture here. It provides an opportunity for people who never had it and, at the same time, has an impact on cultural production" (Downie, 2015).

14.4.8 Resilience against the unexpected (Resilience Design)

(Moberg, & Simonsen, 2011, Zolli & Healy, 2012)

Resilience is *"the capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop. It is about the capacity to use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking. Resilience thinking embraces learning, diversity and above all the belief that humans and nature are strongly coupled to the point that they should be conceived of as one social-ecological system"* (Moberg, & Simonsen, 2011). A key feature of resilience is the creation of stronger caring communities through diverse networks, etc. The importance of cultural development within neighbourhoods (described above in 14.4.7) has the added effect of increasing the community's resilience to disasters and mutual care.

Adaptive design and the development of physical infrastructures is one strategy of achieving resilience to disturbance. However, another way, perhaps less considered, is the creation of stronger person-to-person, local-social networks in which digital technologies have a key role to play in their development. Research reveals that people suffering the same disaster have different chances of survival depending on the robustness of their social networks.

"Take the brutal heatwave that hit Chicago in 1995. The risk of dying varied greatly between two adjacent neighbourhoods with similar economic and demographic profiles, according to research by sociologist Eric Klinenberg [2002]. He traced the difference to social connections between residents and how involved they were in public life. In one community, residents checked in on each other during the heatwave, while in the other they were isolated

and afraid to leave their homes largely because of crime. Social ties became a matter of life or death. Similarly, political scientist Daniel Aldrich [2012] found that communities with robust social networks coped better in Kobe, Japan, after the earthquake in 1995 and in Tamil Nadu, India, following the catastrophic Indian Ocean tsunami in 2004" (Sampson, 2012 & 2013).

Robert Sampson has extensively researched the nature of communities concentrating on the neighbourhoods of the city of Chicago and developed a tool called "ecometrics" for the field measure for social cohesion. Ecometrics measures the strength of the social-ecological infrastructure of neighbourhoods so that weak neighbourhoods can be identified. Weak neighbourhoods are likely to be vulnerable when a disaster occurs because they lack a resilient social infrastructure of networks of friends and aquaintences. Sampson (2013) writes that: *"The more community groups in an area, the greater the collective efficacy, social altruism and collective civic engagement … organizations generate a web of routine activities and associations that lubricate collective action, although they are seldom planned as such. What is important is not the existence of any specific type of organization but the overall organizational infrastructure of a community and overlapping networks among participants."* So that when disaster occurs *"Who has a power generator and is willing to share with others? Who wants to volunteer and where? Who has extra food or will take in a neighbour for shelter? These questions strike at the heart of a community's capacity to respond in times of crisis."*

We all know that climate change is altering weather patterns so that they are becoming unpredictable. Scientists tell us that 'stationarity,' the envelope within which normal weather patterns occur, no longer exists due to global warming (Milly et al. 2008). Consequently, we should not wait for disasters to happen but work towards improving the ecometrics (Sampson, 2012; 2013) of our communities. We need to start developing both resilient design and adaptive design as fields to provide innovations which will reduce the impact of the extremes be it flooding or a heatwave. The field of design for social innovation and sustainability has been enthusiastically developed by Prof Ezio Manzini who has established the DESIS Network Association for the promotion of Design for Social Innovation and Sustainability (http://www.desis-network.org/) and has supported the initiation of many diverse projects worldwide through the DESIS Network (q.v. Glossary: DESIS).

Design for social innovation is a response to community needs in contrast to those of corporate needs. Consequently, it is concerned with projects *"such as community-supported agriculture, co-housing, car-pooling, community gardens, neighbourhood care, talent exchange and time banks. These initiatives propose viable solutions to complex problems of the present (e.g., social cohesion, urban regeneration, healthy food accessibility, water and sustainable energy management) and, at the same time, they represent working prototypes of sustainable ways of living."* (DESIS, 2012) All of which enhances the 'ecometrics' (Sampson, 2012) of the communities, its members and their resilience. It is also a 'grassroots' action which will contribute to wellbeing and sustainability.

14.4.9 Re-ORIENTATION of DESIGN: non-commercial design for need and local welfare

Design is far too valuable as an innovative human resource for it to be only active in the service of commerce, (its historical parent – the old paradigm) and corporate business for feeding consumerism and profit. Design must become re-oriented to serve many non-commercial needs so that its potential can help us to secure a sustainable future (new paradigm). Design education must address the issue of non-commercial design because we can already see that social design is needed for many social problems and fortunately it has already been pioneered by Prof Ezio Manzini. However, this is just one field of non-commercial design because we need design for solving many other problems. For example, for mitigating the creation of problems such as CO_2 emissions (mitigative design) and adapting to future problems such as resource exhaustion, sea-level rise, climate change etc, (adaptive design) and for addressing problems of human need, poverty and welfare (design for human welfare) and environmental care (design for ecosystem restoration).

I do not believe we can delay to start teaching 'non-commercial design' because of the question who will pay? Non-commercial problems are already with us in abundance. Scientific thinking does not limit itself to commercial activity, why should design? We have to recognize that there are many design problems for which there is no client and no budget. For too long commerce has profited from Nature and its resources and not been made to pay (Jowit, 2010; Sukhdev, 2008).

The majority of clients who can pay for design are actually damaging the world.

Commerce has too long determined the design curriculum so that it has become almost subversive (experience design) in its the drive to sell 'stuff.' We need new design departments teaching design to address the problems we have under the rubric: 'non-commercial design', for example:

› Mitigative Design
› Adaptive Design
› Resilience Design
› Positive Impact Design
› Design for Social Need & Welfare
› Design for ecosystem restoration

etc.

Clearly, there are more areas in need of design attention but what follows concerns: Mitigative Design, Adaptive Design, Resilience Design, Positive Impact Design and Design for Social Welfare and Subsidiarity. It is not difficult to anticipate design for other areas based on the foregoing.

Mitigation-Design

Is it possible to develop design so that it does not add to- or create further environmental problems? Can mitigation-design avoid creating anthropogenic impacts on the ecosphere? This sounds the same as designing sustainably but the emphasis is on mitigating consequential problems and externalities resulting from the production of the design as much as the design itself. For example, car design should aim to stop green house gas emissions (ghg) rather than producing cars with low ghg emissions.
Mitigative design *"includes actions which*

(A) compensate for negative effects of human behaviour directly in the ecosphere (correctional measures, e.g. renaturation of damaged areas)

(B) prevent the occurrence of such effects (preventive measures, e.g. regulations to reduce emissions), or

(C) influence human/social systems directly (e.g. development of alternative technologies, stimulating or changing environmental concern, facilitation of a value change)." (Adomssent, et al, 2006) In this context the assumed design response could perhaps be dematerialized and the need fulfilled by a social innovation (see Glossary: DESIS).

Adaptation-Design

The problems which are occurring and will occur as a consequence of, for example, global warming will cause, drought, sea-level rise, etc. and a design response is needed which includes a range of design adaptations or interventions to safeguard human welfare. How can urban environments be adapted for heat waves or sudden downpours of rain and flashfloods far in excess of those experienced in the previously benign climate stationarity (Milly, et al. 2008)?

Kruse describes a range of adaptations in which design could play a key role, for example:

"(D) actions to prevent negative environmental impacts on humans (e.g. construction of dams, use of sun protection against ultraviolet radiation, development of drought resistant crop strains).

(E) curative measures treating damage already manifest or imminent (e.g. evacuation from areas threatened by flood ...), or

(F) measures to preventively reduce vulnerability of the human/social system to global environmental change (e.g. diversification of agricultural systems)" (Kruse, 2006).

We know that our world is in a phase of transition, the Anthropocene, due to the fact that we have and continue to change both the environment and climate. The significantly skeptical population of the US is even being warned by its Environmental Protection Agency *"that climate change is not only already strengthening storms, accelerating ice melt, and raising global sea levels, but that it's happening faster than anticipated. "These indicators make it clear that climate change is a serious problem and is happening now here in the U.S. and around the world," Janet McCabe, acting assistant administrator for EPA's Office of Air and Radiation, said in a statement."* (Neuhauser, A., 2014). Adaptive design measures would therefore strategically explore and address a systemic range of responses to emergency situations such as the hurricane Katrina (2005), hurricane Sandy's impact on New York (2012) or the Paris heatwave of 2003 (see chapter 9).

Climate change is not just going to cause emergency situations based on unpredictable weather patterns. For example: *"The UK's weather will become both too wet and too dry – and also too cold and too hot – as climate change increases the frequency of extreme events ..."* The UK Meteorological Office "*scientists concluded that on average the UK will see wetter, milder winters and hotter,* *drier summers in the long term due to global warming. But the natural year-to-year variability of weather will also mean occasional very cold winters, like that of 2010-11, and very wet summers, like that of 2012 … We have to continue to live with the cold events, but get used to the warm events," said Professor Stephen Belcher, head of the Met Office's Hadley Centre … "The boundaries we have to adapt to are expanding." He said that, on current trends of carbon emissions, the extreme European heatwave of 2003 which killed tens of thousands of people, would become a normal summer by the 2040s"* (Carrington, 2014).

Adaptation design must move forward to exploring a whole range of integrated responses to the widening weather boundaries. The extremes of drought and deluge will require a new attitudes to water management. Roofs no longer merely provide protection from the elements but are providers of energy from solar panels and water harvesters. Roofs must be seen as components in a systemic approach to water management. In order to adapt to droughts water must not simply be got rid of but conserved locally or enabled to infiltrate the soil to become ground water etc. The soft strategy (Lovins, 1977) of local utilities would mean that water could be harvested and stored locally in ponds rather than in centralized large reservoirs. Furthermore, locally distributed ponds could enhance biodiversity since The Living Planet Index shows an average decline of 76% for freshwater species worldwide (WWF, 2014).

In April, 2014 the IPCC published its most serious report. *"This is the last time that the IPCC will issue one of its landmark reports before the all-important global deal on climate change needs to be signed by countries in Paris in December next year … Obstacles remain in the road ahead – most notably, **vested interests, blinkered ideology and political short-termism** – but the IPCC has made it abundantly clear that the lack of available time means we must press on regardless and secure the rapid transition away from polluting fossil fuels and towards low-carbon, sustainable sources of energy. The IPCC has shown clearly that those who once doubted the science and now fashionably claim that we should "just adapt" to climate change are plain wrong. It's not an either/or choice between adaptation and mitigation. We must do both – and urgently … The IPCC will publish an official synthesis of the three reports in Copenhagen in October, but here's my own synthesis report in – as is the vogue – less than 140 characters: Climate change is real. We are to blame. It will get worse if we fail to act. The solutions are available and affordable. But time is short.* (Hickman, 2014).

*… As we saw in working group two last month, which examined the impacts of climate change, as well as working group three, **economists seem unable to factor in the co-benefits of a clean-energy transition, such as improved human health. They also struggle to incorporate the myriad "services" that natural ecosystems provide to humans. Nor can they incorporate the damage climate changes presents to these ecosystems, such as ocean acidification, extreme weather and rising sea levels.***
Take all this into account, and reaching for a clean and sustainable energy future becomes even more compelling and urgent, even if you are unable to express it in terms of GDP or a profit-and-loss column" (Hickman, 2014).

The IPCC (2014) report that was published in October provided clear warnings, for example concerning:

› Changing precipitation patterns and melting snow will affect water supplies. This will impact on food production in particular areas.
› Climate change impacts on natural systems and crop production.
› Health may be affected by heat and climate change will affect the distribution of disease vectors.
› *"recent climate-related extremes, such as heat waves, droughts, floods, cyclones, and wildfires, reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate variability … For countries at all levels of development, these impacts are consistent with a significant lack of preparedness for current climate variability in some sectors"* (IPCC, 2014).
› Populations vulnerable to sea level rise will need relocation.

etc.

This list of impacts is **a shopping list for the design curriculum**. There is an enormous potential for design to contribute to mitigation, adaptation and resilience throughout many kinds of communities. Unfortunately, design's potential role so far is largely thwarted by old paradigm thinking driven largely by commercial activity. Now there is a substantial role for design driven by human need. Education will be important in exploring new models for design activity not driven by commerce and profit. It is obvious that ***we need "non-commercial design."***

Resilience Design

The concept of resilience is relatively new and the hybrid of resilience design opens many new vistas for design activity which will contribute to a sustainable future. Furthermore, it impels further development of design and design education. In order to protect citizens from the impacts of climate change it is essential to increase ecometrics (see Glossary) and to strengthen communities (Sampson, 2013) by design for social innovation.

Positive Impact Design

As has already been mentioned, the shocking news of *The Living Planet Report 2014* (WWF, 2014) that since 1970 vertebrate animal populations around the world have fallen by 52% requires truly innovative social measures. These are necessary to restore our natural capital, the ecosystems and the animal populations which play a key role in their maintenance because the services provided by the ecosystems play a crucial role in our own survival. In addition to our participation in Earth Stewardship, we as designers must design not merely to reduce our ecological footprint so as to make a smaller impact, ('death by a thousand cuts') that is insufficient. We have to design in new ways which remove our ecological footprint completely so that there is more Nature after the design than there was before it! This is real Positive Impact Design.

Design for Social Welfare and Subsidiarity

Prof Ezio Manzini's Design for Social Innovation and Sustainability was a key development for lifting design out of the commercial world and placing it in the hands of communities and the grass roots. The empowerment of the grass roots will become increasingly important in the coming decades as 'big,' from SUV 4x4s to giant corporations, is shown not to work (Schumacher, 1975) because of their destructiveness to the natural world. Rather, Nature teaches us that there is an optimum for everything in a finite world (Bateson, 1980). Politicians show themselves to be increasingly out of touch and inexpert which is why empowering the grass roots with design is essential for local decision making (subsidiarity) across a wide range of needs including, local food production, energy (Rifkin, 2011), housing, local health and welfare care, support for the development of local creative culture etc. We have created an unnatural world in which too often neighbours are complete strangers to one another, now we need to learn to cooperate to bring about holistic change.

14.5 Conclusion

In this concluding chapter to Part One, I have summarized nine intimately interconnected meta-strategies for moving towards a sustainable future. These meta-strategies are, mostly, in opposition to those factors which have brought us into the dead end of the consumer society. In Part Two, my co-editor, Ursula Tischner, has brought together many experts who will provide diverse strategies for how we can design for a sustainable future. Of course, we need many strategies. The conference program of the International Forum on Globalisation held in October 2014 provided a summary list: *"We start with the Primacy of Scale. Not large scale, small scale. Not global, local. Not faster, slower. Not more, less. Not top-down, bottom-up. Not private, shared. Not investor-owned, community owned. Not more tech, less tech. Not meta-economics, micro-economics. Not competitive, collaborative. Not more trade, less trade. Not more energy, less energy. Not big business, small business. Where do we go from here?"*

It will be hard to embrace all of these strategies because they demand new ways of thinking. Charles Darwin has been wrongly attributed with a saying by Leon Megginson, Professor of Management and Marketing: *"It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change" (Matzke, 2009). To which can be added: "We cannot solve our problems with the same thinking we use when we created them"* and attributed to Einstein. Our thinking and core values have been honed by the environment in which we have lived upto now. Consequently, much will appear to us unchangeable, but this is a dangerous perception based on the old paradigm. Change is not an option, it is now a necessity as the authors of Part One have implied. Our ability to change will be profoundly tested. As Professor Will Steffen (b. 2015) has ominously said: *"It's clear the economic system is driving us towards an unsustainable future and people of my daughter's generation will find it increasingly hard to survive. History has shown that civilizations* *have risen, stuck to their core values and then collapsed because they didn't change. That's where we are today."*

Design has an enormous potential to help us to secure a sustainable future. Design must be developed to the full ambit of its potential, well beyond its commercial womb. As our consumption currently accelerates (Steffen, 2015; Steffen, a. 2015) increasing resource exhaustion, pollution, and ecosystem destruction; be we design educators, design students or designers we all have to develop design's potential into many new dimensions so that we can help to secure a sustainable future. It will require dynamic holistic change.

14.6 References and further reading

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Part 2

How to design for sustainability

edited by Ursula Tischner

Scott Boylston

15 Borrowing a M.A.P. for Design Leadership and Sustainability in an Age of Interconnectedness

"Design is the rubric of the future, not just in management but in every field because it is such a powerful determinant of human behavior and experience." Richard Farson

"Designers can be facilitators or mediators but also triggers. They can operate as members of a co-design team, collaborating with a well-defined group of final users, or as design activists, launching socially meaningful design initiatives." Ezio Manzini and Francesca Rizzo

15.1 Introduction

One day, four men sat down at a store counter for coffee. The next day, more than 20 people joined them; the third day there were over 60; and on the fourth day, the number exceeded 300. A few short months later, over 50,000 young adults had sat down at store counters across the American South to order coffee.

The year was 1960, the place, a Woolworths five-and-dime in Greensboro, North Carolina. The first four gentlemen entered the store because they knew they wouldn't get served. The individuals joining them in the ensuing days carried books so they could study while they weren't getting served. And even after the number of sit-in participants increased and the heckling by belligerent whites intensified into acts of violence, the national headquarters of Woolworth's continued to support the store's refusal to serve blacks, stating they would 'abide by local custom,' the custom in this case being the entrenched Jim Crow laws of the segregated south.

It is interesting that the act of demonstration is a common focus of both designers and activists. Both use the art of demonstration to illustrate new possibilities. Yet design uses demonstration not merely to raise awareness, but to shape new desired behaviors through products, services, and experiences. In regards to design's potential influence for shaping a more sustainable future, Victor Margolin makes this observation: "Given the extreme difficulty in reconciling differences between supporters of sustainability or expansion at the discursive level of ethics and values, a strategy which the United Nations and groups like the Club of Rome continue to pursue, it is possible to move forward fruitfully through projects and products that demonstrate new values in action. These may prove more inviting to the public than would an argument that remains propositional rather than demonstrative (Margolin, 2002)."

Changes in behavior follow shifts in perception, and designers possess an understanding of what propels both. Because design is an act of redefining the possible, the ways in which actors in a society transcend the recalcitrance of entrenched norms is a rich area of exploration for designers with a propensity for social innovation. And because sustainability is a movement as sure as civil rights has been, designers intent on systemically addressing our unsustainable ways of living would do well to seek guidance in scholarship that explores the intrinsic challenges of living in a democracy. In this light, strategic perspectives from social movement theory can provide constructive frameworks for designers intent on grappling with so-called wicked problems (Rittel, et al, 1973).

Bill Moyer's Movement Action Plan (Moyer, et al, 2001), while grounded in a grassroots perspective, stresses a systems-based connectivity between communities, organizations, corporations, and governmental bodies in analyzing the way in which complex social dynamics are navigated by those who would change them for the betterment of all people. This chapter follows that lead, so, while primarily referencing sources from the design and social innovation fields, it does so with the idea that changes in perception and behavior occur irrespective of whether people are operating as citizens, professionals, or agents of other organizations. In other words, I argue that an all-encompassing strategy for designers seeking positive change can be a helpful wayfinding tool for individuals in the increasingly diverse arena of 'sustainable design,' and a practice-oriented analysis of social movements provides just such a tool. Such a tool can provide insight, guidance and even a sense of camaraderie for practitioners operating in seemingly different arenas of sustainability and social innovation; addressing wicked problems demands nothing less.

15.2 A Meta-Framework for Design

Designers in sustainability and social innovation are in need of more expansive strategic frameworks. Methods and means for operating in this emerging space – a new breed of tactical tools – already exist, and include participatory design, co-design, and trans-disciplinary design on a broader scale and, more specifically, what Manzini and Rizzo refer to as design devices (Manzini, et al, 2012), such as IDEO's Human Centered Design Toolkit, Frog's Community Action Toolkit, and Dan Lockton's Design with Intent cards, to name a few.

Many of these design devices have been developed through synthesizing original lessons learned by designers with more established theories and practices from the social sciences. They are presently being put through their paces by designers and non-designers around the world; used, misused, tweaked, and appropriated for custom application. And more of these tools will emerge. There will be those who claim such tools should be used in as many locations as possible, and as often as possible. Another view, however, is that design leaders should consider meta-frameworks that place the application of these direct tools in a broader context, so that, even as they are applied in local contexts, the people involved with that application have the means to consider the implications of keeping the broader system's connectivity in mind. The Movement Action Plan (MAP) created by Bill Moyers and expounded upon in his book Doing Democracy, is a strong candidate for not only framing this broader strategic perspective, but for aiding the sustainable design community in the important process of self-reflection.

The Greensboro sit-in can be viewed as an easily identifiable trigger for myriad cultural transformations that ensued in the United States in the following decades. Yet, the continuum this event exists upon is complex, varied, and contradictory. Trigger events in the sustainability movement are equally recognizable, from the first Earth Day in 1970, to the Rio Earth Summit in 1992, to the publication of Cradle to Cradle tens years after that. It is easy to be frustrated by the length of time it takes for lasting change to take hold, yet an understanding of the process of change as something that exists on a continuum of its own – rather than one that is tethered to a life span of a single human generation – is essential in maintaining the necessary focus for increased rates and levels of success.

Social movements, as Moyers reminds us, involve a long-term struggle "for the hearts, minds, and support of the majority of the population (Moyer, et al, 2001)." Moyer has identified eight sequential stages of social movements, and four central roles that players within a movement perform. With the dire forecasts for climate change on the immediate horizon, it could be argued that an understanding of these stages – and the threats and opportunities that exist within each of them – is more important now than ever before. Social change can be rife with unrest even when it unfolds on a timeline dictated by that society's openness to change; in a situation where change is foisted upon it suddenly, these stages occur with unprecedented speed, and the resulting turmoil will require a higher level of expertise in managing that change to assure equitable outcomes.

15.3 Design and the unfolding of a movement

The MAP stages – which align with stages set forth in the ancient I Ching, or Book of Changes – begin with normal times, where an issue does not seem like an issue at all, as much as an acceptable social practice; voting rights for the male gender only; Jim Crow laws; egregious overconsumption by a small global minority, etc. A feeling that something is amiss is sensed by a quiet minority.

The next three stages occur during a period of build up of stress in the system: First, there is increasing evidence of a habitual failure of official institutions to live up to the values they espouse. Within the sustainability movement, the publication of Rachel Carson's Silent Spring in 1962 could be identified as a significant event that publicly proved the failure of official institutions. Forty-four years later the release of Al Gore's An Inconvenient Truth was yet another such event. Incidentally, these two examples speak to the longevity and diversity of a larger movement toward a more sustainable human existence on the planet. Silent Spring upturned the logic of applying massive amounts of toxic petrochemicals in the pursuit of abundance at a time when the word sustainability was all but unheard of, while An Inconvenient Truth busted the myths and misconceptions around climate change, a phenomenon that was not even on the environmental agenda at the time Silent Spring was published.

Despite the differences and the span of time between these two publishing events, they are inextricably interwoven. As Paul Hawkin explains in his book, Blessed Unrest, the commonalities between seemingly disparate initiatives around the world toward a more equitable human existence are akin to the workings of a global immune response. "Just as the immune system recognizes self and non-self, the movement identifies what is humane and not humane (Hawken, 2007)." The first stage of a movement, then, is information-based: a stream of signals that something is wrong, and must be rectified.

Proving the failure of institutions as a stage is followed by a period of ripening conditions, when more and more people grow publicly uneasy with the status quo; until the movement experiences take off, and blossoms into a vigorous public conversation about the need for change, and the kind of change that is possible, palatable or necessary. Take off, which is prompted by a 'trigger' event, is followed by two incongruous stages: perceptions of failure and majority public opinion. Whether the trigger events are positive or negative occurrences – whether they are inspiring or traumatic – is not as relevant as their tendency to crystallize a way of thinking that had previously been inaccessible to the general public. Yet, even as the old norms continue to fall out of favor in the eyes of the general public, individuals within the movement grow dispirited, believing there is no end in sight, and at times resorting to ineffectual behavior.

This contradiction between the growing acceptance of new ideas by the general public on the one hand, and the belief by some actors within the movement that change is not occurring fast enough on the other, can best be understood by considering the intensity in which movement actors operate in contrast to the length of time that any lasting shift in social norms requires. It is all too common for people invested in a movement to grow discouraged with the pace of change if levels of public support are used as the only gauge. Public support is a clear indicator of progress, yet it can be achieved only after two, less visible trends take root.

A broad-based awareness of the problem must occur first; an awareness of the linkage between various phenomenon as symptoms of a larger problem, rather than as unrelated and isolated incidents. Yet because awareness is experienced on a personal level, the outward signs of it are more difficult to discern. The second shift – opposition to the old norms – comes even slower. If a consistent voice is not given to this opposition, it may remain latent for an indeterminate amount of time. That voice is usually nurtured by the considerable efforts of movement actors in keeping the topic at the forefront of people's minds, and it is the nature and intensity of this work that can exhaust committed individuals. Furthermore, even if opposition to the status quo has risen across the society – and even if that opposition is given voice more and more frequently – it does not equate to actual acceptance of the alternative. Dissatisfaction with the old way and acceptance of a proffered new way are two entirely different matters. In fact, the most likely candidates to emerge – the ones with the most validity and objective standing – have often been so demonized by powerholders who have long felt threatened by them, that they are already unpalatable to the general public, deemed 'just as bad as the old way.'

So, while two major accomplishments – raising awareness in the general public followed by increasing the public's opposition to the status quo – come only through great effort on the part of movement actors, this progress can remain invisible until what Tom Atlee calls 'winning the public the third way' occurs. Scholars of social movements accept that this third way – the point at which a belief in or acceptance of a specific alternative as the correct choice is all but confirmed – is the slowest shift to come. Yet, because those beliefs have been collectively gestating for so long, when that shift does arrive, it often does so with surprising speed. Just as a tree rots from the inside and the deterioration is not apparent until the tree is already dead, the steadfast resistance of the status quo can seem as strong as it has ever been, even at the moment it is about to give way.

After a movement attains majority public opinion, a resolution is experienced in two final stages: success, and continuing the struggle, the latter suggesting that all successes are tenuous, and must be protected with the same attentiveness that was necessary to win any preceding stage.

While design practice has not been explicitly referenced in the last five paragraphs, there are very few sentences within them that do not drip with implications for designers. The entire progression defined above is reliant upon a reinforcing network of healthy information flows – from visually communicating the value of new ideals across media platforms to executing real-world demonstrations of those new values in action. Furthermore, an awareness of the larger trends at play in any major cultural shift can better empower designers invested in the acceleration of that shift. Strategic design leadership, in this sense, can envision and propose a rhythmic infusion of interventions that consistently demonstrate the value of sustainability and social innovation, in ways that resonate with intended audiences, whether those audiences be comprised of CEOs, ranchers, pre-teens, or animal owners. As one example, the Victorian Exo Innovation Lab's (VEIL) describes their ambitious Broadmeadows 2032 project as, "changing trajectories of development and overcoming paralysis and short-term resistance, our aim is to identify opportunities – small domains of potentiality – that can become sites of design intervention to shift the path of innovation on a new trajectory: towards sustainable, resilient conditions."

Situating the sustainability movement within specific sequential time-frames can also provide opportunities for internal dialog about the level of success of sub-movements – the advancement of renewable energy adoption, for instance, compared to the level of sustainable waste management practices in the home – and how factors within one sub-movement can be leveraged to better equip elements in another.

15.4 Design roles in an unfolding narrative

Having an appreciation for the nature of change is not enough. Designers engaged with addressing wicked problems, along with possessing an awareness of the typical chronological progression of a movement, must be cognisant of the ways in which they themselves choose to behave, and understand the ramifications of different kinds of behavior, and the implications of those behaviors in varying stages of the movement.

In an essay on scaling social innovation, Ezio Manzini articulates four general activities of 'design experts' within the context of broader social endeavors to instigate sustainable change: 1) To feed the social conversations with scenarios and proposals, and at different scales; 2) To empower existing cases of social innovation, to help them to last in time, and to become more effective and accessible; 3) To up-scale good ideas, making them more replicable, through toolkits and/or specifically conceived products and services, and; 4) to promote large systemic changes, synergizing a variety of local initiatives, through the development of specifically conceived framework strategies (Manzini, 2010).

Yet again, Bill Moyer's MAP, can provide an historical layer of insight over the strategic intention of our actions as designers in the social milieu. Moyer defines four roles that movement actors play: individuals can act as responsible citizens; they can perform as rebels who publicly and unapologetically protest injustices and inconsistencies between rhetoric and action; they can take on the role of change agents capable of seeking constructive opportunities for activists and the general public alike to participate in the progressive change toward movement goals; or as reformers who work directly with official institutions to ensure that change is legitimately instituted and protected. In all movements, a stratification of personalities and skill sets into different roles is quite normal. People are drawn to roles and behaviors that make the most sense to them, and the breadth of needs in movements oblige these multifarious preferences.

Moyers cautions that each role can be as ineffectually played as it can be played to positive effect, and provides ample examples of both effective and ineffective ways of performing each role. In Moyer's view, "to play any of the four roles effectively, activists and their movements need to act in accordance with society's widely held democratic and human values. They must also behave in ways that are consistent with the long-term goals of the social movement and the vision of a good society."

It is both reassuring and inspiring to see Manzini's concise categorizations echo the wisdom espoused by seasoned social movement thought leaders, and an affirmation that design's present leaders are appropriately attuned with spheres beyond design. More specifically, the combined activities that Manzini describes as the domain of 'design experts' closely aligns with Moyer's description of a change agent. For design leaders, then, the timing of selecting roles should be strategic; how much of each role is necessary in any given situation; at any given time; during any given stage of a movement.

And, a critical assessment of how such roles can be played effectively is as important as assessing the timing. Whereas ineffective change agents adhere either to an overly utopian view, or to one that promotes minor reform in an attempt to alleviate symptoms without promoting systemic change, an effective change agent promotes realistic strategies for paradigm shifts. Whereas an ineffective change agent can be patriarchal and insistent upon overt leadership hierarchies, effective change agents promote participatory leadership and design. Whereas ineffective change agents advocate for single issues, effective change agents masterfully realign their energies to promote the most timely elements of the larger movement agenda. And whereas ineffective change agents tend toward absolute truths and rigid ideologies, effective change agents remain adaptive, and aware of the relative nature of truth and reality.

Though it could be said that earlier generations of designers and design leaders have too frequently fallen into the ineffective behaviors that Moyer has identified, a new generation of designers, with their appreciation for diversified methodologies, participatory design tools, and open source iteration, display a proclivity for the traits of effective change agents. They possess a high degree of flexibility and adaptability to any given situation, and an appreciation for the dangers inherent in getting comfortable with unchallenged habits and assumptions. Such evidence of self-awareness reflects the significant steps that have been made toward the realization of design's vaunted aspiration of serving humankind's fundamental needs.

This discussion takes on a different complexion when we consider what it means, not only to be a designer in the larger social arena, but to be a designer within the social arena of one's own discipline. How is the role of citizen played out in the company of other designers? Where lies the difference between an effective reformer in society, and an effective reformer within the discipline of design? Sustainability advocates can find disagreements with one another just as sure as they find disagreements with pollution-heavy industries or socially unjust corporations. A common ineffective behavior that still vexes the field of design, and exists within all four of Moyer's roles and therefore should not be surprising, is acting with a lack of appreciation for the importance of other roles. This is most commonly exhibited between Moyer's rebels and reformers, where ineffective reformers condemn rebels for 'rocking the boat,' while ineffective rebels label reformers as 'sell outs.' This is not to say that such behaviors are not real hazards for individuals in their respective roles – they are very real – just that it can be detrimental to a movement if judgments of such a stereotypical nature go unchallenged, or worse yet, are fostered by leadership. "In human affairs," Richard Farson states, "paradox is the rule, not the exception; therefore leadership is essentially the management of dilemma." So, while factioning can be expected in any discipline or movement, those interested in its strategic advancement must be more focused on leveraging the common ground than on turning a blind eye while factioning deflates the momentum for change.

Paradox exists within the sustainability movement just as sure as it exists beyond it. And empathy, a trait embraced by designers in sustainability and social innovation when it comes to working with 'co-producers' who would benefit from their efforts, must also be exercised in the interactions between members of the design community. Designers must understand these roles as independent elements within a larger toolkit, and consciously select the proper tool for the proper situation, even when the situation at hand involves engaging their colleagues.

15.5 Conclusion

Paul Hawkin identifies the nascent trends in restorative thinking as a social movement unlike any other, and likens them to an interconnected immune reaction. "The ultimate purpose of a global immune system is to identify what is not life affirming and to contain, neutralize, or eliminate it. Where communities, cultures, and ecosystems have been damaged, it seeks to prevent additional harm and then heal and restore the damage (pg 145)." If there does, in deed, exist a collective immune response to the unparalleled destruction of the Earth's capacity to perpetuate its life-giving properties, designers – complicit in this destruction throughout the modern era – must seek ways to align their core competencies with the advancement of this response.

The demonstrative capabilities of design, if calibrated for efficacy within our social spaces, can be undeniably powerful. Yet, as Richard Farson claims, designers must, "move beyond technique and expertise … summon courage to create … invade new territory … In that way they not only provide new models for the spread of design worldwide, but they raise our sights as a society, giving us a new vision of the possible (Farson, 2008)." Designers committed to social innovation and sustainability must consider what influence they will exert in this global shift in appreciation for the essence of human existence on our small planet as it grows increasingly crowded and compromised. And this requires a more conscious focus on matters of design leadership and over-arching frameworks.

Writer and activist Bill Moyer references the Greensboro Sit-in as a 'trigger event' in his book Doing Democracy, or an event that takes place in the midst of a larger societal shift that resonates with the general public in a powerful enough way to trigger a surge of interest in the issue; a combination of a new-found dissatisfaction with the old norms, and a corresponding willingness to consider the merits of alternatives. While Moyer witnesses such moments of upheaval through the lens of participatory democracy, environmental scientist Donella Meadows might have mapped an additional layer of insight over the historical event by identifying the leverage points that were activated by the seemingly simple act of sitting down in the wrong place at the right time. Regardless of the term we apply to define such moments, the moments themselves shift our perceptions of everyday life in a dramatic fashion. And they highlight the way in which certain widely accepted behaviors violate not only commonly held societal values, but the values that are espoused by institutions of power that are complicit in the legitimizing of those very behaviors. Yet, such dramatic moments cannot drive change on their own. Instead, they must be preceded and followed by myriad and often mundane moments of strategic planning and demonstration.

Ezio Manzini has encouraged 'design experts' in the social innovation sector to engage in four activities: shaping the public conversation through demonstrations and concepts; empowering existing examples of social innovation; providing a means for the growth and reproduction of new ideas; and promoting systemic change through strategic frameworks. This framing of design activities is constructive for any designer who falls under the sustainability rubric, not merely for those in social innovation. And it nests seamlessly into the change agent role defined by the Movement Action Plan, crafted by Moyer after spending decades in service to some of the more relevant social movements in modern Western history. Through the study, application, and creative adaptation of such frameworks, designers can meaningfully contribute to "… a new curriculum for humankind emerging," as an integral element in the global immune response to our presently unsustainable models.

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Arnold Tukker

16 Sustainable Consumption and Production, the SCP framework

"Is radical change to sustainability unpleasant? It does not seem so ..." Arnold Tukker

16.1 Introduction

James Gustave Speth (2008), former head of the United Nations Development Program (UNDP) and retired dean of the Yale School of Forestry and Environmental Studies, begins his widely acclaimed book *The Bridge at the Edge of the World* with a sobering summary of the current state of the environment:

"Half the world's tropical and temperate forests are now gone ... About half the wetlands and a third of the mangroves are gone ... An estimated 90 percent of the larger predator fish are gone, and 75 percent of the marine fisheries are now overfished or fished to capacity ... Species are disappearing at rates about a thousand times faster than normal ... Over half of the agricultural land in drier regions suffers from some degree of deterioration and desertification. Persistent toxic chemicals can now be found by the dozens in essentially each and everyone of us (p. 1)".

Speth provides just one of many recent warnings to declare that the economy as we know it is "crashing against the Earth" (cf. Rockström et al., 2009). The International Panel on Climate Change (IPCC, 2007) and Stern (2006) suggest that CO_2 concentrations in the

Type of resource	Fraction of global resource extraction	Basis for planetary limits	Potential limit	Reference
Fossil fuels	20%	Absolute scarcity CO2 emission targets	EU greenhouse gas (GHG) targets (20-20-20 or 30% reduction by 2020) Scientific targets (>80% reduction by 2050)	IPCC (2007), EC (2008, 2010), Meinshausen et al. (2009).
Biomass	30%	Maximum human appropriation of net primary production of biomass (HANPP)	Currently, 30%-35% of available biomass is extracted by humans. Target may be stabilization or minor growth	Vitousek et al. (1986), Haberl et al. (2007).
Metal ores and industrial minerals	10%	Absolute scarcity (varies by metal). Most metal ores need high levels of energy to be transformed, implying a 'linkage' to CO2 emission targets and energy constraints	Focus on 14 critical raw materials identified in the Raw Materials Initiative. Changes in energy and mobility infrastructure (solar cells, batteries) determine future criticality	EC (2010). For linkages with energy use, see Graedel and Van der Voet (2010).
Construction minerals	40%	Absolute scarcity seems irrelevant, except in densely populated areas where space for sand, clay and gravel mining is limited.	Implicit targets for construction minerals that need high levels of energy in their production (e.g., cement, ceramics)	
Land	p.m. (not expressed as mass)	Available bioproductive land, with reservations for nature areas (e.g., rainforests)	Conflicting information about remaining areas that can be converted to agricultural use	Erb et al. (2009), OECD/FAO (2009), Nature (2010a and b), WWF (2010).
Water	p.m. (usually not included in Material Flow Analysis)	Renewable supply (varies by region); agriculture is dominant user	A global 'water gap' of 30% expected in 2030,	Hoekstra and Chapagain (2007), Water resources group/ McKinsey (2009).

Table 1: Potential resource constraints

atmosphere should be limited to 450 ppm to avoid dangerous climate change and temperature rises above 20 C. Meinshausen et al. (2009) calculated that for this, total emissions between 2000 and 2050 should not be more than 1000 Gt CO_2. Their estimate of known emissions for 2000 to 2006 was already 243 Gt. Davis et al. (2010) showed that even if, overnight, we could magically invest only in carbon-neutral energy systems, mobility systems and infrastructure, just using the fossil-fuel power plants, cars, etc. available in 2010 until the end of their economic lives would use up most of the remaining emission budget (496 Gt up to 2060).

The Millennium Ecosystem Assessment (MEA) suggests that irreversible damage to ecosystems has already taken place, that biodiversity is diminishing at an unprecedented rate, and that certain natural systems already face collapse (most notably fish stocks: Mooney et al., 2005). Other potential limits are related to water use (Young, 2011) and net primary production of biomass (Vitousek et al, 1986; Haberl et al., 2002, 2007). Table 1 gives an indicative list of such potential limits, related mainly to resource extraction and resource use.

These types of limits are already becoming apparent in a world with an economic system representing a gross domestic product (GDP) of about US$50 trillion in 2005 (e.g. OECD, 2008). Authoritative forecasts such as the OECD Environmental Outlook expect a quadrupling of GDP by 2050 (OECD, 2011), whereas it can also be calculated that such rises in GDP are needed if one wants to eradicate poverty on Earth by 2050, without reducing income (growth) in the existing rich countries and fast growing economies (Tukker, 2013).

It is pretty obvious that a quadrupling of the economy in combination with a need for stabilizing or reduction of environmental impacts is extremely challenging. For instance, tackling the climate change challenge would require absolute reductions of CO_2 by 50%-80% by 2050, compared to 2000 (IPCC, 2007, Stern, 2006), implying a factor 8 to 20 reduction of CO_2 intensity per Euro or Dollar production by 2050.

Such changes are major and cannot be realized by a slow change to sustainability. Our production-consumption systems need to be (re-)designed. This chapter addresses this topic. We first discuss priority areas for change and strategies for change (section 2), after which some deliberations on policy approaches are given (section 3) and conclusions are drawn (section 4).

16.2 Strategies for change to sustainable consumption and production

16.2.1 Priority consumption and production areas

A first important step in moving toward SCP is to identify the priority areas to which policy attention should be devoted. Over the past decade, a series of comprehensive studies and related reviews have investigated the lifecycle environmental impacts of final consumption expenditures in several countries including Belgium, Norway, the Netherlands, the EU25 countries, and the United States (Suh 2004; Hertwich 2005; Weidema et al. 2005; Tukker 2006; Tukker et al. 2006; Moll et al. 2008).

The studies cited used very different approaches. Researchers focused on different geographical areas ranging from the local to the global, different pollutants and resources, and various product clusters. They used fundamentally different data-inventory methods (i.e., bottom-up LCA or top-down IOA) and used a range of different indicators to measure impacts. Despite these variations and inevitable shortcomings, the main findings of this work are clear and consistent. Table 2 reviews the findings for energy-related impacts. The following COICOP (CP)[1] domains account for 70 to 80% of the lifecycle environmental impacts in industrialized countries and thus should arguably be the focus of policy interventions

- CP01 and 02: Food (meat and dairy followed by the other foodstuffs);
- CP04: Home building and demolition including heating and water use in the use stage;
- CP05: The use of energy-using products (EuPs) in the home;
- CP07: Mobility (automobile and air transport, including holiday travel);

The conclusion is unambiguous. If priorities (from an environmental perspective) have to be set, SCP programs should focus on mobility (including tourism), food, housing, and energy-using products.

1 COIOP is a classification system of consumption expenditure worked out by a United Nations working group that is used by most national statistical bureaus to report on consumer expenditures.

16.2.2 Strategies for change

More sustainable patterns of consumption and production can be realized through various interventions in the economic system. Figure 1 classifies these different leverage points by following a typical product-consumption chain from resource extraction to final consumption (Tukker and Tischner, 2006).

These strategies comprise:

- *Greening production* by reducing the impact intensity of mining and manufacturing activities through the implementation of end-of-pipe measures or structural technical changes in production methods. This is the area of cleaner production which tries to make production processes more sustainable by more resource-efficiency and less emitting technologies. Typically, such approaches may reduce impacts by various degrees of percentage – but in case of radical technical innovations, such as a transformation of the existing carbon-based energy system to a system based on renewables, this can lead to radical impact reductions ('Factor X').
- *Greening products and services* by decreasing material and energy use per functional unit. This is the domain of eco-design. Experience shows that usually products can be designed in a more sustainable way. They can be made lighter. They can be designed so that they use abundant or environmental friendly instead of scarce or high impact materials. They can be designed to use less energy in the use phase. It may be possible to eliminate toxic contents. Products can also be designed in such a way that they are easier to recycle. Like is the case for cleaner production, also here incremental changes are possible, such as a car design that incrementally reduces energy use, or more radical improvements, such as 'hyper-

COICOP	Study	% of total expenditure in EU25 (Tukker et al, 2006)	Collins et al.(2006)	Dall et al. (2002)	Labouze et al. (2002)	Moll et al. (2005)	Jansen and Thollier (2006)	Nijdam and Wilting (2005)	Palm et al. (2006)	Peters and Hertwich (2006)	Huppes et al. (2006)
	Geographical focus	EU25	Cardiff	Denmark	EU15	Germany	Belgium	Netherlands	Sweden	Norway	EU25
	Indicator		Footprint	Energy	GWP	Energy	GWP	GWP	CO_2	CO_2	GWP
	Main approach		Top-down/ hybrid	Bottom-up	Bottom-up	Top-down	Bottom-up	Top-down	Top-down	Top-down	Top-down
CP01-02	Food	19.3%	20,6%	26.2%	7.0%**	13.0%	3.6%**	22.1%	7,7%	12,2%	31.0%
CP03	Clothing	3.1%	0.8%	1.3%	3.3%	2.2%	1.3%	6.5%	0,7%	10,3%	2.4%
CP04-05	Housing	25.1%	30.2%	40.8%	58.8%	54.3%	53.5%	33.4%	29,1%	23,0%	23.6%
CP06	Health	3.9%	0.3%	n/a	n/a	1.8%	0.3%	0.3%	1,0%	1,1%	1.6%
CP07	Transport	14.1%	21,9%	19.5%	29.6%	18.3%	32.9%	17.3%	15,5%	35,9%	18.5%
CP08	Communication	4.0%	0.5%	n/a	0.0%	n/a	2.9%	0.0%	1,7%	2,1%	2.1%
CP09	Recreation	9.1%	10,2%	7.2%	0.0%	8.1%	n/a	15.1%	0,5%	0,5%	6.0%
CP10	Education	1.4%	0.4%	n/a	n/a	1.8%	n/a	0.7%	0,3%	0,1%	0.5%
CP11	Restaurants	9.6%	10.8%	n/a	n/a	n/a	n/a	2.8%	1,8%	1,3%	9.1%
CP12	Miscellaneous	10.3%	4.4%	5.1%	1.3%	0.4%	5.4%	1.8%	6,6%	13,1%	5.2%
Other	Refined petroleum products / Direct household energy*								35,0%		
	TOTAL	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 2: Contribution per COICOP category to energy-related impact indicators in different studies (Tukker et al. 2006)

* Palm and colleagues (2006) reported energy use by households as a separate category. To be distributed over housing and transport

** Jansen and Thollier (2006) did not include food in their study; this value is related to packaging for food. Labouze and colleagues (2003) under-addressed food for a variety of reasons in their work.

n/a: not visible as a specific category in the underlying study.

cars' that use just a few liters per 100 km (von Weizsäcker, 1997).

› *Intensifying use* by encouraging more efficient deployment of products and services This is the domain of sustainable product-service design or sustainable product-service business development (Tukker and Tischner, 2006). Examples include replacing products by use-oriented services (such as cars by car pooling and -sharing systems) and result-oriented services, where a provider does not sell a product at all, but simply provides the service, performance or function. An example are Energy Saving Companies (ESCOs) that do not sell gas or electricity, but ensure that e.g. in an office ambient temperature is comfortable and desks get enough light. This incentivises such companies to reduce energy and electricity use, since this is now a cost factor. Experience with such product service development shows that typically a factor 2 reduction in impacts is possible.

› *Greening consumption patterns* by shifting expenditures to lower-impact product and service alternatives. This is the domain of sustainable consumption. However in a society where the concepts of free markets and consumer sovereignty reign supreme, it is difficult for governments to embark on such policies. We see hence mainly awareness raising campaigns and softer, 'nudging' approaches where consumers tacitly are compelled to consumer more sustainably. We have calculated that the potential impact reduction by just changing consumption expenditure probably limited to a factor 2, since it appears that impacts per Euro of many products vary just various factors. It is hence also important to mobilise consumer pressure that helps to improve environmental performance of products and processes.

› *Reducing consumption volumes* while maintaining quality of life. This is the area of degrowth. It goes well beyond classical sustainability policies, but evidence suggests that despite massive economic growth in the last 30 years, in most western countries the experienced life satisfaction, or quality of life, did not rise (Veenhoven, undated; Shah and Marks, 2004; Layard, 2005; compare Figure 2). It is not a simplistic plea to justify low levels of income since even then life could still be pleasant. It is the contrary: the research cited poses the question: Do current approaches to economic development destroy the (in)formal institutions, non-market goods and services, and social fabric that may be essential for experienced quality of life? By better understanding what really matters in life, we should be able to design an economic system that can provide a much lower ecological footprint than today.

16.2.3 Is radical change to sustainability unpleasant? It does not seem so ...

A society that applies all these approaches in a smart way is in principle capable of realising drastic reductions of impacts and is probably not at all unpleasant or poor. The report underlying Figure 2.1 shows for instance that happiness multiplied by life expectancy in the richest country in the world, the US, is not the highest (indeed, people in a relatively low income country like Cuba live longer). Life in a country that would pursue all these principles may probably be sketched

Production side **Eco-efficiency strategies**				**Consumption side** **Sufficiency strategies**
Mining and Production	Products and services		Consumption	
	Design of products	Use of products	Expenditure mix	Quality of life realised
New tech-nology and end of pipe	Greening products	Intensifying use by sharing, leasing	Spending money on low-impact activities	Improving quality of life without spending money
20-50% **Factor X**	**20-50%** **Factor x**	**Factor 2**	**Factor 2**	**Factor 2-4**

Table 3: Intervention points to realize sustainable consumption and production patterns and typical reduction of impacts per strategy

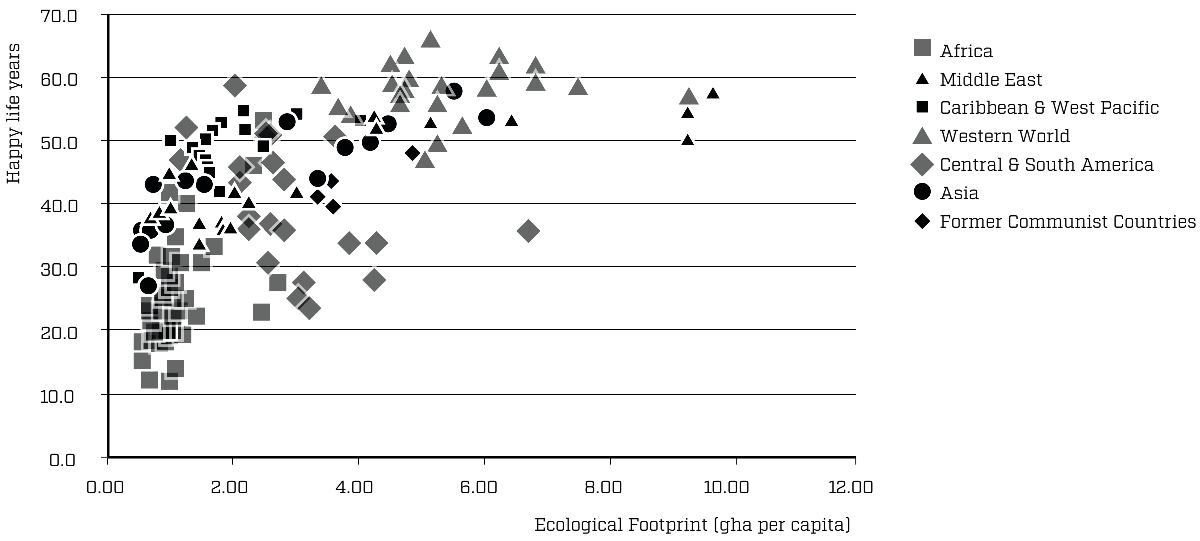

Figure 2: Happy life years versus the ecological footprint for 178 countries (from: Marks et al., 2006: 17)

as follows (cf. Lovins et al, 1997; Pauli, 2010; Jackson, 2009):

› It would see the economic system as a means to an end, rather than pursuing growth per se. The goal would be to pursue quality of life and harmony for its inhabitants, and there would be a well-developed feeling of what to pursue in life beyond materialism. The financial system would be designed to serve the development of the real, physical economy, rather than to serve financial interests in itself.
› It would probably prevent extreme differences in income, or at least ensure a minimum income that avoids extreme poverty.
› It would use the potential of green technologies in production and eco-design of products to the fullest.
› In the area of shelter and living, it would embark on a program that ensures the highest level of energy efficiency for houses, offices, and appliances – how to construct buildings that use no energy has been known for decades;
› In the area of food, it would stimulate to be modest with high impact foodstuff such as meat and dairy, stimulate eating in season food, and avoid air shipped food;
› In the area of mobility, it would try to reduce mobility needs by smart spatial planning and building compact cities, and stimulate the use of (electric) bikes, public transport, and other low energy transport means rather than car transport.

16.3 Framework for change to sustainable consumption and production

16.3.1 Policy approaches for changes towards SCP

Already at the 1992 Earth Summit in Rio de Janeiro, national governments recognized that the problems inherent in contemporary modes of consumption and production, in particular the prevalent systems in place in the industrialized countries, impose the greatest burdens on the Earth's capacity to satisfy human needs and desires (UN DESA, 1992). Broad agreement on this point led to an appeal for more sustainable patterns of consumption and production as part of Agenda 21 and this commitment was reaffirmed at the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. At the latter event, delegates called upon the United Nations Environment Program (UNEP) (in collaboration with the United Nations Department of Economic and Social Affairs) to formulate a "ten-year framework of programs on Sustainable Consumption and Production (SCP)" as part of the Johannesburg Plan of Implementation (UN DESA, 2002). After a process that took 10 years, ultimately at the Rio+20 conference in 2012, a structure for this ten year framework was adopted.

In this period, SCP action plans for Africa and Europe (African Experts Meeting 2005; European Commission 2008) were developed, as were various national strategy documents (e.g., UK DEFRA 2003; Finnish Ministry of the Environment 2005; German Federal Environment Agency 2007). Some typical policy approaches and recommendations are summarized in Box 1.

This article is not the place for a comprehensive review of SCP policy history (see e.g., Fuchs and Lorek 2005; de Wit 2006; Cohen 2010). But it is widely felt that the rate of progress with respect to implementation has invariably been incremental, and this slow pace is at odds with the ambitious changes that many scientific organizations, secondary policy-making bodies, and non-governmental organizations (NGOs) contend is needed (Royal Society and US NAS 1997; OECD, 1997; Marks et al., 2006).

An obvious question now is: if section 2 suggests that there are ways to make the economy sustainable, why doesn't this happen? The next section therefore discusses in short system innovation and transition theories that help to explain the factors helping and hindering major societal change.

Some policy approaches supporting SCP

Changes to SCP can be supported by various policies. Usually policy mixes are more effective as individual instruments, since different interventions at different points in the value chain can be mutually reinforcing (see figure B1.1). Instruments that got specific attention in the context of the UN Ten Year Framework on SCP include Sustainable Public Procurement and Consumer information. The EU has deployed product related policy instruments such as the Ecodesign Directive, Ecolabelling, and others.

Furthermore, it has to acknowledge that consumers are confronted with markets populated by products of which some already score well, and others score badly, on an environmental aspect (see figure B1.2). This gives the opportunity to create synergies between instruments (compare Sorrell (2001), Hood (2011) and OECD (2007))

- Use mandatory administrative instruments to set a threshold for minimum performance of products.
- Use voluntary initiatives, labels, green public procurement (GPP), informative campaigns and pricing mechanisms to reward products that go (well) beyond compliance.
- Use R&D support to encourage new, breakthrough sustainable products not yet available on the market.

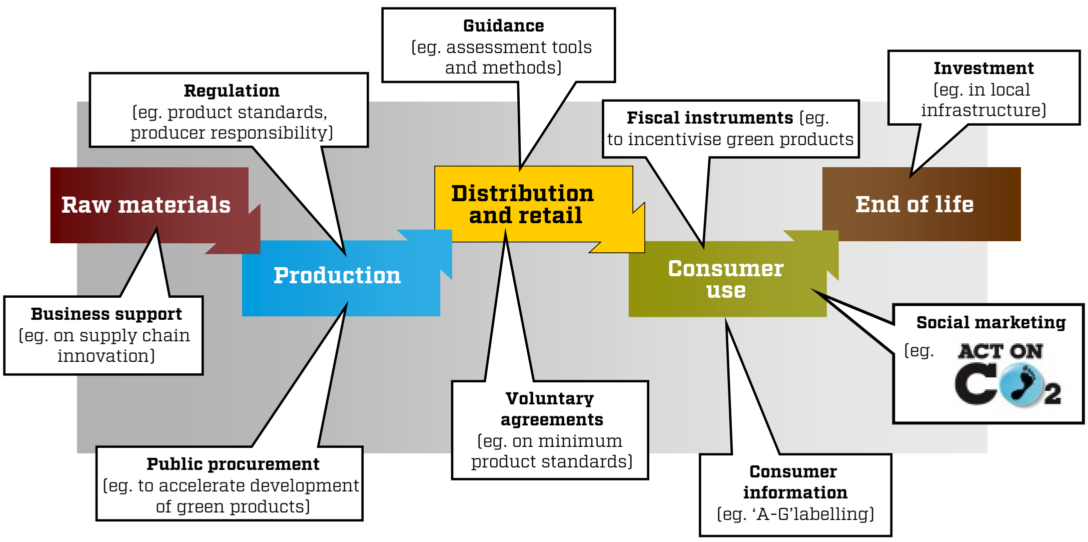

Figure B1.1: Using a mix of policy instruments to change impacts of products at key life cycle stages (from a presentation by Bob Ryder, DEFRA, Prague, October 2008)

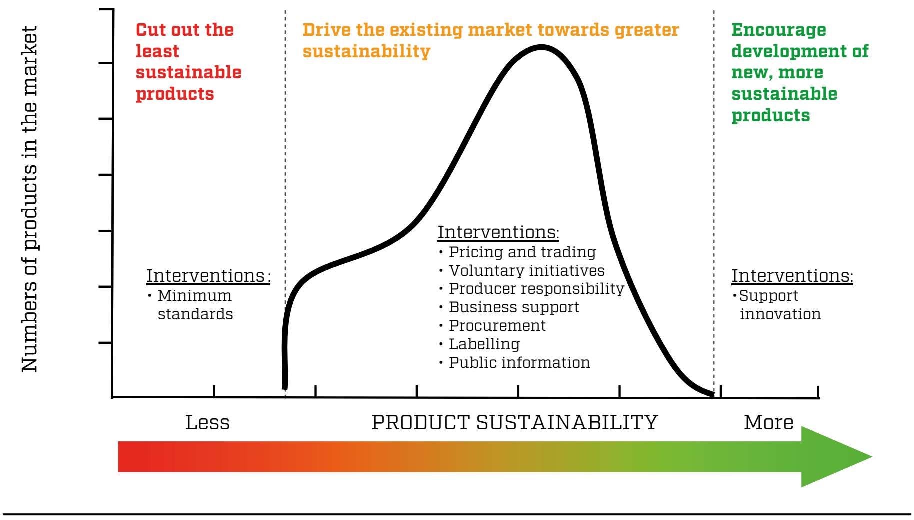

Figure B1.2: Push and pull interventions addressing the full pool of products in a specific market with different sustainability performance (from a presentation of Bob Ryder, DEFRA, Prague, October 2008)

16.3.2 Change to SCP as a systemic challenge

As shown by the authors of this chapter and this edited book, changes towards SCP can probably best be interpreted as "sustainability transitions" or "system innovations" (Tukker et al., 2008; Grin et al., 2009). Such perspectives try to analyse change from a systemic perspective. The conceptual approaches used in this work include actor-network theory (ANT) (Latour, 1987; Callon, 1998), innovation system theories (Tukker, 2005; Andersen, 2008), evolutionary economics (Nelson & Winter 1982; Mulder & van den Bergh, 2001), complex system theories (Meadows, 1999; Kemp et al. 2007; Loorbach & Rotmans 2009), and practice theory (e.g. Shove, 2003). Below we show the theoretical perspective developed in the SCORE! project (Tukker et al., 2008), combining the multi-level perspective from system innovation theory with the production-consumption value chain. There are obviously various interventions and innovations possible along specific positions of the production-consumption value chain, but they tend to be incremental:

› On the production side, that business can contribute significantly to sustainable innovations via a variety of mechanisms: end of pipe, cleaner production, ecodesign etc. Particularly if such innovations contribute to long-term continuity or form in another way a win-win, businesses will have a clear driver to pursue them. On the other hand, businesses can only partially influence the system they are part of and have to obey business fundamentals and the prevailing paradigm of economic growth. This often leads to preferences for incremental changes. It further leads to as such logical but from a sustainability viewpoint less desirable behavior like externalizing costs, bringing hitherto free goods in the market economy, and enlarging the aspiration gap to sell consumers more products and services.
› On the consumption side, consumers in principle can drive change via voting power on the market, and in their role as political agent, worker and citizen, capable of bottom-up action. But at the same time consumers may also find that sustainable choices not always lead to the same quality or level of experience as less sustainable choices. Practice theory shows that consumers often are locked in contexts that make certain behavioral changes difficult (Shove, 2003). So, also here we see that bottom-up or micro-action has to be followed by macro-action to realize lasting implementation of more far-reaching and radical sustainable innovations.
› With a lack of support from business and consumers, governments – who depend on support of the former – are unlikely to design

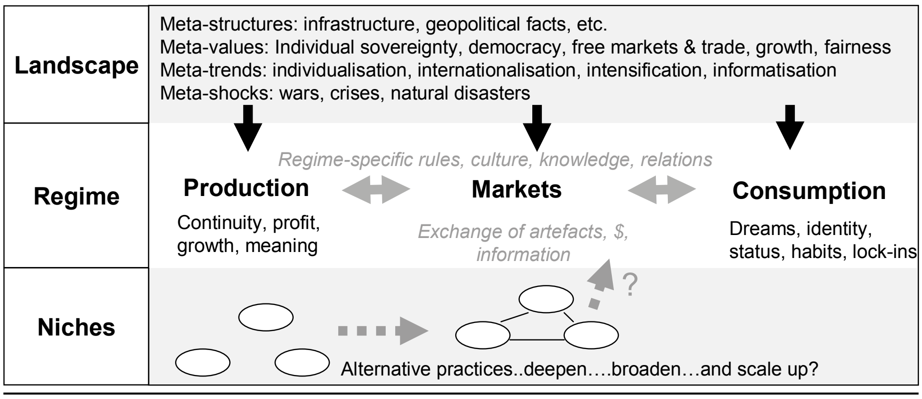

Figure 3: The production-consumption regime embedded in a landscape context and with competing (niche) practices

policies stimulating far-reaching change on their own.

› The points above make clear why a more overarching systemic view on innovation is hence essential to understand particularly the more radical changes to sustainability. System innovation scholars like Geels (2005) make an analytical distinction between three levels:
  › A macro- or landscape level, which is to be taken for granted on short- and medium term. It poses boundary conditions for the next lower level (the regime) to evolve, and is hence normally a source of stability (with the exceptions when disruptive shocks at this level occur, such as wars and natural disasters)
  › A regime level. The regime itself is an interdependent and co-evolving set of technologies, symbolic meanings, services, consumer practices, rules, financial relations and expectations. It is difficult to change one part without the rest. This dynamic equilibrium changes usually only incrementally. A simple example: you cannot put a hydrogen car on the road without hydrogen gas stations, new safety rules, maybe even new driving license standards, etc.
  › Niches, where groups can try out new consumption and production practices. It is however often difficult for niches to become mainstream, due to the stabilizing effects at regime and landscape level.

The implication is that many sustainable innovations are of an incremental nature. System innovation theory suggests that radical change can take place under the following conditions. First, niches should be available that have matured (deepened) and got connected (broadened). Second, there should be tensions in the regime, or a misalignment between regime and landscape. Then, the pressure on the regime may become so high that rapid change may become possible (niches 'scaling up'). The regime breaks down, and niches plus the remnants of the existing regime will develop new structures, which eventually will stabilise and form a new regime (cf. Geels, 2005; Kemp and van den Bosch, 2006).

16.3.3 Implications for supporting radical change to SCP

The fact that issues are controversial does not mean, though, that policy makers should set them aside. There are at least three types of activities that can help to prepare the ground for more radical measures and agenda's with regard to SCP (e.g. EEB, 2009). These include:

1. Developing inspiring, bottom-up examples of radical change to SCP
2. Developing and credible evidence of systemic sustainability problems, and how consumption and production systems can be organized more efficiently in providing quality of life.
3. Organising a process of deliberation and agenda setting that develops and disseminates novel thinking.

Currently, such activities are mainly bottom-up organized by advocacy groups, alternative scientific think tanks or other 'mavericks'. The UK think tank new economics foundation promotes new metrics for economic progress (e.g. Marks, 2006). The US Centre for a New American Dream, an NGO, promotes radically different life styles, based on quality and slowness[2]. The Sustainable Everyday project initiated by Ezio Manzini and Francois Jégou has collected various dozen inspiring cases of local citizen groups, that have developed alternative, sustainable practices in areas like food consumption, mobility and living (e.g. car sharing systems, joint purchasing schemes for organic food, etc.). This all is presented on an open web platform for discussing sustainable futures[3]. The WWF has developed a 'One planet living' campaign, highlighting examples of sustainable living such as BedZED, a climate neutral residential area near London developed by the entrepreneurial charity Bioregional[4]. Even individuals can make a difference. Steven Vromman, a Belgian, set out with his family to live during one year using only the maximum 'ecological footprint' available per world citizen. Labelling himself as the 'Low impact man', he sought and got a lot of media attention, inspiring others to think differently in the process[5]. The International Society for Ecological Economics endorses thinking on 'de-growth'[6]. There is however no reason why formal institutions should shy away from supporting such activities. With EU support various very successful conferences were organized on e.g. topics like 'Beyond GDP'[7].

In line with what has been addressed in the former section, one probably cannot force the moment of shifting paradigms and regimes. Yet, governments and other actors could embark on the type of activities indicated above, which consist of a mix of bottom-up, mind changing action, supported by enabling activities, until a window of opportunity arrives that allows for more traditional top-down steering towards the desired transition.

2 http://www.newdream.org/, accessed 30 December 2008
3 http://www.sustainable-everyday.net/SEPhome/home.html#scenarios accessed 30 December 2008
4 http://www.oneplanetliving.org/index.html
5 http://lowimpactman.wordpress.com/
6 http://www.degrowth.net/, accessed 30 December 2008
7 http://www.beyond-gdp.eu/, accessed 30 December 2008

16.4 Conclusions

To conclude, there is a need for radical changes towards SCP. The economy still has to grow significantly to eradicate poverty whilst at the same time significant reductions in impacts are needed, particularly in the field of climate change. A combination of cleaner production, ecodesign, shifts to product-service systems, sustainable consumption, and 'de-growth' (improving quality of life without material growth) could achieve this. However, experience shows that all formal policies with regard to SCP developed since the Rio conference of 1992 have been rather incremental. Policies tend to be regime compliant, do not fundamentally touch the consumer, and frame the debate in terms of realising resource-efficiency, improving products and production, and making markets greener. The fundamental issue of changing patterns of consumption and production is not addressed.

One realistically cannot expect any government, let alone international policy circuits, to go so far that such fundamental issues are taken up effectively. We live in a society that is driven by consumerism, growth, free markets, and free consumer choice. Across the world, citizens in their role of consumers appreciate more wealth, and particularly in developing countries this is probably a rightful desire. Businesses still tend to embark on growth targets, and in any case do not see it as their role to intervene with consumption levels, and in most cases also not with consumption patterns. As a result, governments (and the even less powerful International Governmental Organisations) cannot be expected to have appetite to embark on a strong SCP policy: they are not legitimized and sometimes opposed by their voters, industry lobby groups, or governments of other countries in international negotiations. Sure, bottom-up action has provided the world with interesting examples of how SCP systems could look like, but usually such examples are confined to niches. Actors pursuing radical changes hence have to bet on organising learning strategies, and have to embark on paradigm challenging activities: providing evidence that certain patterns of consumption and production cannot be sustained, showing shining examples of alternative patterns, and providing a deliberative platform where this debate can take place.

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Cameron Tonkinwise

17 Radical Sustainable Innovation

"There seems to be only one cause behind all forms of social misery: bigness. Oversimplified as this may seem, we shall find the idea more easily acceptable if we consider that bigness, or oversize, is really much more than just a social problem. It appears to be the one and only problem permeating all creation. Whenever something is wrong, something is too big."
Leopold Kohr, The Breakdown of Nations (1957)

17.1 Introduction

The unsustainability of our societies is a big problem. To some extent, it is a problem of bigness. Our societies are unsustainable because they are too big: they require too much stuff to be moving too far, too fast.

Unsustainability is also a big problem because it seems so difficult to work out how we could possibly get our societies to use less, more slowly. It is difficult not just because the problem exists on such a large scale, but also because the problem seems so ingrained.

On the one hand, the problem is ingrained because it is the outcome of big systems – for instance, consumer capitalism, growth-based economic modernization, fossil-fuel dependent suburban planning, etc. – systems that have been in operation fairly unchallenged for around a century. As is often remarked, this means that the project of enhancing societal sustainability is like trying to mid-course correct a super-tanker – it takes enormous force and a long time to slow, let alone turn such a vast thing with so much momentum (Anderson, 1999; Braungart & McDonough, 2002).

On the other hand, the problem is ingrained because it manifests at a small-scale, in the semi-conscious everyday activities of billions of households and workplaces around the world. Developing more sustainable societies is not just something that can happen through a few top-down decisions. It is something that will involve changes to nearly every thing every one of us does each day: what we have for breakfast and how it got into our homes, how we clean our teeth and where our waste water goes, what we wear and how we care for our clothes, where we need to go to work and how, how those work environments are heated and/or cooled and lit, etc. The bigness of unsustainability comes from how many small things are going to need to change.

So, tackling unsustainability requires big thinking, or thinking bigger. Designers are forever being told that sustainability demands start to expand the scope of any particular design problem they are working on: that they better understand where all their working materials come from and will end up going; that they question the short-term business models of their clients and the expectations and habits of customers; that they take more responsibility for redirecting the supertanker filled with billions of everyday household activities. Designers, in order to play a leading role in remaking our societies more sustainable, need to become much more radical in the scale of their ambitions.

The problem is that knowledge, in particular quantities, sometimes seems to be paralyzing: you need to know more about the nature of the problem of unsustainability, all its dimensions and complexities; but the more you know, the more you realize how inadequate each potential move you might make toward increased sustainability seems to be. Designers concerned about sustainability are often frustrated by this cycle of research and impotence. Frustrated by realizing how radical change needs to be at the same moment as realizing how unradical their options are.

However, designers are, to my mind, often not very good at thinking big. Designing well usually does not require being very systematic or expansive. It requires care, an almost fanatical attention to crafting materials and components, for instance; but that kind of systematic work normally only occurs in very focused ways, at the level of detailing. And it does require being lateral and fitting new ideas into complex adjacencies; but again, as noted in a frequently cited Eero Saarinen quotation, the designer's job is only to design something with reference to the next bigger context (Serriano, 2005) – not to design every thing with reference to all the other higher systems. Good design seems to be an oscillation between the meso and the micro, and not really something that happens in terms of the macro. And I want to argue that this is ok. Being a radical sustainable designer, with a view to confronting the bigness of unsustainability, can, and must in fact, happen in that oscillation, between meso and micro. Radical redesigns of our societies toward more sustainable futures can, and can only, come from working at multiple levels. Because sustainability is such a big thing, it is precisely not something that can be accomplished through one big move coming from one hugely complete picture of our current unsustainability. Nor is it something that can be accomplished by concentrating on one particular strategy even over a long time. Sustainable design is a diversified project. There is no trick to massive change. Radicality lies only in persistently multiplied changes.

The easiest way to access this kind of radicality is for designers to never work alone. Designing has always been a collective exercise – involving negotiations with clients and customers, suppliers and manufacturers, and so marketers and anthropologists, engineers and managers, etc. – but only recently have designers been invited to be part of wider interdisciplinary initiatives. Often under the guise of 'design thinking' designers are increasingly present in interdisciplinary attempts at tackling complex and wicked problems for two key, though somewhat opposing, traits.

The first could be called Solutionism (Morozov, 2013). This is in fact a disparaging term; efforts at presenting politically fraught social problems as quickly solvable by apolitical technologically-focused innovations, often crowd-sourced – hackathons for example – are accused of Solutionism, an excessive focus on quick fixes that tends to drown out more considered critical evaluations of a situation. Nevertheless, it is true that the first tendency of designers is to leap in and start proposing interventions into a situation – they do tend to be 'solution-oriented.' Sometimes these are more a way of learning about the context, seeing how it responds to this or that quick-and-dirty, low-fi prototype, but they can also be useful propositions whose creativity comes from the willingness of the designer to try anything at first.

The second trait is however Reframing. Whilst designers are fast at making pragmatic propositions to gauge a situation, they are also known for being reflective practitioners. They make moves, but then critically examine whether the move is productive or insightful. To do so requires having an emerging sense of what would count as a desirable response to the situation. In other words, designers engage in a process that co-evolves the problem and the solution: making a propositional move might solve one aspect of the problem, but will also reveal another that was not in the initial framing (Dorst & Cross, 2001). The way the situation is understood will need to change from the perspective of what is not yet adequate about a particular proposition. So designers are not, in the normal course of designing, systems thinkers, systematically identifying all the components and relations of a situation so as to identify beforehand and from the outside what is to be done. But nor are they just trial-and-error interveners. Designers have more-or-less explicit ways of approaching situations, frames, which they test by making solutionist moves.

To start getting at what radical sustainable design involves, it is important to look at the sort of frames that designers tend to bring to their search for sustainable solutions. One way to do this is to ask: behind the specific sustainable design you are espousing, what is the 'theory of change' you are assuming?

A very schematic typology of these 'theories of change' in the background of much sustainable designing might be:

		PRIORITY	
		Design	Research
TEMPORALITY	Cumulative	2. Make it easier (cheaper, sexier)	1. Get it eco-right
	Sudden	3. Break-through innovation	4. Mindset conversion

The columns refer to whether change toward more sustainable futures is believed to come from design as a kind of creative thinking (left column) or from more comprehensive research that rigorously briefs design (right column). The rows refer to whether the radical change is considered to be something that will happen over some time as a result of numerous initiatives building on each other (top row) or something that will happen faster, more like a gestalt switch of paradigm shift (bottom row). Let me explain.

17.2 Get it Eco-Right

Let's start with the top right. Anyone serious about sustainable design will begin the task of trying to ascertain which designs are more sustainable. The task of the sustainable designer, according to this approach, is to deploy their systems thinking in relation to our material culture to identify, creatively, but positivistically – that is, in terms of scientific, evidence-based methods – the most sustainable ways forward.

This is however a very complicated endeavor, with no clear stopping point. When designers begin doing this kind of research, the first effect is the realization of how much more research is necessary. At these early stages, the assumption is that there is a definitive answer, if only our systems of analysis were comprehensive enough. For practical purposes however, Life Cycle Assessments for example, must set boundaries for their analyses, even though the first principle is the interconnectedness of materials and processes over space and time. As a result, that boundary setting is always pre-scientific, the result of values. For example, when calculating the amount of energy it takes to make a product, it is normally decided that this does not include the energy involved in the workers at the factory – their food at work, the clothes they wear at work, or their transport to work, let alone energy used at their houses where they replenish for the next day's work.

This is no longer just the situation with Life Cycle Assessments; our approaches to sustainability more generally are also maturing beyond the hope that there are simply factual determinations to be made. Ecologists now believe that ecosystems before or outside human participation are not in a state of harmonious balance, but dynamic flux, with population booms and crashes, mass migrations and transitions to entirely different systems (Botkin, 1990). Sustainability is therefore a choice to maintain one particular kind of ecosystem. It is a valuing of specific ensembles of species in certain kinds of relations. There is no definitive answer as to which ecosystem we should be valuing; and certainly hoping for a version of 'nature' unimpacted by human manufacturing is futile (Latour, 2009; McKibben, 1989).

And if we managed to come to some consensus about which ecosystems we wish to sustain, the ability of that system to sustain its current configuration would remain probabilistic. Sustainability is an evaluation of risks, a measure of the capacity of a system to respond to a series of more or less likely impacts, precisely something that cannot be articulated definitively (Beck, 1995). The sustainability of an ecosystem, especially one subject to complex interactions with our industrial systems, is not a fact that we can know; it is at best a process filled with changing risks that we can only sense as they happen.

The assumption of the designer working in this top right quadrant is that knowledge has inherent agency, even if cumulatively over the long term. As people get to know what is the most sustainable option, they will take it – whether 'people' here refer to consumers staring at supermarket shelves, or executives making decisions about manufacturing options, or governments setting regulatory standards for manufacturers. If all these agents are unsustainable at the moment, it must be, it is assumed, because they are ignorant of how unsustainable they are and of how much more sustainable they could be.

There are many problems with this. It is now very apparent that merely announcing what is right does not guarantee that it will be heard. Those who stand to be disenfranchised by that information are actively censoring and/or discrediting it. (I am referring to, for example, Big Oil corporations who sponsor doubt mongering in relation to climate change science.) People who are convinced by certain worldviews have cognitive biases that allow them to ignore or dispute those messages.

And then the whole of project of sustainability is now well-aware of the knowledge-action gap – that, contrary to models of rationally planned actions, people can know what it is they should be doing and yet still not do it. Often they are not able to do it, and consequently feel frustrated or guilty; but even when they can, there are many reasons why in the end they do not – many reasonable reasons, not just irrational ones.

This is exacerbated when it is admitted that sustainability is not a definitive phenomenon, but an evaluation of probability, one framed unavoidably by political values.

Take for instance claims about the finiteness of resources. It seems indisputable that our planet has a limited supply of resources that cannot sustain unlimited growth, especially given the second law of thermodynamics. But what is at issue is when supply issues will actually begin to impact us, and how. This of course depends on a complex set of interrelations between economics, innovation and global relations. Scarcity is often manufactured before it is ever real. So limits that seem factually determinable are in fact politically variable risks. As a result, a phenomenon that seems to clearly demand radical action peters out as a motivator.

To recover the force of knowledge about sustainability requires participation in the development of that knowledge. The Post Normal Science movement, as well as others negotiating responses to the reflexive modernization of the risk society (Beck, 1994), insist on the inclusion of non-scientists in the process of establishing scientific knowledge and its implications (Funtowicz & Ravetz, 1992). 'Radical' ideas like 'lay peer review' and 'citizen science' are necessary not only to hasten the dissemination of knowledge about sustainability (by ensuring that its production is from the outset catering to non-experts), but to foreground the mix of fact and value that is unavoidable for any scientific undertaking. The same now goes for designers.

Let me give an example. In Life Cycle Assessments, the use phase is often a crucial variable: a car that is driven hard and not maintained will have a very different eco-impact profile from one driven carefully and well-maintained; how a garment is laundered, and in particular, how often, can radically change the eco-impact profile of a fashion item. Life Cycle Assessments must normalize all these use variables to do their calculations; but it is the designer's job to be ambitiously creative about use phases, about the extent to which people could be helped, through design, to tip a Life Cycle Assessment in the opposite direction. Designers must therefore not only know how the 'scientific' evaluations are being conducted, but must be involved in them.

Of course, often experts who develop a personal knowledge of what they consider to be sustainable know that knowledge is not inherently efficacious. In those situations, experts use their authority to give that knowledge regulative force. If politicians cannot be convinced to enact radical legislation on behalf of more sustainable futures, designers can lend 'artifact politics' to the task. Jaap Jelsma has usefully characterized the options available for 'delegating morality to things,' (to paraphrase Bruno Latour); from using affordances to make sustainable behaviors more likely, to using scripts to foreclose on unsustainable behaviors (Jelsma, 2006). Since his writing, a space between legislation and design has opened in the form of 'nudging,' that is, deploying 'choice architecture.'

Again, there are problems that limit this pathway to radical societal change. Getting a design to embody a knowledge of preferred sustainable ways of living and working is one thing; getting a sponsor to produce and sell that design is another. That alliance building is no less a political act. And as is often pointed out, designers are only rhetorical; their suggestions can always be worked-around or hacked or refused. In the US at the moment, a substantial number of seemingly common sense sustainable designs are being repoliticized and resisted: incandescent bulbs, water efficient toilets, smart meters, etc.

As a result, the same prescription as for knowledge applies to this attempt to materialize the agency of that knowledge: participation is required; people must consent to being acted upon by things in full understanding of why it is valuable.

17.3 Make it Easier (Cheaper, Sexier)

In the top left are designers who believe that with whatever it is that is considered sustainable – and often it is assumed by these designers that this is easy to know – the real trick is to get people to buy/use it. Eco-products and services to date are either too expensive, in terms of money and/or time, or are of an aesthetic that cannot compete with more unsustainable designer-ware. The designer who can recast environmentally friendly products and services as simpler options, or, in cases where more effort is unavoidable, value-add in other ways to make up the difference, will tip the system in favor of more sustainable futures.

What assumptions underlie why this might be a way to cause radical change (in the end)? One assumption is that we humans are in essence the way economics casts us: satisfaction seekers – where satisfaction is mostly about doing things more efficiently or conveniently, with occasional distractions offered by aesthetic pleasure. We are the kind of people, it is claimed, who are fundamentally lazy hedonists; we rarely decide to change how we live toward what might be less pleasurable, volunteering to do things that are harder to do.

However, the history of most societies does not evidence this at all; societies might evolve, or drift, in these sorts of ways for periods, but significant changes in how a society organizes itself seem to almost always come from hard-won effort at redirecting society, on the basis of values that are elevated beyond those of convenience, cheapness and short-term pleasure.

A more sophisticated version of this assumption suggests that satisfaction-seeking be used pragmatically as a means to merely begin wider change based on different values. People will not initially adopt something that looks like more effort or expense, but if the designer can reduce the barrier to adoption, by making that sustainable product or practice easier or more pleasurable, then that adoption becomes a first step toward the adoption of many other sustainable products or practices that may require greater effort. This is sometimes referred to as the 'spill-over effect;' take up recycling, because of an attractively-designed recycling system and a convenient curbside pick-up infrastructure, and it becomes more likely that you will take up a composting initiative, and then an initiative to reduce wasting energy.

When this assumption is made explicit, the theory drawn upon often concerns 'cognitive dissonance,' the idea that we humans do not like to be (perceived as) inconsistent. So when we find ourselves doing one sustainable thing, perhaps initially just because it had been designed nicely, over time we adjust other things we do to fit with that sustainable thing.

Though this may be true in some situations (especially in relation to taste-matching, sometimes called the Diderot-effect, used in luxury brand marketing with cheap-leader accessories that get a foot in the door of a consumer who then trades-up) (McCracken, 1988), there has been significant criticism of this 'small steps lead to big steps' argument (WWF UK, 2014). For a start, it requires actively recoding the initially adopted practice in terms of the wider value. If the initiative was adopted because it was well-designed, that initiative must be recast in the mind of the adoptees as sustainable. But even if this were done, it will only be effective if the other things/practices that you are hoping will be in turn adopted are similarly recast as sustainable.

In fact, current movements in social theory suggest that everyday life tends to be lived as a series of discrete, or only loosely associated practices: cooking, washing, commuting, holidaying, etc. (Shove, Pantzar, & Watson, 2012). Values are at most only one third of what sustains a practice – the other two thirds being know-how/skills and devices/infrastructures. Even if I acknowledged that I should be commuting more sustainably each day, in a way that is consistent with my sustainable home waste management (recycling, composting, etc.), I would only step from the latter to the former if I have the infrastructure (public transport, for instance, or a renewable energy supplied electric car) and the associated know-how (getting up earlier to catch the bus, or planning my day around the range limitations of my vehicle). At the least, what this 'practices' approach to social change points out is that the 'small steps to big steps' assumption underplays that small steps are very different in nature from big steps: practicing composting does not inherently lead to finding the money and time to renovate a bathroom with water conserving toilets and showers, nor is it on a natural continuum with voting for an environmental third party who might if elected introduce incentives for, or regulations requiring, such renovations.

Quite to the contrary, there is some evidence that when sustainable practices are framed in terms of other more consumerist values like saving money, increased convenience or sexy style, those values are reinforced even if the particular practice that is then adopted is more sustainable, enhancing the obstacle those values present to valorizing sustainability over other satisfiers (Lakoff, 2010). So whilst radical change requires many changes, some smaller, it is not an incrementalist, cumulative process. It must rather be multi-level.

17.4 Breakthrough Innovation

A common response to the fact that humanity faces enormous challenges in relation to sustainability is to expect a major new technology. Necessity, it is assumed, is 'the mother of invention.' If humans start to run out of (a currently dominant but unsustainable) fuel, they will develop a new one; that is their evolutionary trump card. Humans have the capacity to make creative leaps to disruptive new technology platforms that enable society to be quickly reorganized.

However, as discussed above, necessities must be acknowledged to have force. More importantly, any 'Moon Shot' or 'Manhattan project' approach to impending resource depletion for example, will require significant resources: time and money to develop the technology, and then vast time and resources to manufacture and install (Greer, 2011). An important issue then is acknowledging resource constraints before resources are too constrained to develop alternatives.

There are reasons to be skeptical of the capacity of technological innovation as we know it to respond to constantly increasing global energy demand. Most of the examples we have of new technologies over the past century that have resulted in major transformations in resource productivity have been based on the stable energy density of fossil fuels, something that is perhaps unique in the universe, given that it is derived from millennia of concentrated life forms. All other forms of energy on our horizon at the moment are variable and dispersed (renewables), or unstable (nuclear).

This means that the most radical options may not be technological, but social. As John Thackara is fond of saying, in relation to futurism, what we need today is not science fiction, but social fiction, the capacity to imagine very different ways of living.

An interesting example is sharing economies. Given the inefficiency of equipment sitting idle between occasional usage in each household when owned, being able to access goods only when they need to be used, irrespective of who owned them, would seem to make possible major resource productivity gains. It would be a radical configuration of how we live day to day to move from an 'ownership society' to an 'access economy.' But that transformation would not involve major new infrastructural technologies. Initial, mainly European, attempts at business innovation of sustainable product service systems in the mid 2000s seem to have had difficulties that more current communication and information technologies like geo-locative media and social software, and the coming 'internet of things,' make up for. These new digital systems, and the cultural habits that they have afforded, seem to be making 'collaborative consumption' more convenient and reliable. So a radical transformation seems possible, based primarily on social innovations that merely make use of existing technologies.

Even if a large-scale more sustainable technology in relation to energy for example were invented, it must not be forgotten that innovation diffusion is a lengthy and complex process, not least because it is unavoidably social. People with money and power must be convinced to invest in the new technology, workers must be tooled and trained to install the new technology, the old technology must be removed, devices that connect to the new technology must be reconfigured, and users must learn to interface with the new infrastructure. Central to the unsustainability of our current societies is the extent to which they have been literally concreted into current resource systems. The way modernist forms of development were perceived as eternal meant that they were constructed in very error-unfriendly ways (Hommels, 2008). And of course the other problem is that those cities are full of people who cannot simply be put on a cruise for a month or so while the renovating is done.

By contrast with material restructuring, social innovation could be much faster and more extensive; though if, and only if, people can be convinced to change. Innovation diffusion theory, which concerns itself with the social mechanisms that facilitate faster take-up, has foregrounded the importance of potential adopters being able to trial new technologies to discern their relative advantage. Again, a major issue for the dream of big technological breakthroughs is that it is very difficult to trial large-scale new infrastructures.

17.5 Mindset Conversion

For many sustainable designers, the scale of the problem of societal unsustainability derives from problems with how we think, in everyday life, in politics and in professions like design. Sustainability demands more holistic thinking for instance, a capacity to understand and anticipate complex systems of interrelations. If more people, or even just more designers, developed this distinctive way of negotiating situations, sustainability would be more attainable.

But it is always important to ask how one enters a new mindset. If it is really new, how was it discerned in the first place? Who fell out of the existing mindset in order to be able to perceive it, and how? If it is really new, then presumably it requires a sudden move into a different way of thinking, a 'conversion experience' like a gestalt switch; there should be no transitional states with a little bit of old ways of thinking and a bit of the new. What then are the triggers for such a complete transformation?

There are several competing paths proposed by which a radically new, more sustainable mindset can be installed: be more engaged with (the otherness of) nature, particularly its more sublime manifestations (e.g., wilderness parks); experience the suffering of (anthropomorphic) creatures disabled by ecological destruction (e.g., polar bears struggling to survive in changed climates); become more informed about self-organizing stochastic systems (e.g., integral science); pay greater head to the ways in which your (embodied) self is not a self(-contained thing) (e.g., ecosophy); listen to mytho-poetic stories of elders, indigenous peoples, people with a close connection to a bioregion over a long period (Bowers, 1992); confront the normally invisible scale of where all our stuff comes from (e.g., giant holes in the ground, clear-felled forests) and where it goes to (e.g., the photographic work of Chris Jordan, for example, 2009); realize the extent to which traces of toxic industrialism are in your body and the bodies of those you love (Smith & Laurie, 2010).

If one or other of these experiences is affecting enough to restructure the way you think and feel about the world, what happens then? As the terms suggest, mindsets and worldviews are very immaterial. How do you translate a new cognitive paradigm into material environments and everyday practices? Is the metaphor here that of installing a new operating system; after rebooting, operations just naturally then flow according to that new infrastructure of values, perceptions and meanings? This question is particularly important when you realize that not everyone will have faced the conversion experience at the same time. The rest of the (material) world and everybody else continue to proceed under the old paradigm. Without a clear sense of how transition is implemented after a radical mindset change, the problems that concern the 'Make it Easy' approach to sustainable design remain for the Mindset Conversion approach.

These complaints about how radical conceptual disruption takes place suggest that the assumption of suddenness is incorrect. There is in fact emerging literature on how transitions to new systems occur, quickly, if conditions are right, but never instantly. Much of this work derives from Thomas Kuhn's own account of paradigm shifts in science, which recognize a period in which there are anomalies – something between feelings of discomfort and questions, but senses that different ways of proceeding are possible and necessary without knowing yet what those ways are.

Unfortunately, much of the work currently being done on cognitive shifts in relation to sustainability appears to be going in the opposite direction. In response to the lack of success of communicating environmental information, whether facts about ecological impact, or actual guides to more sustainable choices and behaviors, social psychologists now blame cognitive frames underlying such messaging. On the one hand, the argument recognizes a kind of 'worldview' perspective: messaging sustainability in terms of 'saving money' for example, might initially advance its receptability, but in the long run what is being normalized is not the specific sustainability action being promoted, but the structuring frame of the message, which is, 'be economic.' It should be no surprise then when the recipient of that message takes the money saved by undertaking a sustainability initiative in one area of his or her life and respends it on an ecologically impacting behavior in some other domain – an overseas holiday, a bigger television, this season's fashion, etc.; doing so is consistent with the overarching consumer economy message. Sustainability must therefore be a thoroughly applied message, a comprehensive mindset brought to all aspects of environmental communication.

However, on the other hand, social psychology is being used to temper this argument. Current work in this area is advocating Schwartz's value circumplex (WWF UK, 2010). This is a model that posits that the way people organize their lives, including the way they receive messages about sustainability and then translate those into action (or don't), is driven by a deeper, but more psychological, set of characteristics. People live their lives pursuing immediate pleasure, or feeling challenged; or they like to feel that there is secure authority; or they go out of their way to do things for others; etc. The argument is that sustainability is something that should be conveyed in different ways for different kinds of people, catering to their primary lifeworld-organizing values.

If sustainability is indeed something demanding radical change, then this approach is problematic. It assumes that people's organizing values cannot be changed; sustainability is a more contingent value that must be made to fit people's more inherent dispositions. It frames sustainability as not a fundamental value on the circumplex; nor is it something that it more associated with certain values on the circumplex than others, therefore requiring that people subscribing to less-sustainability-disposed values be convinced out of them.

What should now be apparent is that sustainability is a big problem, requiring radical responses because it questions some fundamental values. Sustainability is a challenge to our existing notions of freedom: it is about a certain kind of choice architecture; it is about acknowledging limits; it is about accepting responsibility for longer term and wider afield consequences; it is about accepting interdependence rather than autonomy. What counts as pleasure and authority and even benevolence are all challenged by sustainability.

17.5.1 Radical Designs (always plural)

I have tried to explain the different models of change that seem dominant in sustainable design when aiming at radical change, either suddenly or over time, and whether research-based or creativity-led. In each case, I have been critical of nearly all the different aspects of these strategies as they are being done distinctly at the moment. I would like to therefore give examples in each of the four corners of the matrix I began with that I think nevertheless open onto the possibility of radical change toward more sustainable futures. The point of how this chapter opened emphasized that all these strategies must be done at more or less the same time, not as some massively coordinated total design, but as a multi-level approach that will allow distinct initiatives to reinforce each other, and also open up wholly new possibilities:

	Design	Research
Cumulative	2. Translated *DESIS*	1. Participatory / Networked *Strategic Niche Management*
Sudden	3. Decisive *Transition Towns*	4. Historial *Urmadic*

17.6 Networked

When discussing the qualitative value-based aspects of Life Cycle Assessment, I mentioned the Post Normal Science movement, which is advocating the necessity of distributed lay participation not just in decisions following scientific research, but in the scientific research itself. Post Normal Science does not just assume academically that science is socially constructed, but designs mechanisms to ensure that it is socially constructed, building agreement as it proceeds. Importantly, Post Normal Science creates a participatory epistemology not only because there is no clear separation between fact and value when it comes to something like the ecological science of risks to sustainability, but also because there is no clear separation between studying and intervening. As Ulrich Beck has argued, with many sustainability phenomena, the only way to ascertain the risk is to treat the world as a laboratory (Beck, 2009). Controlled closed lab conditions will not tell you what you actually need to know, which is, what is going to happen when this phenomenon (nuclear power, or genetically modified species, or fracking, etc.) is interacting with the uncontrollable complexity of the world? As a result, the space between testing and trialing, between designing an experiment and designing a prototype, disappears. The science of ecological risk analysis is a design-based form of research, where things need to be built and deployed to find out as you cannot know for sure beforehand.

This is not a reason to jettison The Precautionary Principle, as some argue. It is instead precisely an argument for making moves in error-friendly, reversible, insurable ways. Nevertheless, moves need to be made, because radical change is required. The point is that these moves, which blend research and design, finding out and making happen, require widespread participation.

There has been a long tradition of government involvement in technological developments in the Netherlands, both in terms of fostering innovation and evaluating the consequences of those innovations. The traditions of Environmental Impact Analysis and Social Impact Analysis have now evolved into Strategic Niche Management. This discourse begins with the recognition I discussed in relation to technofixes, that technological innovation diffusion is constrained by capital intensive, ‘concreted-in’ infrastructures on the one hand, and social expectations, habits and skills on the other. These two co-dependently form what are called ‘regimes’ to signal how hard it is to disrupt them and so transition to a different collection of technologies, infrastructures and social modes of living. Nevertheless, change can and does happen. Historically, sociotechnical regimes evolve the way ecosystems transition. They are in some sort of dynamic equilibrium when, meanwhile, at the fringes, some mutations occur. Those mutations prove successful in certain-micro-environments or niches and are then able to evolve further, in ways that make them more resilient. When the wider ecosystem, or regime in which they are surviving still somewhat marginally undergoes some other kinds of changes, an opportunity arises for them to become more mainstream. With a more widespread presence, they place pressure on the infrastructure of the ecosystem to shift in turn, until the whole reorganizes in ways that allow the innovation to flourish.

Transition Theory therefore deliberately seeks out niche areas of society in which a more sustainable technology might succeed before it is acceptable to a wider public. This is the Post Normal participatory component. Meanwhile, Transition Theory also advocates a diverse strategy of multi-level change, some of which are at larger infrastructural levels, such as regulation and financing, some of which are entrepreneurial and others of which are research-focused. The aim is to build up a widely networked approach, pulling at different "levers of change." There is no guarantee that the system will transition in the way planned. In fact, that is precisely why the approach is distributed, to allow for capitalization on unforeseen opportunities as the regime evolves unpredictably (Shove & Walker, 2010).

Transition Theory affords the best opportunity I can see for radical change toward more sustainable futures. But details of its machinations need to be fleshed out with reference to other aspects of the 2x2 matrix I am following.

17.7 Translated

When I was discussing the role of design in making sustainable actions easier and more pleasurable, I was primarily discussing 'small step' environmental behaviors. These were fairly generic contributions to developing more sustainable societies, meaning that they were generally applicable to different kinds of societies; things like energy and waste reduction.

The DESIS Project (www.desis-network.org), initiated primarily by Ezio Manzini (2014), pays attention to what could be characterized as the next level of sustainable initiatives. These are small community based projects aimed at resourcing some aspect of everyday life in more sustainable ways. They are therefore bigger than individuals or households, but they are smaller than businesses or formally established community organizations. Because of this scale, there is great opportunity for significant shifts in everyday resource provisioning, but not available systems for sustaining those activities. Their innovation and sustenance mostly depends upon the political will of the participants.

The method of the DESIS Project is to

› find these instances of 'grassroots innovation'
› lend them design expertise to make the effort required to maintain these innovative practices
› by working with these groups, learn about their innovation
› find ways of disseminating those innovations to other communities

There are some important assumptions underlying the DESIS Project:

i. innovations can and perhaps should come from the people negotiating their own lived situation, rather than specially trained 'creatives' like designers
ii. the designer's job is therefore to improve existing ideas, making the ones that are found more likely to be sustained.

There is a 3rd assumption: that the role of the designer is to scale-up, multiplying an idea from one community to others. This has in fact always been the roll of designers: to make technological innovations invented by engineers mass producible and mass marketable. Done well, the job of a designer is to increase quantity without losing the quality of the original idea. The danger here however is commoditization, when a product, or idea, is stripped of its originating context so that it can circulate more freely in capitalist systems, reducing everywhere to consumerist sameness. DESIS therefore aspires to change design's role in the economy, which is why I would characterize this 3rd assumption instead as 'translation;'

iii. the designers job is to spread good ideas, but on a local-to-local manner; some aspects of an innovation can work in several places, others will need to be particularized; there is no generic design that will make a sustainable innovation available to a wide range of disparate communities – that is exactly the type of scaling that leads to systems of high unsustainable materials intensity.

This 3rd assumption, insisting on multiple translations rather than commoditization, is why the outcomes of DESIS are frequently toolkits; attempts at guides that allow re-localization of sustainable innovations.

By being more case-based and design-based, DESIS adds detail to Transition Theory, making clear that the process must be cumulative. There is going to be no 'breakthrough' sustainable design, nor even a 'tipping point' to the transition. Radical sustainable design just means designing little things a lot, all over.

17.8 Decisive

There is a 4th assumption to DESIS work, though in some way it is a first assumption: that sustainable innovations are being created by groups of people fed up with government and business inaction in relation to creating more sustainable ways of living and working. This kind of 'bottom-up', 'community-led' innovation is more common than often acknowledged by technology-, business- and expert-focused media, though lead-user innovation is a partial corrective. What is significant in the DESIS examples is that the motivation and the process, prior to designers joining as improvers, is explicitly political. The reason the innovations can be enhanced by redesign is that they have been developed for people who believe in the value of what the innovations accomplish, and who therefore are prepared to do things that are not convenient and sometimes even not pleasurable or expensive. The innovations do not need to be designed for efficiency and elegance because those who started them will do them whether or not they are efficient and elegant – so there is always room for design improvements.

The point I want to underline here is that there is no avoiding politics. Radical change, incrementalist or sudden, invariably dreams of change that just happens without people needing to be argued with in messy political ways: the facts are revealed, the implacable evolution of small steps leading to big steps, a new technology, a conversion experience. However, in the end, even in pro-sustainable innovation niches, there is a need for people to make a decision, without having all the facts, or the easy steps to take, or the powerful tool, or an established ideology to draw on. And those who make the decision to start to innovate a way of accomplishing what governments and business will not, must argue with neighbors and colleagues and suppliers to start the innovation process.

This kind of political decisionism, which is essential to radical change, is apparent in a movement like 'Transition Towns' (Hopkins, 2001). These are communities that have formed an opinion about the risks of the resources we currently depend upon having decreased supply from now on (Peak). This is an evaluation of a situation, not a special fact that only these communities know. On the basis of their evaluation of those risks, they have decided to begin to voluntarily restructure their economies before resource crunches force them to restructure in less manageable and so less equitable ways. To be in a Transition Town is to decide to design the transition to less carbon intense, slower, more local economies. That political decision needs to be argued with others in the community until there is enough of a consensus – there is no nudging, or low hanging fruit to begin this process; no government regulation, nor even some calamity or skyrocketing prices or rationing, to force the process. It is a decision to begin to design.

Design, especially communication design, can obviously assist in the persuading stage of building that consensus. But the breakthrough starts with judgments; judgments that are never certain, always interpersonal and hard won; judgments that we should begin to design change before knowing that we must change, and certainly before being changed.

17.9 Historial

Throughout, I have been arguing that radical sustainable design is not about massive change but instead multiple changes. However, I do not want to give the impression that radical sustainable design is only about the micro. I argued at the outset that designers are in fact not inherently good at being systematically macro in perspective and so should aim instead for the meso, though I did so with reference to an oscillation. In this sense, having a bigger background frame is essential to radical sustainable design.

For instance, the difference between Transition Towns and the sorts of cases DESIS enables is precisely the historical scale of the former. Whilst not feeling historically determined, Transition Towns have a temporality to their thinking that extends beyond their immediate community. The site of action remains local, but the framing of that action is historical, or what is sometimes called historial, in the sense of history-making.

Sustainability is nothing but this larger recontextualization of everyday actions: what appears to be a quotidian habit like preparing dinner is in fact part of The Anthropocene, the fact that the biosphere is now almost entirely dominated by humans, built environments, food production and waste deposition.

Whilst radical sustainable design is multiple, its radicality comes from this longer horizon. An important current example is the Urmadic University project initiated by Tony Fry and his graduate students at Griffith University in Australia (Fry, 2011). Urmadic refers to the fact that: humans were nomadic for their first, let's say, 20,000 years; it is only in the last 2,000 years or so that humans began to live in settlements; it was only 2 years ago that the number of humans living in the concreted-in settlements of cities surpassed 50% and will continue to grow; however, at the very moment that humans are trying to completely settle, climate change will unsettle those cities, forcing retreats from coastal areas, disrupting food supplies, etc. Urmadic therefore refers to the design challenge of giving urban settlements some nomadism. This is clearly very large-scale thinking; designing responses is truly radical history-making. So much is this the case that the Urmadic project asks: what institution is capable of thinking, and acting, at this historical scale? It should be universities, but their now almost 1000 year history of departmentalism and non-interventionism make it impossible for them to respond creatively to challenges like cities adapting to climate change. So tackling Urmadic briefs also requires establishing new kinds of institutions of research and learning.

For this sort of radical sustainable design thinking to not be overcome by utopianism, it must keep finding access points in the present: those involved in the Urmadic University project have worked on briefs for the relocation of towns subject to mining subsidence and ports planning for the end of the resources currently being shipped out from there. New York City following inundation by Hurricane Sandy is just such a situation now having to make quotidian level plans for century-scale phenomenon. And others like New York City will now only become more common. All places are starting to have to move as fast as urbanization in China, though everywhere else will now have to deal with what has been concreted into place previously.

17.10 Critical

I would like to conclude with a 5th component to radical sustainable design that would lie outside the 2x2 matrix that has been informing this paper. What makes the radical 'radical' is its opposition to everything that is not sufficiently radical. There is a necessary criticality. To undertake radical sustainable design is not only to do what is required across the multiple levels discussed so far, but it is also to actively critique kinds of designing that are not thinking in terms of participatory social innovations and transitions of historical scale.

This can be put in terms of curriculum at design schools. It is often believed that design for sustainability can be one more requirement added to how else design is taught: design for marketability, design for manufacturability, design for usability, etc. The overriding message, or frame, for this way of approaching curriculum is that sustainability is just one of many competing values. The underlying logic is that of trade-offs; sometimes sustainability must lose out to cost or style. Conversely, sustainability is inevitability seen as something requiring a sacrifice in other demands we have of design, and life.

But to make a sacrifice for something you truly believe in is no longer to make a sacrifice; it is a principal value by which you judge everything. This means that every design and every aspect of a design must be judged in terms of its sustainability, in terms of its capacity to create futures that have a future, that work in concert with multiple other initiatives to create multiplier effects over time enabling transitions to wholly different ways of organizing our societies. There is only: design for the marketability of sustainability, design for sustainable manufacturability, design for sustainable use, etc.

And what seems (in a post normal risk evaluation way) unsustainable, what risks having multiplier effects that restrict futures, however good that design might be in other ways, must be criticized, radically, which may even mean being eliminated (Fry, 2009).

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Elizabeth B.- N. Sanders

18 Is Sustainable Innovation an Oxymoron?

"We face significant economic, environmental and social challenges today. Even "radical innovation" is not enough to address the challenges of wicked problems. Design innovation can help to address these challenges and ensure sustainable futures, but only if we open up the design process to everyone. Design-led innovation is not likely to support sustainable futures unless it is co-design-led innovation. Co-designing puts tools for creativity and communication in the hands of the people who will be served through design, giving all of us the means to collectively make sense of the future. Sustainable innovation is not an oxymoron."
Elizabeth Sanders

18.1 Introduction

The pattern of the last 50 years can be seen clearly now, particularly in the United States. Consumerism had been growing since the 1960's and has resulted in many unsustainable products and practices flooding the landscape. Today many consumers are not aware of or are confused about the negative environmental impacts of their behavior. Consumerism has also led to a preoccupation in the business sector with innovation at all costs. Companies seek "radical innovation" (Verganti, 2009) in order to stay ahead of the competition.

A countermovement to this pattern of increasing consumption has recently become evident. First, the recession has made it abruptly and abundantly clear that continuous conspicuous consumption can no longer be maintained. And at the same time we see that many people, especially young people, are seeking ways to be economically, environmentally and socially responsible. Organizations are also making efforts to think and behave sustainably.

Can radical innovation be sustainable? Can radical innovation be socially responsible? Or is "sustainable innovation" an oxymoron? I will argue that innovation from a consumer-led perspective cannot be sustainable but innovation that is driven from a human-centered perspective can be sustainable. Taking a human-centered perspective requires a long view of the design development process and the use of collective creativity to explore what shape the future will take. Collective creativity refers to acts of creativity that are experienced jointly by two or more (and sometimes even crowds of) people.

18.2 The design process is changing

Where does design fit into this picture? The shape of the design development process has changed over the last ten years with the emergence and growth of a very large front end as shown in Figure 1. The large front end is often referred to as the "fuzzy front end" because of its messy and chaotic nature. The fuzzy front end is made up of the many activities that take place in order to inform and inspire the exploration of open-ended questions. In the fuzzy front end, there is no clear path on how to proceed and there may be many divergent paths to explore before any questions can be answered. It is often not known whether the deliverable of this process will be a product, a service, an interface, or something else like a building. The goals of this exploration are to define the fundamental problems, identify opportunities for design and to determine what should not be designed. Design teams that are open to discovering what not to design can make very important contributions toward sustainable futures!

It also happens that today designers are being increasingly called upon to join, and sometimes to lead, teams that are tasked with very large challenges and problems to solve. These problems are often referred to as "wicked problems". What does this mean? In 1973, Rittel and Webber compared wicked problems to relatively tame problems, i.e., problems that could be solved. "Wicked problem are difficult or impossible to solve because of incomplete, contradictory, and chang-

Figure 1: The shape of the design development process has changed with the growth of a large front end.

ing requirements that are often difficult to recognize. Moreover, because of complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems" (Rittel and Webber, 1973). Working in the fuzzy front end of the design development process on wicked problems is a new and growing territory for designers and design teams.

As the front end of the design development process has been growing, so, too, has the gap between the front end and the back end. This so-called gap is the subject of discussion today, both by design practitioners and by design educators. There are actually two gaps. The first is the *gap between the designer and the user*. This gap happens when designers design stuff that people don't need, don't want, don't like or can't figure out how to use. Designers are well aware that they are designing for others, but they often lack the means to do this well. Most designers today acknowledge that they cannot know exactly what the "user" would say or do. Applied social scientists and other types of researchers have come into the picture to provide information and insight about people. They often serve as the representative or advocate for the "user". This has helped to narrow the gap to some extent. For example, ethnography has been recognized as providing knowledge about people, context and experience that can be useful in the design process.

But with the entry of the researchers into the design landscape, there is now even more talk about the *gap between researchers and designers*. The gap can be the source of conflict, misunderstandings and lack of respect. The gap is due to differences between people from a range of disciplines with their specialized skill sets, languages and mindsets. So while the fuzzy front end provides the context for design exploration, it also introduces gaps and barriers relating to the expertise of the people who are working together there.

Who are the real experts when we talk about designing and innovating for future experience? I will argue that the real experts are the people we are attempting to serve through the design process, not the designers, researchers, engineers and business people. With this shift in mindset, we can invite future "users" into the fuzzy front end of the design process and move toward designing *with* them, not just *for* them. A shared participatory mindset can break down the disciplinary and/or cultural boundaries. And when we add the appropriate environment and materials to support and provoke collective creativity (Sanders, 2013), we have a design space that supports the exploration of new ideas, even in wicked problem situations.

18.2.1 New roles for designers and the people that they serve

The move from *designing for to designing* with requires dramatic changes in the roles that people play. These changes relate to both designers and to those served by design. Figure 2 shows how these roles and relationships have changed over time.

Starting at the bottom of the diagram where the time is the recent past, we see that designers served industry while people played the roles of customers and consumers. Moving up the timeline, user-centered design is a pivotal point where the attention shifts toward the future users but the mindset is still one of designing for them. The top four rows describe the various role relationships characteristic of the designing with mindset. Here we can see that designers change in their role to become facilitators of the co-designing process and the future users become participants in that process. It is at this stage that designers learn how to facilitate the creativity of nondesigners. Moving up the timeline, designers are also exploring how to make scaffolds that others can use to support and provoke their own creativity (Sanders, 2002). In the top two rows, their roles blend together to the extent that is often difficult to tell who is who. In these situations the designer may play the activist role and serve mainly to catalyze the process of collective creativity for the people being served by design.

It is important to note that all the role-defined relationships shown in Figure 2 are important and relevant today. Design needs to serve both industry and the people. In fact, the proliferation of role relationships and

co-creators	
co-designers	
“scaffold” makers	adapters
facilitators	participants
user-centered designers	users
designers	consumers
designers	customers

time

Figure 2: The roles that designers play (in the left column) and the roles that people play (in the right-hand column) have been changing over time

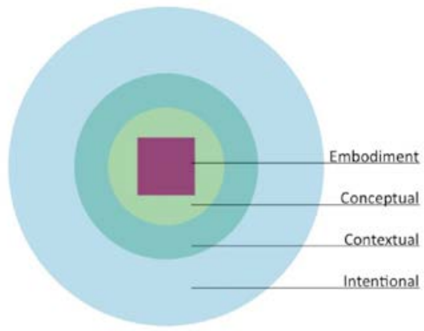

Figure 3: A framework for navigating the fuzzy front end of the design development process where the problems are wicked and the landscape is fuzzy

the different objectives for designing are causing a radical rethinking and remaking of design curricula at the university level. We need to give students experience in both designing for people and designing with people so that they can decide for themselves what kind of designer they will become.

18.2.2 What are the spaces of co-creation?

The stages on which design takes place are different today from the stages of the just recent past. Design is not just about visualization and the application of individual creativity anymore. The problems that designers are being invited to help solve cannot be addressed by the individual, no matter how smart or creative they are. The situation is far too complex. We face significant challenges in that the problems are wicked and the new landscapes of design are fuzzy. The only way we will be able to address the important challenges we face today is to do so collectively. Collective creativity can lead to relevant and sustainable innovation. What does it look like to be at the fuzzy front end of the design development process where the problems are wicked? Figure 3 shows a conceptual representation of nested design spaces as a framework for navigation (inspired by Lerdahl, E. 2001).

The *embodiment* of the idea (e.g., the resulting artifact, activity or experience) is shown at the core. This is the ultimate deliverable of design. Embodiment can take on many different forms depending on what the goal is and how the challenge is approached. For example, the embodiment might be the output of one of the traditional design disciplines (e.g., product, communication, space or system, etc.) or the myriad of forms that are emerging from the new landscapes of design (e.g., service design, social design, design fiction, etc.). The *conceptual design space* surrounds the core. It consists of all the territory that has been or will be navigated in design exploration. The conceptual design space in nested within the *contextual design space* that is described by the larger and constantly changing domains relevant to design development including: use and ownership, environments of use, manufacturing constraints and opportunities, distribution patterns and processes, sales and marketing, etc.

The contextual design space is nested within the *intentional design space* which sits in the speculative future. It is here that we figure out what makes sense in the future. The intentional design space affords the solving of wicked problems and the identification of latent opportunities. For example, the exploration here might address issues such as:

› how can we improve people’s lives?
› what is meaningful to people?
› what do people value?
› what do people desire?
› what will people find to be useful in the future?

The intentional design space points toward the future. Design embodiments that emerge from an exploration of intentional design space include organizational transformation, behavior change, and/or social transformation. Figure 4 shows that the fuzzy front end of design sits in the intentional design space.

As we move from embodiment to concept to context and to intention, the space gets fuzzier and more complex. New tools for imagining, visualizing and communicating will be needed to navigate in the larger design spaces. We need tools for both two- and three-dimensional imagination and expression. We also need tools for four-dimensional (i.e., designing over time) imagination and expression in order to enact and reflect upon future scenarios of use. Each larger design space requires more different types of people to be working together. We need a collective lens to make sense of what we see so that we can act from many simultaneous perspectives. If we work collectively in the fuzzy front end, we can get a very long view that will give us a far greater chance of achieving relevant and sustainable innovation.

18.2.3 How do we practice co-creation?

How can we work collectively in the fuzzy front end? The participatory prototyping cycle (PPC) is a model for co-creation in design (Sanders, 2013). It invites all relevant stakeholders into the design process and supplies them with tools, methods and activities that they can use without having education or experience as designers. The PPC combines making, telling and enacting and uses each activity to fuel the next. For example, making is a skill that many adults do not necessarily feel comfortable using these days. Telling and enacting, on the other hand, are skills that everyone has familiarity with, especially when conducted in inviting environments. By putting making together with telling and enacting, we can empower people who are not skilled in making to externalize their ideas and feelings about the future.

The participatory prototyping cycle (PPC) is a framework for action in design. Prototyping unfolds as an iterative loop of making, telling and enacting in the future design domains. A unique characteristic of the PPC model is its emphasis on the cyclic and iterative relationship between making, telling and enacting. You can enter the PPC at any point, i.e., by *making* things, or *telling* stories about the future or *enacting* future experiences. And from each entry point, you can move in any direction.

In making, we use our hands to embody ideas in the form of physical artifacts. The nature of the artifact changes from early to later stages in the design process. Artifacts made early in the process are likely to describe experiences while artifacts made later in the process are more likely to resemble the objects and/or spaces. Telling is a verbal description about future scenarios of use. We might tell a story about the future or describe a future artifact. But this can be difficult for people who don't have verbal access to their own tacit knowledge. Enacting refers to the use of the body in the environment to express ideas about future experience. We also call this pretending. Acting and performance can also be considered forms of enactment that are particularly useful later in the design process. There has been some interest lately in various forms of enactment as a design tool (e.g., Burns et al., 1995; Suri and Buchenau, 2000; Oulasvirta et al, 2003; Buxton, 2007; Simsarian, 2003; Diaz et al., 2009) and some of this work has been done collaboratively with end-users and other stakeholders.

18.2.4 How does the PPC work in the design development process?

How does the PPC work in the design development process? Think of the PPC as a generative seed moving and tumbling across all phases of the design process over time (See Figure 6). The leading activity (i.e., making,

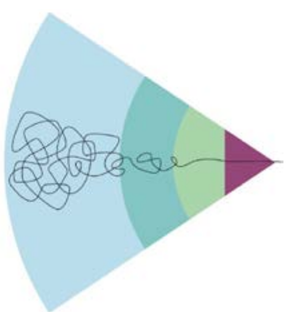

Figure 4: The fuzzy front end of design sits in the intentional design space.

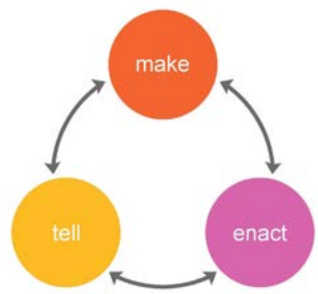

Figure 5: The participatory prototyping cycle (PPC) is a framework for action and a model for co-creation in design

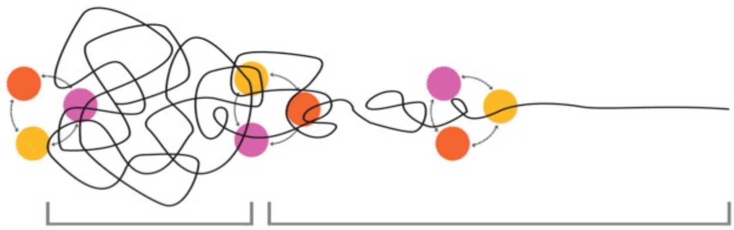

Figure 6: The participatory prototyping cycle in action

telling or enacting) will vary by phase, influenced by team composition and project type.

In the fuzzy front end, enactment is the lead activity because the focus is on exploring and understanding experience (i.e., past, present and future experience). Enacting is the ideal medium for this. The earliest forms of enactment can be best described as 'pretending'. Later forms of enactment might include improvisation and performance. Enacting can be done alone, but the results are far more evocative and provocative when done collaboratively. Enacting will be further synergized when followed by making and telling activities.

Making is the PPC mode that is in the lead across the gap. The purpose here is to explore and visualize ideas in order to figure out what future situations make sense. The various forms of making give shape to the future, with enacting and telling being ways to enrich and extend future artifacts. The earliest forms of making include maps, timelines and collages. Later forms of making include props, Velcro-models and really rough prototypes. The traditional forms of prototyping such as sketching and model making appear much later in the design development process.

Telling is the PPC mode that is in the lead later in the design process. The purpose of telling is to keep the idea alive and evolving. The earliest types of telling come in the form of stories. Later forms of telling include descriptions of the artifacts that are imagined. Even later forms of telling include presentations and selling events. If a participatory process has been used throughout the design process, the primary activities will be telling or sharing since buy-in to the idea by future users and other stakeholders is likely to already have occurred. On the other hand, if a participatory process has not been used, the primary activity can better be described as selling since those who will be affected by the design may still need to be convinced that the idea is good.

The chart in Figure 7 compares the activities and artifacts that emerge in the use of the participatory prototyping cycle over time. The iterative use of the PPC throughout the process can help to bridge the gap between the fuzzy front end and the design development process.

	Fuzzy front end	**Gap**	**Design development process**
Making	Maps Collages Timelines	Very rough models Velcro-models Props	Sketches Mockups Models Prototypes
Telling	Sharing dreams Telling stories	Sharing thoughts Presenting ideas	Presenting the concept Selling the idea
Enacting	Pretending Role playing	Improvising Scenario building	Performing Presenting

Figure 7: Making, telling and enacting take on different forms in the fuzzy front end, the gap and in the design development process.

18.3 In conclusion: Where are we going?

We face significant economic, environmental and social challenges today. Design innovation can help, but only if we open up the design process to everyone. Most of us come to the table with our own disciplinary tools, methods and mindsets, but participation from people across many disciplines is necessary. Radical innovation, with its focus on the individual designer, is not enough to address the challenges of wicked problems. Design-led innovation needs to be *co-design-led* to address sustainable futures. Participatory prototyping that starts in the fuzzy front end of the design development process can result in innovation that is sustainable.

Younger people are more open toward participatory practices than are older people. The Millenials, in particular, are often wonderful students and practitioners of co-designing since their worldview places high value on participation and collaboration. Co-designing will flourish in the future as more young people take on increasingly more influential positions within organizations and communities. Sustainable innovation is not an oxymoron.

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Ursula Tischner

19 Design for Sustainability, Strategies, Methods and Tools

"Be the change that you wish to see in the world." Mahatma Gandhi

19.1 Introduction

All over the world more and more consumers, manufacturers and designers are starting to look beyond the way products appear and perform, to consider what goes on during production and disposal phases. They question, whether a product that performs well and looks beautiful has been produced using dangerous chemicals or child labor, and how it can be recycled at the end of its useful lifetime. They ask, if it is healthy to use the product, or if users will experience adverse side effects. They are concerned about globalization and that some multinational companies still exploit workers in less industrialized countries and can be controlled neither by political nor consumer systems.

If we want the earth to nurture an increasing number of people (c. 9 Bio in 2050), we must live within the earth's 'environmental capacity', i.e. the limits of our natural environment. The challenge is to provide the highest quality of life possible for the maximum number of people with minimum negative environmental impacts. This principle should be upheld with consideration of the whole life cycle of goods, i.e. from the excavation of raw materials, over production and use to recycling and final disposal.

Designers can – and hopefully will – play an important role in the transition towards a sustainable society. They are responsible for the shape of most of the products, infrastructures and an increasing portion of the services that we deal with in every day life, as well as the communication that accompanies them.

If creative experts are allowed and motivated by their customers to design environmentally friendly and socially beneficial goods, assuming the availability of sufficient information, they are able to develop equivalent or even better solutions, using far less resources (energy, water, material etc.), thus avoiding harmful environmental impacts. Design for sustainability, can help to promote lifestyles that are less based on unsatisfying overconsumption and more on creating real fulfillment and quality of life for many. Designers, product managers, engineers and others working in product and service development processes can become part of the solution to global problems instead of contributing to negative impacts.

19.2 Environmental Impacts

Virtually every product places a burden on the environment. Truly environmentally friendly goods are rare. Therefore, in the majority of cases, the question is not whether a product, infrastructure or service causes environmental damage, but to what extent and how it can be minimized. Humans extract materials from nature, use them for their own purposes, and return them to the environment in a moderately or completely changed form, e.g. waste, sewage and emissions. Many materials are transported from one place to another – for example, in the mining industry through excavation pits and rubbish heaps – without making any truly useful contribution to the economy as a whole. As a result, every level of production, use and disposal is usually accompanied by the consumption of resources and energy, environmental burden through transportation, emissions that are harmful to humans and the environment, waste generation etc.

People in industrialized countries as well as those living 'western lifestyles' in developing and emerging countries, commonly have the largest environmental footprints. If everybody were to live like people in industrialized countries, according to the Global Footprint Network, four to six planets would be required[8]. Products impact the environment in a variety of ways (e.g. associated emissions, consumed resources etc.) in areas such as air, water or soil pollution, climate change etc. A product's environmental impacts are largely determined by the material and energy inputs, and outputs generated at all stages of a product's life cycle.

Inputs generally fall into two broad categories: **materials** (including water and air) and **energy**.

› **Material inputs** are associated with a variety of environmental aspects. For example, the use of non-renewable or renewable resources, exposure of humans and ecological systems to contaminants, emissions to air, water and soil and the generation of waste materials and their accumulation.
› **Energy inputs** are required at most stages of a product's life cycle. Energy sources include fossil and biomass fuels, waste materials, nuclear, hydropower, geothermal, solar and wind energy. Each type of energy source has identifiable environmental aspects.

Outputs generated during a product's life cycle fall into several categories: the product itself, intermediates, co-products, by-products and other outputs, such as air emissions, effluent discharges, also noise and waste.

Environmental impacts need to be evaluated in every design project and designers should search for solutions that have minimal negative or ideally, promote positive impacts on the environment. In some cases it is indeed possible to create positive impacts on the environment through design. For instance using the material cork in a sustainable way helps to preserve the valuable oak forests, the precious and beautiful woodlands that have uniquely clustered in the western Mediterranean for millennia. These woodlands are a vital source of income for thousands of people and support high levels of forest biodiversity, including endemic plants and endangered species such as the Iberian Lynx, the Iberian Imperial Eagle, and the Barbary Deer (see Bugalho et al. 2011).

8 Global Footprint Network, 2013. The National Footprint Accounts, 2012 edition. Global Footprint Network, Oakland, CA, USA

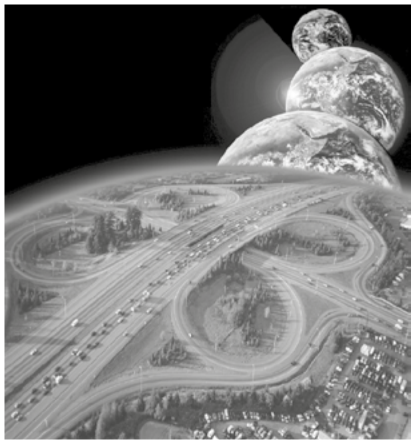

Figure 1: Current Western Life Styles for all would mean that we needed four planets. Source: Agim Meta

19.3 Social Impacts

Goods (products, services, infrastructure) can negatively impact society in several ways. In the production chain, they can be produced via the exploitation of workers and other citizens (sweat-shops, unfair wages, discrimination, unhealthy working conditions, displacing people etc.). Furthermore, they can have many negative societal impacts including reducing cultural diversity, promoting racial or sexual prejudices, communicating the western lifestyle as the **one way** of living for all, etc. The function and use of goods can also have damaging effects on people's health and safety, e.g. deaths/ injury from weapons and military equipment or automobile crashes. Other products such as unhealthy or genetically modified food, cigarettes, fast fashion products have often been linked with extremely unethical practices. Finally materials like conflict minerals, gold, diamonds and mineral oil support crisis and war in some regions of the world. Designers must educate themselves on the social impacts associated with goods and services and search for developmental solutions that have positive rather than negative social influences.

19.4 Sustainable Development

The many potential negative impacts described above demonstrate the need for more responsible environmental and social interactions; especially as social disparity increases and a growing world population needs to find ways to live together in peace and justice. With this principal in mind, the 'Sustainable Development' paradigm was formulated. The World Commission on Environment and Development defined it as *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development 1987).

Following the 1992 Earth Charta in Rio de Janeiro, over 170 countries accepted the paradigm 'Sustainable Development' as a guiding principle. The explanatory document 'Agenda 21' outlines the principal and its key concepts. It contains important agreements for combating poverty, population policy, waste-, chemicals-, climate- and energy-policy, farming-policy, as well as financial and technical co-operation of industrialized and less industrialized countries. Agenda 21 clarifies that poor and rich countries have to function together and that the concept of sustainability is based on the three pillars of development: Economic, ecological and social. However, without a stable natural environment, sound social or economic activities are not possible in the long-term. Therefore, a somewhat higher priority should be placed on the protection of the natural environment.

In more recent years the paradigm of sustainable development has been reframed to include institutions and culture, and perhaps more importantly, to introduce a hierarchy where the sphere of our natural environment is the basis of existence for the social sphere in which the economy is embedded (Figure 3). We call this the Sustainable Development 2.0 Paradigm. It expresses that the economy should serve society as a whole and not the other way around. In a thriving society economic value must be created for all stakeholders rather than maximizing profit for the privileged few.

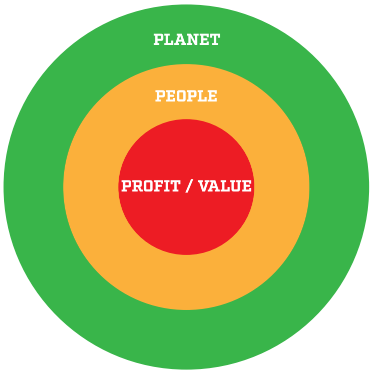

Figure 3: Sustainable Development 2.0

19.5 Sustainable Development by Design

Many *'Design for X'* methods, strategies and movements have already been developed focusing on one

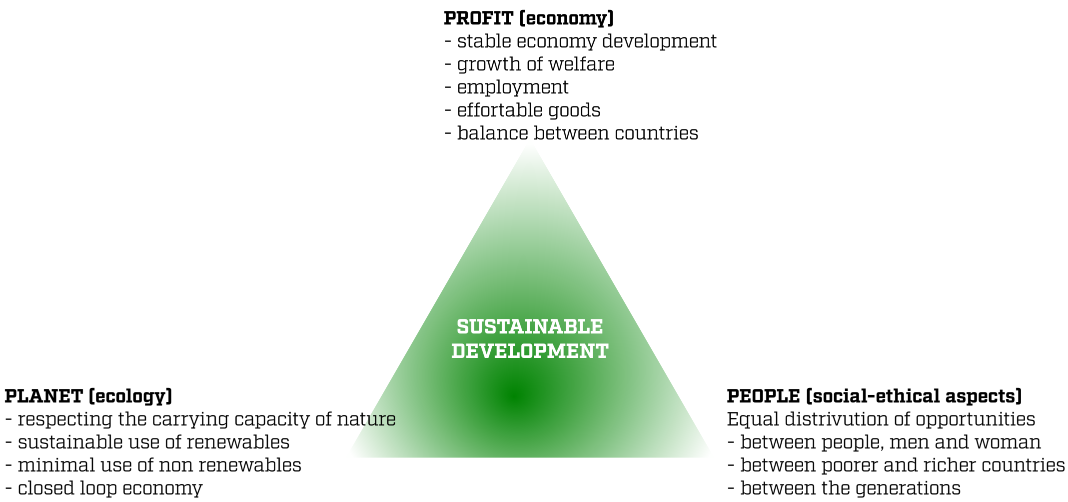

Figure 2: The three pillars of sustainable development

or multiple dimensions of Sustainable Development. Historically, the economic dimension has always been included in good design criteria. Later *Design for Environment* methods have been introduced, such as *Green Design, Ecodesign, Design for Recycling, Design for Eco-efficiency, Design for the Circular Economy* etc. Then the broader sustainability dimensions were taken up more holistically in design methodologies: *Sustainability Design, Sustainable Design, Design for Sustainability* etc. Simultaneously, the design field expanded to include not only product communication and interaction or user experience design, but also more sustainable *product-service-systems* and even whole *production-consumption-systems*. Nowadays an increasing amount of designers are trying to foster social benefits through design using methods such as *Social Innovation, Humanitarian Design, Responsible Design* etc. *Universal Design* and *Design for All* methodologies can also be seen as part of the social design realm. *Base of the Pyramid Design* aims especially at improving the quality of life for the poorest of the poor. This is done best by including these groups in design activities, i.e. designing with them not for them, a tactic which is also at the core of *Participatory* and *Co-Design methodologies.*

Resilient Design is a younger concept that requires designing urban infrastructure and systems in such a way that they are resilient against climate change and other crises to come. Even more recently designers are considered to play an important role in creating societal change resulting from *Design for Change* or *Transformation Design* approaches. The question then arises, whether the necessary transformation of virtually all social and economic systems towards more sustainability can be generated by design or will be a result of necessity following disaster (by design or by disaster).

The following paragraphs explain in more detail the difference between Eco- and Sustainable Design and how designers can practice these methods.

19.5.1 What is Ecodesign?

Ecodesign (or Design for Environment) is **e**nvironmentally **co**nscious product development and **design**. This term describes a procedure, which aims at integrating environmental aspects in the product planning, development and design process as much as possible. This means that 'environment' is added as a criterion of product development alongside other common criteria, such as functionality, profitability, safety, reliability, ergonomics, technical feasibility, aesthetics etc. The term Ecodesign directly expresses the fact that **Eco**logy and **Eco**nomy must be joined inseparably by means of good **design**.

Ecodesign covers the entire product life cycle (raw material extraction, manufacture, transport, use, recycling and disposal) and aims at improving environmentally relevant properties such as energy efficiency, materials efficiency, minimization of use and discharge of hazardous substances, emissions and waste. This

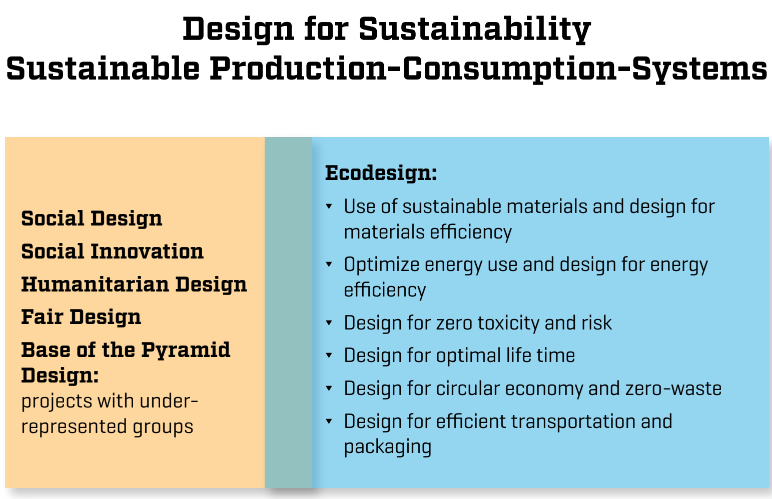

Figure 4: Different Design Strategies with focus on environmental or social aspects under the umbrella of Design for Sustainability

is done along the product development and design process starting with the analysis and idea generation stage through to product design, implementation and 'end of life' management e.g. upcycling, recycling, remanufacture, reconditioning and upgrading.

19.5.2 What is Design for Sustainability?

Design for Sustainability (Sustainable Design) is closely bound to Sustainable Development. In addition to relevant conventional design aspects like cost, marketability, functional aspects, safety, aesthetics etc. and the environmental aspects added by Ecodesign, Design for Sustainability (DfS) also takes social and ethical issues into account during the design process. Furthermore it considers much broader systems, such as whole production consumption systems, and aims to create radical innovation, improvements and change towards sustainability.

With respect to the definition of sustainable development, Design for Sustainability aims at creating solutions for urgent problems and improving quality of life for many by minimizing negative environmental impacts (or even inducing positive ones), and by creating economic benefits to as many stakeholders as possible. Designers implementing Design for Sustainability create solutions (products, services, systems, social innovation, education, enabling platforms, interventions etc.) that offer the best possible combination of benefits in the three sustainability dimensions: people (socio-cultural-ethical aspects), planet (environmental aspects) and profit/ value (economic aspects). Design for Sustainability often adopts a participatory approach, i.e. to design *with* the people (consumers, users) rather than *for* the people. This can also include the involvement of other stakeholders beyond producers and consumers, like supply chain actors, NGOs, municipalities, local communities etc.

19.6 Design for Sustainability Strategies

Sustainable goods are designed to reflect as much as possible the following attributes (see also Datschewski 2001):

They are

- **Sensible:** Deliver a sensible function, solve a real problem.
- **Efficient and effective** in using resources, energy and land.
- **Solar:** Use renewable energy in production and use, like solar, water, wind, geothermal, human power, or sustainably produced bio-fuels and bio-gas.
- **Safe for humans and the environment:** Risk free, healthy, ergonomic, safe to be used, free of toxic substances and emissions, respect the ecological limits and not reduce but foster biodiversity.
- **Durable as appropriate:** Depending on the function and expected use time shorter or longer lasting, but always appropriate. If they are short lasting consumables they need to be especially cyclic (see below).
- **Cyclic:** Waste equals food, design for technical or natural cycles or re-use of materials, components and products, zero waste design.
- **As regional as possible and sensible:** With as little transportation and packaging as possible.
- **Social:** Deliver a beneficial function for society and improve quality of life for as many people as possible, secure employment, produced under (regionally) acceptable working conditions.
- **Economically beneficial:** With a reasonable cost-benefit ratio, create value for the customers as well as for the producers, upstream suppliers, and as many other stakeholders as possible.
- **Encouraging:** Motivate consumers, producers and other stakeholders to change towards more sustainable behavior, for instance by communicating about, educating, and rewarding sustainable behavior.

All of this has to be planned for the whole product/ service life cycle and system. Often it is difficult to fulfill the above criteria equally well simultaneously. Sometimes trade-offs or compromises have to be made, such as between regional production and efficiency, or durability and efficiency. The goal is to design the most feasible and marketable combination of environmental, social and economic benefits.

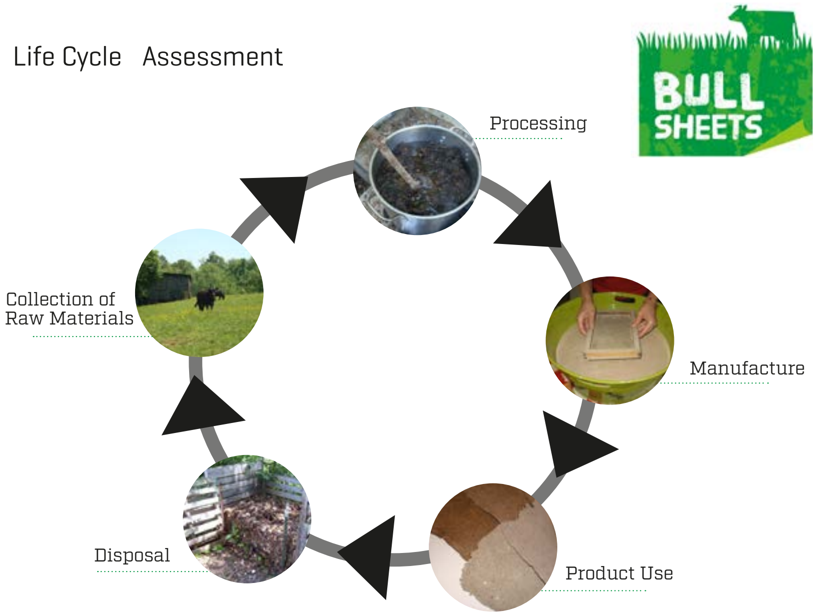

Figure 5: A life cycle of a real cyclic product, the Bull Sheet paper based on waste from grass fed cattle Source: Erin Fenley, MA Design for Sustainability at Savannah College of Art and Design

19.7 How to do Design for Sustainability

There are three basic levels of Design for Sustainability, each with a different scope.

a. **Eco-/Sustainable Redesign:**
These are projects that are aimed at identifying and alleviating harmful environmental and social impacts of an existing product, service or process.

b. **Eco-/ Sustainable Innovation:**
Here the aim is to develop a completely new process, technology, material or product, with environmental and social considerations playing a major role from the beginning.

c. **Sustainable System Innovation/ Sustainable Product Service Systems/ Sustainable Consumption Production Systems**
These are approaches aimed at finding radically better systems, which create social benefits, offer long-term value and avoid negative or create positive environmental impacts at the same time.

Additionally, there are four important principles for practicing Eco- and Sustainable Design:

i. **Early Integration: Start as early as possible**
The freedom to make decisions and 'change the course' is reduced further along the development process. Therefore, the greatest potential for improvements exists when environmental and social considerations are integrated early in the design process.

ii. **Life Cycle Thinking: Cover the whole life cycle/ the whole system**
A life cycle and system approach is used to identify the design strategies most appropriate to a specific product, service or system. It is important to take into account all stages of the product's life cycle and as much as possible the whole system to recognize where the largest and most urgent problems are and where the most interesting opportunities lie. Shifting impacts from one stage or part of the system to another without reducing the overall negative effects must be avoided.

iii. **Functionality Thinking: Think in functions and services – not in products**
When developing products and services, there may be considerable value in thinking in terms of functionality (function, performance, service and useful lifetime) rather than of a specific technical solution. A broad approach should be taken when searching for

new options and to highlight the functionality required in order to fulfil customer or user demands and needs. Think 'drinking great tasting coffee', not 'coffee machine'; think 'wearing clean and nice looking clothing', not 'washing machine'.

iv. **Multi Criteria Approach and setting the right priorities**
In addition to traditional design criteria (e.g. performance, quality, cost, aesthetics etc.), a variety of environmental and social criteria should be taken into account. This generally involves considering a range of different potential impacts through a multi-criteria concept. It is important to recognize that different interested parties (government, environmental groups, customers, etc.) may have varying perceptions of the importance of environmental and social issues. Designers also have to adopt a pragmatic approach. Development/design projects often lack the adequate time and resources necessary to conduct in-depth research of all relevant aspects. It is important to conduct as much research and investigation as possible while also managing uncertainties using appropriate tools. Ultimately, it is better to take action based on decisions supported by evidence, information and informed judgement than to avoid risk by taking no action at all. In a creative environment and a culture of continuous improvement, failures can foster learning.

Design for Sustainability can be implemented in an organization bottom up, starting from the design and operational departments, or top down, initiated by the strategic management levels. A combination of both often proves most successful. Once the decision to implement Eco- and Sustainable Design has been made in an organization, activities should be focused around the following steps.

- Investigate where environmental and social problems exist both in the company and related to its offers (products, services, from extraction of raw materials through production and use to recycling and disposal).
- Determine the most considerable windows of opportunity for the organization to improve social, environmental and economic sustainability.
- Consider the steps required to solve problems/seize opportunities, and develop a Roadmap that includes the following actions:
  - Determine areas of responsibility.
  - Launch and establish pilot projects.
  - Acquire the necessary information and working materials and adapt them to the specific needs.
  - Set up co-operative ventures (e.g. with suppliers, core customers or end of life actors).
- Evaluate experience gained from pilot projects and the initial Eco- and Sustainable Design activities and establish a systematic Design for Sustainability strategy including continuous improvement.
- Communicate Eco- and Sustainable Design successes inside and outside the company. Motivate and train the work force, including external design agencies accordingly.

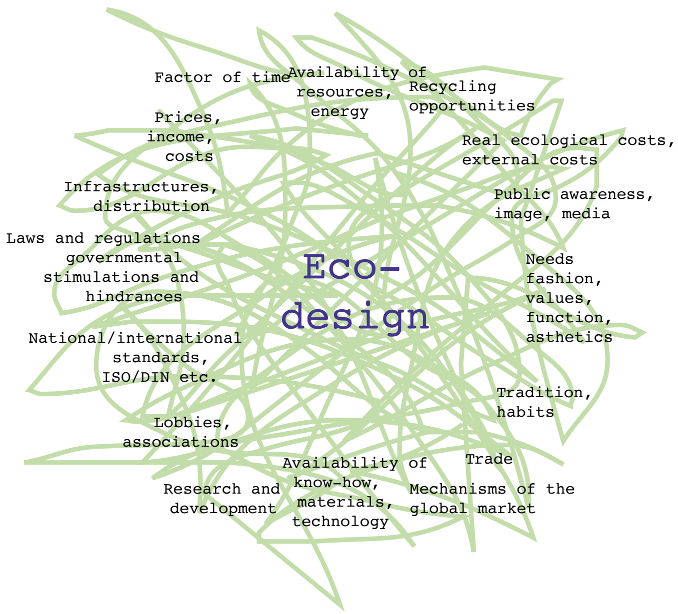

Figure 6: The Multi Criteria Approach in Ecodesign

The following simplified and generic model of a development and design process is used to explain how environmental and social aspects can be integrated in product/service development and design and which tools can be useful.

1. Analyse the problem / situation
   Define the project / challenge
2. Search for more sustainable solutions/radically new ideas
3. Select the best ideas
4. Detail the ideas selected to become feasible solutions
5. Sustainability Evaluation
6. Implementation (or return to previous steps)

Figure 7: Simplified schematic of the design process

Step 1: Define the task, analyze the state of the art

What exactly is the planning task? – What problem, user's needs, system or product are we dealing with?

How fundamental can our deliberations be? Redesign, technical-/social innovation or a completely new concept/service/system?

› Market research tools, Action Research, Design Ethnography, strategic analysis of existing system or product/SWOT, Ecodesign checklist, Life Cycle Assessment, Benchmarking, Briefing/Specifications, Project plan, Roadmap.

Step 2: Generate ideas for sustainable solutions

Is it possible to fulfill the requirements without producing a new product? Can a service substitute the product? Can social innovation solve the problem? What would be the ultimate most sustainable solution? Ideate new solutions that provide an appropriate function.

› Creativity Techniques, Eco-Social-Innovation-Methods, Scenario techniques and backcasting, Biomimicry, Living Labs, participatory Co-Creation Methods, Multi Stakeholder Workshops

Step 3: Select the best ideas

Eliminate obviously unrealistic options and choose the most promising solutions.

› Portfolio or Spider diagrams for comparison and selection of ideas, screening Life Cycle Assessment

Step 4: Detail the ideas selected

Sustainability relevant (product) properties and the functionality/ specifications defined in step 1 must be considered. The solution should be defined in terms of most relevant aspects: map the system and context of use, define the users and other stakeholders involved, specify the most important physical and organisational aspects along the whole life cycle, value chain and system etc. Search for the best options in all three sustainability dimensions.

› Eco-/Sustainable Design Guidelines and Checklists, Rules of Thumb

Step 5: Sustainability Evaluation

The new solutions from step 4 should be compared with each other and the reference system/ existing situation to find out, which is the best solution and if further options for improvement exist. Ensure that all existing optimizations have been taken into account.

› Spider Web Diagram, Eco-/Sustainable Design Checklist, Life Cycle Assessment (LCA)

Step 6: Prepare for Implementation

If a new solution was found to be most promising and been optimized as much as possible, the implementation process should begin. Otherwise the previous steps should be revisited. For implementation a management presentation/client presentation has to be prepared clearly communicating the sustainability benefits in all three dimensions (environment, social, economic) and the specific client benefits, be it a company, a municipality or community. A communication strategy for the new solution should be developed to address the most important target groups.

› Marketing Tools, Communication strategy, Checklists and Spider diagrams as controlling tools. Management presentation, Business Model Canvas[9]

9 e.g. by Alexander Osterwalder and Yves Pigneur see http://www.businessmodelgeneration.com/downloads/businessmodelgeneration_preview.pdf, accessed 10th February 2015

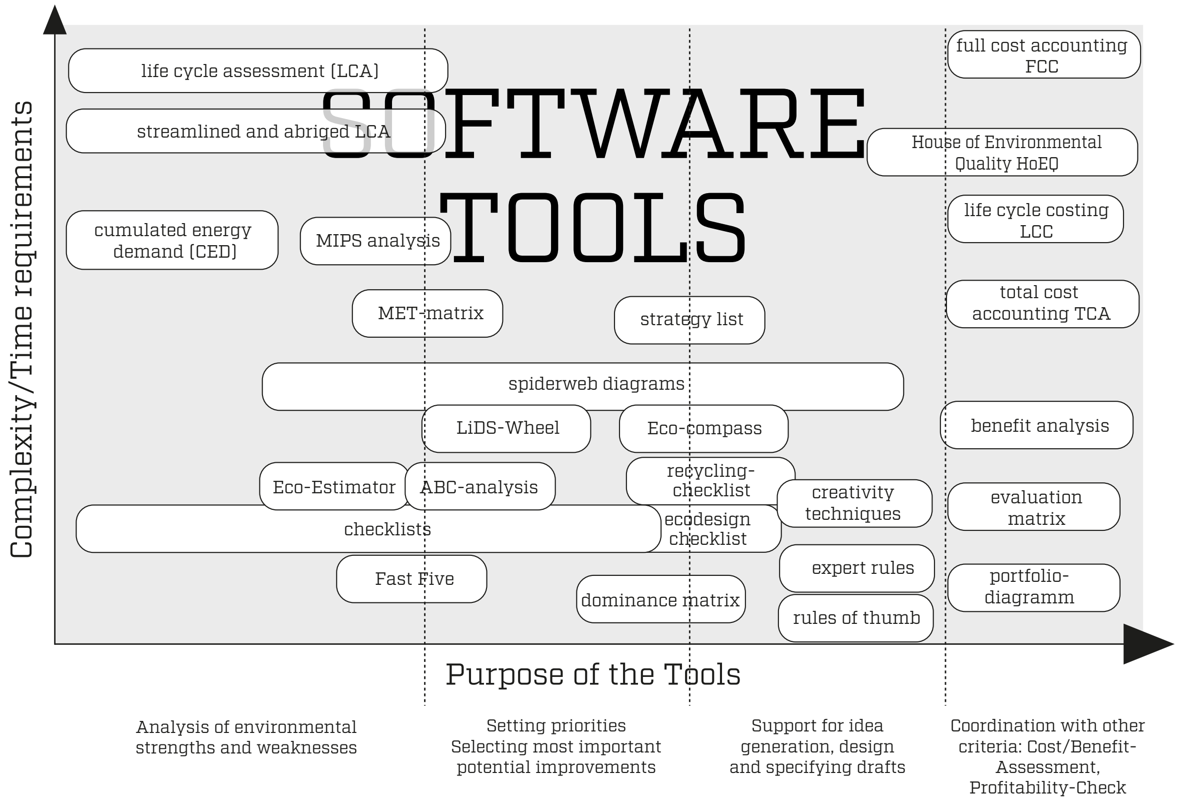

Figure 8: Categorization of Tools that are useful for Eco- and Sustainable Design

19.8 Simple Tools for Design for Sustainability

For the various stages of the Eco- and Sustainable Design process described above various tools exist. There are different kinds of tools, for example those for enhancing creativity, analyzing or comparing, setting priorities and evaluating. Useful tools that are relatively simple and can easily be used by students or in cases of time constraints in a design process are introduced below.

18.8.1 Tools for Sustainability Analysis

Before designing a new solution, weaknesses and problems in the current situation and the existing system should be analyzed as well as new opportunities identified. The exact design project challenge should be clarified and the briefing and specifications for the new design formulated. Tools that combine conventional considerations with environmental and social aspects can help achieve this.

A more strategic tool recommended for strategic analysis is the **SWOT Analysis**, defining **S**trengths, **W**eaknesses, in the current situation and expected **O**pportunities and **T**hreats in the future. The **Sustainability SWOT** adds environmental, social and economic dimensions to the original tool as developed in the 1960s at Harvard Business School.

SWOT	Current Situation		Future Situation	
	Strengths	Weaknesses	Opportunities	Threats
Environment				
Society/ social-ethical				
Economy - for the company - for the customer				
Technology				
Legislation				

Figure 9: Sustainability SWOT Analysis

More suitable to analyze specific products for improvement and re-design is the Ecodesign Checklist. It asks for environmentally relevant aspects of products covering their complete life cycle.

Ecodesign Checklist	+	+/–	–	O	?
Please judge whether the existing solution/ system is good or not so good in the specific aspect. Give marks: + = good, +/– = medium, – = not so good, o = aspect is not relevant, ? = unknown					
Extraction of raw materials/ choice of raw materials					
reducing material input					
reducing energy input					
minimising land use (raw materials extraction, production)					
avoiding input or emission of hazardous substances					
avoiding emissions (e.g. by transports)					
reducing waste production, recycle materials					
preferring regional raw materials					
using renewable raw materials produced by sustainable methods					
using socially acceptable substances that will pose no health hazards					
using recycled materials					
Production					
reducing material input					
reducing energy input					
minimising land use					
avoiding input or emission of hazardous substances					
avoiding emissions (e.g. by refinement procedures)					
reducing pre-consumer waste production, recycle materials					
preferring regional suppliers along the whole supply chain					
minimising packaging					
using renewable ancillary materials produced by sustainable methods					
using socially acceptable processes that will pose no health hazards					
Use / service					
creating excellent customer benefits					
appropriate design for target group					
minimising complaints and returns					
keeping service available					
The following alternative strategies might be discussed					
Strategy 1					
design for longevity					
timeless design					
'long life' guarantee					
robust, reliable wear-resistant design					
design for easy repair and maintenance					
possibilities of combination					
variability, multi-functionality					
possibility of re-use and shared use					
design for update to the best available technology					
Strategy 2					
design for short-lived products					
fashionable design					
design for product take back					
design for recycling					
design for environment-friendly disposal, e.g. biodegradable					
understandable design for the user					
design for self controllable and optimizable functions					
dirt-resistant, easy to clean design					
reducing material and energy input during use					
avoiding input or emission of hazardous substances					
Reuse/Recycling (closing technical material and energy cycles					
recycling strategy in place?					
guarantee for take back in place?					
re-use of the complete product (e.g. second-hand, recycling cascade)					
recycling of components (e.g. upgrading, reuse of components					
recycling of materials					
dismantling of products					
separability of different materials					
low diversity of materials					
low material and energy input for reuse/ recycling					
Final Disposal					
biodegradable, fermentable products (closing biological cycles)					
combustion characteristics					
environmental aspects at deposition					

Figure 10: Life cycle-wide Ecodesign Checklist

The most complex and advanced analysis tool is a complete **Life Cycle Assessment (LCA)** that considers all environmental impacts and aspects over the whole life cycle of a product. Software tools are commonly used to reduce the amount of time it takes to complete a thorough LCA. Tools that can help designers with this process include, 'Eco-it' by Pre in the Netherlands www.pre-sustainability.com/eco-it, 'Sustainable Minds' from the USA, www.sustainableminds.com, or the Ecolizer, an online/offline tool from OVAM in Belgium www.ecolizer.be.

19.8.2 Tools for creativity and finding new ideas

Creativity Techniques are important and inspiring tools also in the Eco-/Sustainable design process, especially

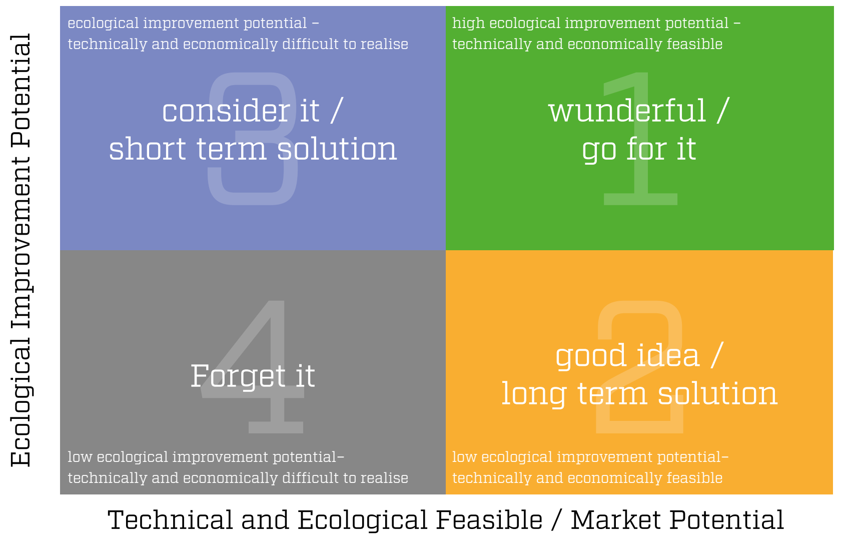

Figure 11: Sustainability Portfolio Diagram

during the idea generation phase. In this context creativity means the ability to find ideas and solutions to problems through interplay of rational, conscious factors with intuitive, subconscious processes. Aside from the widely used **Brainstorming**, many additional tools exist to foster creativity within the design process.

Biomimicry for instance is much more than a creativity tool. It is also very useful to spur the development of new, more sustainable ideas in the design process. The basic idea behind Biomimicry is to observe systems or structures in nature and learn from them to develop outstanding technical or social and organizational solutions. The impetus for the idea need not necessarily come from a concrete technical problem: it can also be that the principles discovered in nature inspire a search for technical and design problems, which they can help to solve. Several online sources feature biomimicry as a design tool. The website www.asknature.org established by Janine Benyus' Biomimicry Institute is very useful.

Role Playing can also enhance creativity. An example is De Bono's 6 Thinking Hats, where each participant (in a creativity workshop) is assigned specific roles or the adoption of a perspective in which they think about a defined problem or situation in new ways. Role playing can also be used to imitate multi stakeholder workshops where different actor roles are portrayed by each member such as 'the politician', 'the scientist', 'the consumer', 'the activist', 'the industrial lobbyist' etc. This spurs out of the box thinking and consequently, the development of new solutions.

A very useful tool for increasing the level of abstraction to tackle problems is **Progressive Abstraction**. Here a defined problem or assignment at hand is re-thought by repeatedly asking the question 'What is actually the problem (or issue)?' This leads participants from the problem at hand, for instance to design a washing machine, to a higher level of abstraction: Why do people use washing machines? To clean clothing. Why do people clean clothing? Because they smell, etc. Trying to solve problems at a higher level of abstraction can eliminate the need to deal with lower levels. For instance, designing fabric that does not get dirty or smelly can eliminate the need for washing machines altogether.

19.8.3 Tools for comparing, setting priorities and selection

The following tools help in decision-making, selecting solutions and adding environmental and social criteria in design activities alongside the mainstream criteria of function, price, customer satisfaction, reliability, aesthetics etc. The aim is to increase the overall design quality together with environmental and social performance.

Portfolio Diagrams can be used in different versions for a variety of problems. For instance it is very useful to cluster and rank several ideas that have been developed during the creative ideation process. The **Sustainability Portfolio** questions the feasibility and the sustainability improvement potential of different design alternatives

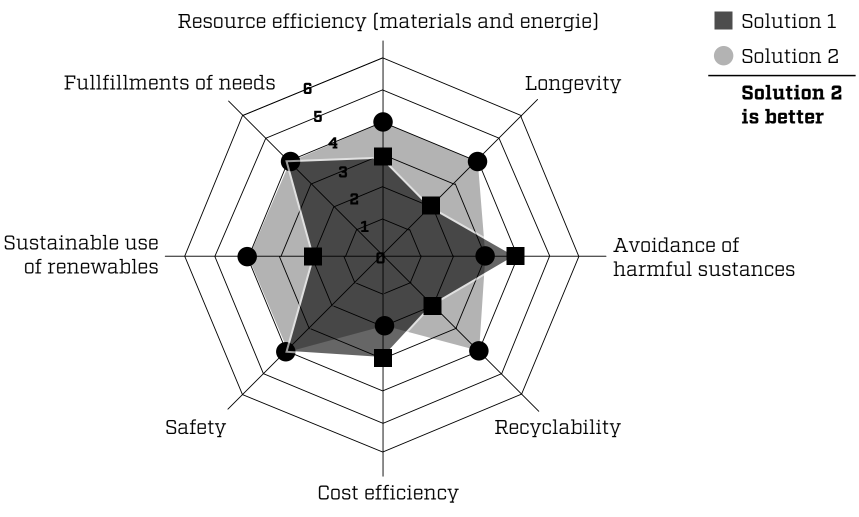

Figure 12: Typical example of a Sustainability Spiderweb Diagram

or solutions. Solutions are entered into the diagram according to their economic and technical feasibility (high or low on the vertical axis) and sustainability improvement potential (high or low on the horizontal axis). Those solutions that are entered in the top right-hand box are those, which will probably lead to win-win situations and should be selected for development. Solutions that are assigned to the upper left box promise quick wins, with an emphasis on the technical and economic side. Those in the lower right box are very interesting from a sustainability viewpoint but usually reflect more long-term strategies, as they are currently difficult to realize from a technical or economic viewpoint. Solutions in the bottom left-hand box should not be considered, as they offer neither economic nor sustainability advantages.

Spider Web or **Polar Diagrams** are used to evaluate and compare different solutions in specific criteria. These can be defined as needed. For sustainability purposes it makes sense to select the most important environmental, social and economic aspects. The spider web also works well in combination with the Ecodesign Checklist (above). Once the checklist has been used to identify the most relevant life cycle criteria, they can be used as aspects for evaluation in the spider web diagram. Two or more new solutions can be evaluated in comparison to each other and against the existing or reference situation. Points are given for each individual criterion from 0 (lowest) to 6 (highest). The reference or average should be set at 3. The points given for each solution are connected to form the quality profile of the solution. The winning solution is the one that spreads furthest to the outer line of the diagram.

19.8.4 Tools for detailing Concepts

After the development and selection of promising design concepts, they need to be detailed so that they can be presented to clients and management and, if they pass the final evaluation, can go for implementation. For detailing product solutions the Ecodesign Checklists for analysis can be used to integrate important sustainability aspects in the design. One important task in product design is the selection of the most sustainable materials. In *Material Selection* the avoidance of certain materials is more obvious than others. For example, it is clear that dioxins, highly toxic materials and high-risk radioactive substances should be avoided. However, in order to determine whether plastic or steel is the more sustainable option, thorough life cycle and system-wide considerations must be taken into account. It is important to understand, that the sustainability of a specific material always depends on the purpose, the life cycle of the product and the system it is used in. Thus important specifications, e.g. price, stability, lifetime, production method, aesthetics, etc. must be firstly identified. Following this Internet, databases, material suppliers etc. should be consulted to find the materials that best meet the requirements in the most sustainable way possible. To evaluate the sustainability of materials the following criteria can be used:

Checklist for more Sustainable Material Choice

- **Consumption of resources:** How resource intensive (including water) is the production and supply of the material? *Try to reduce resource consumption as much as possible and prefer sustainably grown renewables.*
- **Consumption of Energy:** How energy intensive is the production and supply of the material? *Try to reduce energy consumption as much as possible and prefer sustainable renewable energy sources.*
- **Hazardous substances/ emissions:** Are there any hazardous substances involved in production and supply of the material or use, or recycling/ waste disposal of the material? *Try to eliminate and reduce hazardous substance use and emissions.*
- **Origin and transportation:** Where does the material come from and how much transportation is involved in production and supply? *Try to reduce transportation distances as much as possible and prefer environmentally friendly transportation means.*
- **Aspects of lifespan:** How easy or difficult is the maintenance and repair of the material? Can the material be recycled and therefore used again and again? How easy or difficult is the (legally prescribed) disposal of the material? *Try to use materials that have the right lifetime for the product and purpose it is used for and enable easy re-use, recycling and safe disposal.*
- **Waste generation:** How much waste is caused by production and supply of the material as well as the use of material in production, during use of the product and at the end of life phase? *Go for minimal waste options.*
- **Bio-diversity and protection of natural areas:** Do material production and supply reduce bio-diversity and threaten protected natural areas? *Try to use materials where production and supply do not threaten any protected natural areas, endangered species or areas that fulfill important biological functions, e.g. rainforest. Care for sustainable management of forestry, agriculture etc.*
- **Social aspects:** Do production, supply, use and recycling/disposal of the material have any negative social aspects, e.g. neglect of human rights, health risks, destruction of living space, restriction of freedom, exploitation etc. *Try to use materials with positive social effects.*

19.8.5 Tools for Product Semantics and Communication for Sustainability

A product or service should be sustainable not only through its material components but also through its function, shape and aesthetics. The aesthetic dimension is a social stimulator; giving direction to the choices of a great number of individuals and to the way of using a product or service. Thus aesthetics, product semantics and accompanying communication can contribute towards a shift in consumer's attitudes.

Aesthetics can play a major role in the transition to a more sustainable society. By making the more sustainable alternative more aesthetically appealing, the likelihood of consumers purchasing it as opposed to the less sustainable option increases. This is one of the core competencies of designers.

The challenge is to translate the environmental and social benefits of a product or service into benefits and positive aspects for consumers/customers. The communicative means to do so are via product semantics and market communication.

For Sustainable (Eco-) offers it has to be decided, how the eco- and social qualities shall be communicated towards customers/users. This depends on the values and expectations of the specific group of customers to be addressed regarding eco- and social aspects. For example, different communication strategies are necessary for consumer groups that are interested in Lifestyles of Health and Sustainability (LOHAS, see www.lohas.com) – or laggards, who only adopt innovation when forced to.[10]

One useful tool is *'Design with Intent Cards'* by Dan Lockton[11] that describes and inspires several ways (in a deck of 101 cards and 8 'lenses') in which designers can influence consumer behavior towards more sustain-

10 see e.g. Rogers, Everett (2003): Diffusion of Innovations, 5th Edition. Free Press, Simon & Schuster, New York

11 Design with Intent Cards:101 Patterns for Influencing Behaviour Through Design' by Dan Lockton with David Harrison & Neville A. Stanton, see http://www.danlockton.com/dwi/Download_the_cards accessed February 11th 2015

ability (see also Chapter 20 Tischner/Stebbing in this book).

Very often Eco- and sustainable offers do not experience marketplace success due to inadequate or poorly designed marketing and communication strategies. Retail channels, packaging design, available (independent) labels that might be used, consumer information and education as well as training of sales personnel are extremely important aspects to be planned and designed. The so called 'bottleneck', the point of sale in the selected retail channels, needs to be able to communicate the specific benefits of sustainable products and services in positive ways adequately designed for the selected target groups [12]. Furthermore communication design for Sustainability covers two dimensions: (a) the means of communication and (b) the message.

The message should support sustainable life styles as much as possible as described above – and not the throwaway society and un-sustainable life styles with disastrous consequences. Communication designers should be aware of how the messages that they convey influence receivers.

The communication means can be designed according to the Sustainability Design Criteria as discussed above. The following checklist for communication and graphic designers supports a more sustainable design of communication means (see also Dougherty 2008).

19.8.6 Rules of Thumb for more Sustainable Communication Design

For Print Products

- Reduce the amount of paper and other materials used overall by designing smaller pieces and using thinner materials.
- Reduce wasted paper and other materials through clear decision-making during production.
- Replace wood fiber papers with agri-fiber papers when doing so is regionally and environmentally preferable.
- Aim for 100% post-consumer waste (PCW) recycled content paper.
- Choose paper manufactured using renewable energy, or offset by legitimate renewable energy credit programs.
- Select a greener, CO_2 neutral printer for production.
- Use vegetable-based, low-VOC inks on press.
- Stick to digital printing for shorter runs.
- Avoid additives or excess finishing like foil stamps, varnishes, and laminates.
- Design the piece for extended use, or intentional reuse.
- Include verifiable information about the environmentally aware aspects of the piece.

For Packaging

- Eliminate excess or unnecessary material.
- Reduce material complexity as much as possible.
- Be made as light as possible without sacrificing durability.
- Be made with nontoxic, renewable materials.
- Be manufactured and transported using renewable energy.
- Be designed to fit its purpose, for the right lifetime, and intentional reuse.
- Be easily disassembled for appropriate disposal channels.
- Be compostable, or at least recyclable.
- Avoid polyvinyl chloride (PVC).

For Digital Products

- Be hosted by a company that powers their facilities with renewable energy (wind, solar, hydroelectricity), or offsets its non-renewable energy use by donating directly to renewable energy projects, or by purchasing certified carbon offsets through a legitimate program.
- Include a specially formatted print-friendly option designed to minimize paper waste for every web page created (css styles make this easy).
- Be produced on energy efficient (Energy-Star-rated) equipment.

12 see the project: Ecobiente, nachhaltige Güter erfolgreicher gestalten und vermarkten' (Ecobiente, more successful design and marketing of sustainable goods), with its two publications in German: www.econcept.org/index.php?option=content&task=view&id=61 accessed February 11th 2015

- Be created by a studio that has a formal environmental policy in place, including an equipment recycling program and energy conservation plan.
- Consider including an environmental-awareness component, or message about the environmental impact of the project.

see also http://www.re-nourish.com

19.9 Conclusions

It is urgent for the design community to get on board with the sustainability movement and establish more educational programs as well as more practical skills and competencies in the exciting field of design for sustainability. Lots of helpful information, tools, supporting organizations, action groups and case studies are out there already. Designers simply have to ask the right questions at the beginning of each design project, apply the right mind set and skills during the process, collaborate with the right stakeholders and experts, and communicate well about the benefits of the improved more sustainable solutions. Unfortunately, the majority of professional designers still lack the necessary competencies and educational design programs do not yet teach the necessary Design for Sustainability skills. With increasing demand from companies, consumers and political actors for better more sustainable design solutions, this situation is soon to change. There is a whole new generation of young designers and entrepreneurs that are not satisfied with current systems. They will likely be the ones to drive change to secure a better future. To quote Mahatma Gandhi: "Be the change that you wish to see in the world."

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Ursula Tischner & Peter Stebbing

20 Awareness – Despair – Design – Change – Celebrate

"Never doubt that a small group of thoughtful committed citizens can change the world. Indeed, it is the only thing that ever has." Margaret Mead (1901-1978)

(this chapter was first presented as a paper at the Denver Cumulus Conference in September, 2011, and has been updated)

20.1 Introduction

In this chapter we discuss how interventions through design, art, and other forms of cultural expression and media can help to change behavior towards sustainability.

There is much apathy and inaction currently characterizing the general response to global warming and other severe crises. Research has shown that warnings of dire consequences result in a negative response and inactivity. The American Psychological Association (2009) has identified a number of characteristics, which should be used to motivate appropriate action to change our behavior.

We propose that design has the potential, the creative power and obligation to move us beyond the recognizable apathy currently characterizing our response to achieving a sustainable future at every social level. Several initiatives explore the potential of design and art to bring about behavioral change needed to create more sustainable life styles, e.g. by designing enabling solutions, infotainment, edutainment, fun- and game-theory, scenarios envisioning the future, and probes/ experience prototypes.

In this chapter we bring together and propose some ways to help motivate appropriate changes in the behavior of design professionals, their clients, stakeholders and consumers. Part of this is to demonstrate scenarios of visions of the consequences of our contemporary and inadequate response to some of the problems now seriously threatening us. But information is not enough, actors have to be able to experiment with new behavioral patterns in a safe and motivating environment and in an entertaining and positive way – just like children learn their behavior in the first place.

This text describes possible design and art interventions as enablers for such experiences and suggests how such approaches can be used in the design profession and education.

20.2 The Problem of Sustainability: Problems are too big

Winston Churchill observed that "Democracy is the worst form of government, except for all those other forms that have been tried from time to time (Churchill, 1947)." Creating our sustainable future is difficult because of the diversity of motivations that we, the human race, possess. This is well illustrated by our democratic systems, which are allowing themselves to be replaced by the oligopoly of multinational companies and banks whose aim is total control of the resources on which they and ourselves depend, such as finance, water, oil etc. Meanwhile, multi-nationals operate as states within (or outside of) states for the sole aim of maximum profit. Witness the Shell oil company, which infiltrated every ministerial department of the Nigerian government in order to acquire information and control for its own benefit (Smith, 2010). Shell is clearly embroiled in the intrigues, which have resulted in massive pollution in the Niger Delta, the murder of local protesters and the poverty, which predominates a potentially rich country. These kinds of subversive activities extend beyond companies to national services such as the UK police infiltrating environmental protest groups (Evans & Lewis, 2013). It seems that democracy is unable to cope with either the banks, the stock exchanges or the empires of the world's Rupert Murdochs who, despite a political 'smack' and to almost everyone's dismay then return to business as usual.

What does this have to do with sustainability? Everything, because we all need to recognize the milieu of the single motivation of 'pure profit, the whole profit, and nothing but profit', in which the developed countries now live. Actions, which will amend climate change and achieve a sustainable future, require an equally clear objective. The London Agency Trucost, (http://www.trucost.com/) conducted an investigation into the activities of the 3,000 biggest firms. They reported that their operations damage the eco-system to the cost of one third of those companies' profits and, just for the year 2008, the damage to nature and the eco-systems on which our survival depends was calculated at $2.250.000.000.000 (or $2.25 trillion). Eco-system services include the provision of: clean air, freshwater, food, biodiversity, forest and ocean products, carbon sinks and inorganic resources. Of course, we should not forget that these companies furnish us with the comfy western consumer lifestyle (Jowit 2010)!

It is not our aim to summarize all the scientific evidence for the urgency for action in this text, but we will cite just two papers. The first one was compiled by a team of 29 scientists (Rockström et al 2009) who identified nine planetary boundaries, which must not be exceeded if we are to maintain an environment, which will safely support our existence (relatively). Their benchmark paper identified a new approach for defining preconditions for human development stating that:

› Crossing certain biophysical thresholds could have disastrous consequences for humanity and
› Three of nine interlinked planetary boundaries have already been overstepped.

The 9 important parameters for environmental sustainability identified by the team were:

1. Atmospheric aerosol loading
2. Chemical pollution
3. Ocean acidity
4. Ozone depletion
5. Freshwater use
6. Change in land use
7. Climate change
8. Nitrogen & Phosphorus levels
9. Biodiversity loss

In 2009 human kind had already exceeded the boundaries for climate change, nitrogen in the environment, and biodiversity loss. Indeed, biodiversity loss now parallels the last great extinction and scientists are referring to the contemporary loss as the 6th extinction. In addition the World Wildlife Fund has reported that the world's vertebrate animal populations have been reduced by 52% (WWF, 2014). The unknown risk is that these nine planetary systems are interlinked in complex ways whereby reaching a tipping point in one boundary could have severe consequences for the others and be disastrous for us. It is as though we are walking around in the dark near a cliff. The second paper published early in 2015 which follows on from Rockström's et al 2009 paper provides the depressing update that: "Four of nine planetary boundaries have now been crossed as a result of human activity, says an international team of 18 researchers in the journal Science (16 January 2015) [Steffen, W. et al, 2015]. The four are: climate change, loss of biosphere integrity, land-system change, altered biogeochemical cycles (phosphorus and nitrogen).

"Two of these, climate change and biosphere integrity, are what the scientists call "core boundaries". Significantly altering either of these "core boundaries" would "drive the Earth System into a new state."

In the light of these overwhelming issues and problems most people and even experts feel too small to do anything about it. When even the political systems fail to take effective action to deal with this, what can an individual within a company or a single consumer do? And still a lot of people have doubts about these issues mainly because the messages conveyed by companies (with considerable advertising budgets) and the media (because of ignorance, bias or lack of time for thorough research) try to convince us that most of this is made up by ideological ecologists or politicians to scare us. In fact billions of dollars have been spent by wealthy industrialists employing 'think tanks' to create a 'counter-climate-change' movement and through the media to deny the truth of climate change and to confuse the public (Brulle, 2013).

The science, however, is clear on the dangers our survival faces because of the Western life style's 'great acceleration' of consumption (Steffen, 2015) posed by the increase of the world's population to an estimated 9 billion by the middle of this century from 7 billion this year. We need concerted action and we need it fast.

20.3 Learning and un-learning behavior in the context of complexity

Why is it that we allow ourselves to threaten our own future? Why is there so much apathy? Clearly many factors are involved at many levels ranging from the psychology of the individual to the political, corporate and diverse pressures and motives of the public, business and industry.

Maybe it is now time to recognize and accept, that due to our evolution, our brains are hard-wired in the wrong way for today's global problems. 'Our brains were optimized for finding food and mates on the African savannah. Nature has installed in each of us a threat-detection system that is exquisitely sensitive to the kinds of threats our ancestors faced – a slithering snake, a romantic rival, a band of men waving sticks – but that is remarkably insensitive to the odds and consequences of the threats we face today.' and again 'We will change our lives to save [one] baby but not our light bulbs to save them all' (Gilbert 2011). Gilbert recommends the strategy of posing problems in ways that will appeal to our morality and described the situation when up to 1986 the Texas highways were covered with rubbish. Then the state adopted the slogan: 'Don't mess with Texas' which conveyed the idea that causing litter would be 'an insult to the honor of every proud Texan, at which point littering decreased by 72%.

29.3.1 Conveying the Message

Larson (2011) addressing our inadequacy to respond to complex problems has proposed that language and the use of metaphors are a key element in both formulating and communicating ideas in science. Larsen who is basically concerned with 'the under acknowledged relevance of language in seeking sustainability' proposes ways 'toward finding metaphors that encourage sustainability' and maintains that 'sustainability requires rethinking personal and societal actions (which in turn depends on rethinking language).' Larson's reviewer, Golubiewski (2011), concludes that: 'While words alone will not save the world, the art of conversation may lead to better conservation' and quoting Larsen: 'Part of what a poet does is to come up with novel language that reveals something that was previously unnoticed. Such metaphors can help enliven environment science, especially when they inspire love for local places that people care about.'

The potential and the need for the dissemination of accurate information has never been greater so as to make sustainability and our survival a central issue in our culture through both the arts and design. We have the potential through diverse media to refute the climate skeptics who have misled the public such as the Wall Street Journal.

The American Psychological Association (APA) initiated a Climate Change Task Force (2009) addressing the psychology of responding to climate change and what makes people receptive and how can messages effectively communicate climate science. It addressed questions concerning how could psychology make a contribution to fighting climate change and we propose that these questions could also be considered by designers:

1. How do people understand the risks imposed by climate change?
2. What are the human behavioral contributions to climate change and the psychological and contextual drivers of these contributions?
3. What are the psycho-social impacts of climate change?
4. How do people adapt to and cope with the perceived threat and unfolding impacts of climate change?
5. Which psychological barriers limit climate change action?
6. How can psychologists assist in limiting climate change?

The psychologist Robert Gifford, who was also a co-author of the APA report, states that the five requirements needed for an effective communication about Climate Change are (Gifford, 2009):

1. It has to have some urgency.
2. It has to have as much certainty as can be mustered with integrity.
3. There can't be just one message: there must be messages targeted to different groups.
4. Messages should be framed in positive terms. Evidence … shows that people are less willing to change their behavior, if you tell them they have to make sacrifices. If you tell them they can be in the vanguard, be a hero, be the one that helps – that works.
5. You have to give people the sense that their vote counts and that their effort won't be in vain.

Another member of the APA Climate Change Task Force, Paul Stern, (Gardner & Stern 2008) had previously identified that one of the problems with getting people to respond to climate change was that there were too many recommendations: A list of 50 recommendations to save the world 'paralyses people' into doing nothing or too little. Householders were unsure which actions would bring significant benefit on the one hand while still lacking the necessary knowledge on the other. With this in mind Gardner and Stern (2008) produced 'The short list: the most effective actions U.S. households can take to curb climate change' suggesting 17 actions for US households to save energy.

More recently, the affect of belief and its influence on our behavioral responses has been investigated and the research indicates that belief plays a key role. If dire predictions concerning global warming are made to motivate action they may produce the opposite response and actually increase doubts about global warming. Ted Norhouse of the Californian think tank, the Breakthrough Institute, observed that dire warnings backfired when he was a pollster (Kaplan 2011). Meanwhile, Matthew Feinberg (2010), at the University of California, considered that if children were presented as the principal victims of global warming then this might be perceived as unfair because children do not cause global warming. Consequently, he thought that this might threaten people's belief that the world is basically a fair and stable place. Earlier research has shown that undermining this belief inhibits peoples' ability to intervene in the events occurring around them and also causes them to ignore reality (Lerner 1980). Feinberg and Willer (2010) found that there has been hardly any research into the psychology of response to global warming messages. Contrary to previous studies, their experiments revealed that when subjects were primed to have a strong belief in a just world that their level of skepticism was 29% higher and that they also had a 21% lower willingness to reduce their carbon footprint than those primed to see the world as an unjust place.

20.3.2 Changing behavior

The next question we have to ask is, why is it that although a lot of people (professionals and consumers) know a significant amount about the sustainability threats we are facing and the connection of their personal behavior to those problems, still they do not act? Is it laziness, lack of time and budget, convenience, being locked-in to un-sustainable systems and infrastructure? Very likely a mix of all of this and different reasons for different target groups.

In research about System Changes towards more Sustainable Production and Consumption Systems (SCORE, see www.score-network.org) Tischner et al. (2010) analyzed for the area of agriculture and food that behavioral change is likely to happen in the event of crises (e.g. food scares), in life changing events (such as parenthood, retirement or a severe disease) or motivated by peer groups or role models. In addition they describe a phenomenon known as the 'behavioral gap', where a high percentage of the population in surveys say, that environmental protection is important and that they want to save the environment, but in reality only a much smaller percentage really takes action in line with these values. Similarly, a poll conducted by Stanford University, in August 2008, showed that 75 % of Americans believed that global warming could be reduced if individuals changed their lifestyles. The question then arises – why are they not doing more?

In the area of food choices and purchasing decisions in supermarkets, 80% of the choices are happening as routinized behavior, which means that we have learned to buy a specific brand or a specific type of product and every time we shop we select the same without even thinking about it. If this routinized behavior is un-sustainable it is a great challenge to work with consumers on reflecting about, questioning and changing these behavioral patterns towards more sustainability (Tischner et al. 2010).

Generally, behavioral change includes the following elements (acc. to Kanfer & Schmelzer 2005 and own research):

1. **Awareness** about a problem, issue and how the existing behavior relates to it
2. **Motivation to change** the behavior (intrinsic or extrinsic)
3. **Opportunities to change**, feasible options, positive environment to test new behavioral patterns
4. **Positive Reinforcement:** Reward (financial, ideological, emotional etc.) and affirmation by peer group or other institutions with high influence on the individual

General obstacles to changing behavior are particularly, that every change in behavior requires more work than just sticking to known routines, and that every new behavior seems to have unknown consequences for the individual and thus changing behavior can be scary.

Thus cultural change can be a painful, long-term process with no short-term results. However, new media, social networks, interaction/experience design and other fields can speed up cultural learning considerably. Meanwhile there are several new models for Cultural Change to happen faster. One interesting approach by Herrero (2008) is called 'Viral Change Model®' and consists of the assumption that a small set of behaviors, spread by a small number of people with a high degree of influence and via their networks of connections is able to create new routines and behaviors (new ideas, new processes, compliance with new methods, innovation, new ways of working etc.) which constitute sustainable change. This new model is based on recent 'discoveries' across disciplines such as network and behavioral sciences. It shows 'how a combination of the right language and frame, a small set of non-negotiable behaviors (all spread by a small number of activists) and the creation of 'tipping points', creates lasting cultural change in organizations' (Herrero 2008).

The recent revolutions in the Middle East can be seen as examples for radical and fast cultural change enabled by the Internet and social media. Herrero's concept is similar to that of the 'meme' coined by Richard Dawkins (1978) for a 'unit of cultural transmission' be it a catchphrase or a concept, for example 'eco-footprint' or 'greenhouse effect'.

20.4 Case Studies and Models for (F)Un-learning

It seems to us that the arts and design can play a very important role in overcoming most of the main obstacles for behavioral change that would lead us towards more sustainable life styles as described above.

The arts and design can for instance:

1. **Communicate better**, and be more engaging and entertaining about severe sustainability issues,
2. **Create motivation** to change by showing great role models or visualizing the benefits of the new behavior, enhancing the desire to change,
3. **Design opportunities** for change, feasible options and a positive environment to test new behavioral patterns with new products, infrastructure, services and strategies,
4. **Organize positive reinforcement and reward** in several dimensions from awards and user communities to financial gains or peer group attention etc.

Thus making it easier, more interesting, more fun and more convenient to change routines and reducing the fear of change and its unknown consequences.

In the next paragraphs we describe examples from very different fields of art and design where one or more of the points above are realized. The last section explains the new A2D2C model in more detail. It is not possible to provide a complete review of the creative means directed to behavior change for sustainability here. Rather, it is to glimpse briefly some of the poten-

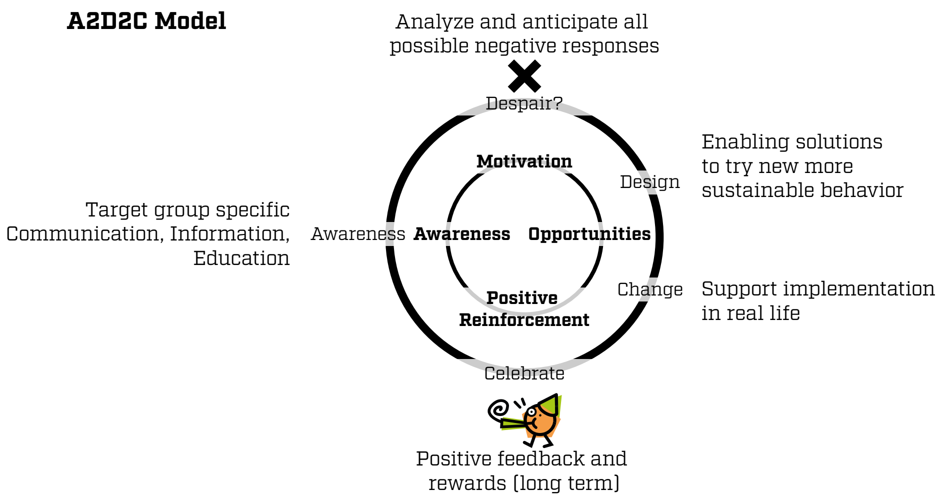

Figure 1: The A2D2C behavioral change model including design interventions

tials, the techniques for creating a message and possibly creating fun out of a serious situation. By listing these cases the traditional separation between design and art activity becomes fused because the design problem is to change behavior towards sustainable actions. Therefore the strategy is concerned with the use of any cultural media to create info- or edutainment, drama, art, games, scenarios envisioning the future, and probes/experience prototypes to reach different audiences to provide accurate information and the motivation to change behavior towards more sustainable routines. For instance, it is possible to provide through different art forms, media and other means a 'taster' experience that could result in an individual permanently changing their behavior. As we know, that is the great significance of literature and the arts, that, through the power of imagination and the fiction of make-believe and metaphor, we are able to experience: firstly, more than we have time for in our own lives and secondly, without threatening our survival.

20.4.1 Designing products and infrastructure to motivate change

This is a wide field also touched upon by 'user centered' design or usability and design semantics. With all design of physical artifacts and buildings, but as well software and systems we influence consumer/user behavior. If designers were more aware of these effects and use them more strategically in their work we could reach a more positive effect towards more sustainable user behavior. One example of how behaviours can be changed is well illustrated by 'nudge theory.' Many men will be familiar with the fly printed in urinals. Men's lavatories posed a cleaning problem at Schipol airport because users were not concentrating on urinating. Aad Kieboom, an economist, came up with the idea of having a black fly etched into the ceramic of the urinal with the result that spillage was reduced by about 80% which significantly saved on the cleaning costs. This strategy is called "soft paternalism" or "nudge theory" because no-one is forced to behave in a particular way. This behaviour modification occurs because in many situations there are a range of choices from which a person can choose a course of action, what is termed the "choice architecture" and the choice architecture can be arranged so as to influence the choices people make. One of the most frequent situations concerns the choice of food displayed in self-service cafeteria or supermarkets where the easy access of foods has been found to influence customer choice (Thaler, Sunstein, 2009: see Glossary).

A very interesting example of a tool to strategically influence consumer behavior towards more sustainability are the 'Design with Intent Cards' developed by Dan Lockton with David Harrison and Neville A. Stanton (see www.danlockton.com/dwi/Main_Page). The toolkit offers '101 Patterns for Influencing Behaviour Through Design' in nine lenses: Architectural, Errorproofing, Interaction, Ludic, Perceptual, Cognitive, Machiavellian, Security. It also includes real life examples for the different patterns of influencing consumer behavior.

20.4.2 Designing campaigns to motivate change

During WWII in the UK various campaigns were implemented to involve every citizen to give them the feeling that their contribution would help to win the war against the Nazis and contribute a difference. Some of the actions implemented by the UK government included:

- The Dig for Victory Campaign: Everyone was encouraged to grow vegetables in any piece of ground.
- The Home Guard: All men who were unfit for active service were encouraged to join voluntary army units and train as a last line of defense against invasion.
- Women's Voluntary Service and the Land Girls: Were created to carry out many duties left vacant by men due to them being recruited into the services.
- Industrial campaigns for saving energy and resources, recycling metals etc.

One of the most successful campaigns was the IADOM campaign, which stood for It All Depends On Me and became a phrase included on many posters issued in the UK during the war. Similar to those dark times today many people also feel ineffective against global warming and this apathetic reaction is one, which must be clearly countered. Small actions, if adopted as habits, and repeated millions of times can have a massive cumulative effect. This is well illustrated by the enormous quantity of energy consumed by 'standby' technology or turning off engines at traffic lights.

20.4.3 Instant feedback devices for communication and reinforcement of change

For those who take action, instant feedback devices (e.g. which monitor energy, water, or other consumables) are important to enable people to see that 'their actions have effects that are local, immediate and concrete' (Coghlan, 2008). In other words the users should feel rewarded and their actions acknowledged, thus the fourth element of behavioral change, positive reinforcement, is addressed.

20.4.4 Experience design

User experience design is an area that can help to support behavioral change. While every project comes with its own unique situations, user experience experts such as Shawn Borsky (2011) suggest user experience techniques that work well and always produce results, such as

- Focus on key experiences not particular elements and smaller details. Important are 'First impressions', 'Peaks or 'wow' moments' and 'The ending'.
- Set expectations for users so that they will not be disappointed at the end.
- Be clear in functions: studies have proven that users will have a great experience as long as they are able to easily understand what they are doing and enjoy doing it.
- Reach beyond usability: Usability is focused on providing an easy path to the user's goals. Usability is functional but not inherently enjoyable. However, good experiences are engaging, meaningful and enjoyable. These are factors that reach far beyond the simple ability to complete tasks without difficulty. Working towards delight and happiness in product and service designs goes a long way.

Experience prototyping and experience probing are very promising fields for participatory design and co-design with customers with good chances to support more sustainable behavioral patterns (see e.g. Westerink et al. 2008). Already for decades good designers have worked with users in providing and testing prototypes of new design solutions, be it material artifacts or immaterial services, systems, software. Sometimes users are actively involved in the design, sometimes they are sparring partners for the designers. In all cases, users are able to experience a new behavior, test how it 'feels' in a safe environment, and influence the way the solution is designed to make it the most beneficial and positive experience for them.

20.4.5 Design Interventions in public space

Several design initiatives and awards have been started to focus on behavior of citizens in public space. Very successful is the 'Funtheory' Website and Competition organized by the company Volkswagen (see http://thefuntheory.com/). Here ideas for small interventions related to activities like the collection of recyclables, throwing waste in public bins, taking the stairs instead of escalators, obeying speed limits etc. were developed, demonstrated and evaluated with considerable success. People improved their behavior because they were offered a fun and rewarding way to change.

20.4.6 Infotainment and Edutainment

The idea behind these concepts is to make learning fun (see e.g. www.edu-tainment.de, http://www.e-teaching.org/didaktik/konzeption/methoden/lernspiele/game_based_learning/, http://www.seriousgames.org/index.html). Successful examples are for instance, the 'Story of Stuff' activities by Annie Leonard (see www.storyofstuff.com), who produces video clips telling viewers about the environmental and social aspects (stories) behind everyday products in a very intriguing and entertaining way. Also games like Ökolopoly by Frederic Vesper or the FishBanks game by Denis Meadows are very interesting simulation games that enable players to understand complex sustainability issues and the problems of shortsighted human behavior.

20.4.7 Literature

There have been few novels which have employed climate change as a context and probably one of the most well known is Solar, the satire written by Ian McEwan (2010) who made the key observation that 'Climate change is difficult because it's not in our nature to perform favors for people that aren't born yet' (Griggs, 2010).

The best selling novel Swarm by Frank Schätzing was published in 2004 and describes the destabilization of methane hydrates which, in his story is caused by marine worms and bacteria. The effect of the destabilization is to cause an underwater landslide (as happened about 8,200 years ago, the Storegga landslide) which in turn causes a tsunami. Schätzing's story is well told and excellently researched and his mix of fact and fiction creates a 'nail-biting' story. However, the danger of melting methane hydrates is no longer fiction but is now taking place off the west coast of North America (and elsewhere) where an estimated 2.5 gigatonnes is destabilizing over an area of 10,000 square kilometers (Phrampus & Hornbach, 2012) due, not to marine worms and bacteria, but the warming of the Atlantic Ocean and the Gulf Stream current.

20.4.8 Theatre (Musical, Opera and Dance)

Theatre, writes George Clark '... addresses one of the most notorious challenges of the sustainability project: moving people from the status quo to sustainability action' (Clark 2009). He reports that the Swedish International Development Cooperation Agency funded a study which reviewed programs in six African countries and recommended that rather than producing a finished play that a production was more likely to have a deeper effect if practitioners involved '... local participants in creating new scenes, testing actions, and solving problems'. This strategy was also supported by Mavrocordatos at the University of Warwick, '... who warns against top-down performance and emphasizes the need to work directly with the community' (Clark 2009).

Two plays, 'Greenland' and 'The Heretic' conveyed much of the ferocious debate, which has polarized the climate change issue. The reviewer in Nature, Kerri Smith (2011) writes that 'Greenland' is a rational but disjointed assessment of how urgent and alarming our predicament is, whereas 'The Heretic' is an entertaining family drama with a climate skeptic as the protagonist. In 'Greenland' the audience is given a sense of the convoluted process of achieving an international policy agreement. Unfortunately, the contrasting characters and the convoluted storyline laced with statistics and quotes make this play not only difficult to follow but at times seem even like a lecture (Smith 2011).

'The Heretic' elicited a more positive response from Smith with its linear storyline. The characters are entertaining and have 'laugh-out-loud' dialogue. The story line parallels the incident of the hacked e-mails of the Climate Research Unit at the University of East Anglia and the 'Climategate' issue that 'was seized upon by climate skeptics.' Unfortunately, the factual errors and science is 'sloppy in places' and 'will infuriate some scientists.' A helpful aspect of the play is that it shows 'the problem of objective scientists without an agenda struggling to be heard' (Smith 2011). Several conclusions can be drawn from Smith's review and they are:

- get the facts right despite the complexity
- don't lecture
- make it interesting
- better still, use humor

20.4.9 Film

'Mad Max', 'Water World', 'The Road' and 'The Age of Stupid' amongst others allow us to experience in a more realistic form possible future scenarios. However, an actual change in behavior by viewers is less likely because the fiction appears more extreme and is removed from the present experiences. Documentaries are a different story. Consumers who have watched 'Food Inc.', 'Plastic Planet', 'The no impact man' or 'The world according to Monsanto' questioning current production-consumption systems, may at least gain some motivation to change un-sustainable practices.

20.4.10 Exhibitions

'By 2080, climate change may deliver a 60-cm rise in sea level along with more frequent and more violent storm surges to New York City's waterfront. Rising Currents (the first of five exhibitions in the series 'Issues in Contemporary Architecture') presents five proposals for reconfiguring the area's shores to adapt to such a threat.' This exhibition explored adaptations to sea level rise through models, maps, drawings and videos (Jasny 2010). Exhibitions have enormous potential to provide the facts and consequences of our lifestyle. Factual information provides the reasons for changing our behavior but may not arouse the necessary motivation for achieving behavioral change.

20.4.11 Pop Music/ Rap

Singer/ songwriter Jack Johnson produced a song about 'Reduce, Reuse, Recycle – the 3 R song', which he also performed for the TV program Sesame Street. Baba Brinkman, a rising star of Rap, has made a hit with the theme of Evolution and plans a next project on climate change. Already now we can listen to his ironic rap 'Canada: The world's only haven from climate change!' In October, 2012, posted a You Tube video responding to "Mitt Romney's mockery of climate change" entitled "Baba Brinkman Takes Down Romney On Climate Change" (Brinkman, 2012). In addition, on his own web site he presents Climate Skeptic (with published text) which provides an excellent humorous account of our sustainability problems, the debate and needed actions.

20.4.12 Simpsons, South Park and much more

The Simpsons, South Park, comics and cartoons of all manners can all provide vehicles for the communication and motivation for climate change facts and the situations to come. Michael Hopkin (Hopkin, & Maher 2007) interviewed Al Jean, the executive producer of 'The Simpsons' film (screened 2007) and asked: 'The Simpsons Movie – is there much science in it?' Al Jean replied 'The crisis that precipitates the plot is environmental – Lisa's trying to warn the town about it and she gives a lecture entitled 'An Irritating Truth.' She's often the voice for the writers, even though she's eight years old a lot of us identify with her. But she is also depicted as socially unpopular, and is not always listened to.' Which perhaps poses the question: can living sustainably be presented as a more attractive lifestyle than consumerism?

Step	Activities	Example: Sustainable Food
Awareness	Define which information users/consumers need to know to understand the larger complex issue or problem and their role in it. Provide this information in a comprehensible and target group specific way.	Related to food consumption and nutrition habits the most relevant issues for Sustainability are to: - Eat less meat (and dairy products) - Prefer organic and fair trade products - Prefer local AND seasonal products - Prefer low processed food with little packaging - Use efficient cooking methods - Eliminate food waste, re-use leftovers
Despair	Collect all possible negative reactions to the information provided, such as despair, neglect, doubt, ignorance and the possible negative actions that follow, e.g. no action at all.	Most decisions related to food are routinized decisions, i.e. learned in childhood/ early adulthood and not reflected any more in daily life. Most people know about the facts above but are not willing or think they are not able to change their food habits, especially when it comes to less meat consumption. Eating habits are also very much related to the culture and peer groups people live in. Thus very difficult to change. Convenience also plays a big role.
Design	Design interventions that take the negative reactions as a starting point and help consumers to test a constructive set of actions in an entertaining, fun and save way. Include consumers/ users in the design as much as possible. Enable consumers to move out of their comfort zone by providing a positive experience.	Examples for possible design interventions: - Interventions at the point of sale, food testing, fun educational exhibitions and events, reduced prizes for the good food etc. - Combined with a good food club (online and offline), where people can register and team up to participate in joint activities from cooking classes to visits at organic farms or purchasing cooperatives etc. - Test subscription to a good food service where a consultant works out a strategy with individual consumers about their own good food behavior, that they can try for a defined period of time and then evaluate its success. - A local competition for good food ideas where people can enter their best strategies for sustainable food/ nutrition and are highlighted and the best ideas are rewarded.
Change	Allow and motivate consumers to take the experience into their daily life and experiment with it. Help them to modify their normal environment and community so that the behavioral change can be successful. Provide opportunities, motivation and stimulate action.	Organize continuous support for the desired behavioral change related to food through online clubs, peer groups, publicity, competition and rewards, subscription and reduced prices for good food etc. over a longer period of time, so that consumers have the chance to experience the desired behavior as a very positive model.
Celebrate	Reward the behavioral change by recognition, awards, financial gains, peer group attention etc. for a longer period of time after the intervention has happened so that the new behavior is very positive for consumers and they include it into their routines.	Create a good food event, a larger public exhibition, a concert, a play, a TV Show, a feature in relevant magazines etc. where the people who successfully participated in the good food action are featured and rewarded. They can be great role models for others and the good food movement hopefully spreads. Encourage them to talk with their neighbors and peer groups about the experience. Reward them for bringing new members in etc.

Table 1: The Awareness–Despair–Design–Change–Celebrate Model (A2D2C)

20.5 Synthesis: a new model of design and art interventions for learning Sustainable Behavior: the A2D2C model

The foregoing is combined into a new model for creative interventions that enable people to re-think their existing behavioral patterns and experiment with new behaviors within a 'secure space', so that experimentation and affirmation can lead to a constant change of behavior in the real world. The model includes the behavioral change elements as described above and is called the Awareness–Despair–Design–Change–Celebrate Model (A2D2C): See Table 1 and Figure 1 above.

All of this has to be done in an interactive process with the users/consumers, and should not have the character of programming or manipulation. The process can be repeated for several types of un-sustainable behavior and over a longer period of time. So that the most environmentally and socially relevant behavioral patterns of consumers can be reflected and questioned by them. Design and Art are enablers.

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21 Social innovation and design – Enabling, replicating and synergizing

"Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime" Tao Te Ching

21.1 Introduction

Worldwide, contemporary society is facing new problems in everyday life. A growing number of people are using their capabilities and existing assets to invent new and sustainable ways of living and doing. Even though these inventions, as a whole, are still far from being considered mainstream, a new world is emerging: a sustainable world, an alternative to the still dominant one.

Is this interpretation a consistent one? Or is this emerging new world only wishful thinking? Or, on the contrary, it is a concrete possibility: something that is not yet a reality, but that could become real if the necessary moves were taken?

To aid in the development of this process, this chapter will propose a journey that, starting from an introduction to the notion of social innovation, focalizes some strategies *to empower, replicate and synergize* the most promising cases. It concludes by outlining, within this framework, what *design* can do to conceive and enhance such cases.

21.2 Social innovation

Once we start to observe society in search of social inventions, a variety of interesting examples appear: groups of families who decide to share services to reduce economic and environmental costs, but also to create new forms of neighborhoods (*co-housing* and a variety of forms of *sharing* and *mutual-help* within a residential building or neighborhood); new forms of exchange and barter (*local exchange trading systems*, LETS, and *Time Banks*); services where elderly and young people help each other and, at the same time, promote a new idea of welfare (*collaborative social services*); neighborhood gardens set-up and managed by citizens who, by doing so, improve the quality of the city and of the social fabric (*guerrilla gardens, community gardens, green roofs*); systems of mobility alternative to individual cars (*car sharing, car pooling, the rediscovery of the possibilities offered by bicycles*), Fair and direct trade between producers and consumers (*fair trade initiatives*). The list could continue touching every area of daily life and emerging everywhere in the world (To read more about social innovation cases, navigate the website of Young Foundation, Social Innovation Exchange, NESTA and DESIS).

The first and most evident common characteristic of the these initiatives is that they are sociotechnical changes emerging from the creative re-combination of existing assets (*from social capital to historical heritage, from traditional craftsmanship to accessible advanced technology*), which aim to achieve socially recognized goals in a new way. The second one is that they are forms of innovation driven by social demands rather than by the market and/or autonomous techno-scientific research, and generated more by the actors involved than by specialists. We can name them, as a whole, social innovation (Mulgan, 2006; Murray, Caulier-Grice, Mulgan, 2010). More precisely: bottom-up social innovation towards sustainability (Jegou, Manzini, 2008).

21.2.1 Promising cases

Looking at such cases of social innovation we can observe that they challenge traditional ways of doing things and introduce new, different and more sustainable behavior. Of course, each one of them should be analyzed in detail (to assess their effective environmental and social sustainability more accurately). However, we can easily recognize their coherence with some of the fundamental guidelines for sustainability.

First of all, many of them have an unprecedented capacity to bring individual interests into line with social and environmental ones (for example to reinforce social fabric) and generate new and more sustainable ideas of wellbeing, where greater value is given to the quality of the social and physical context, a caring attitude, a slower pace in life, collaborative actions, new forms of community and new ideas of locality (Manzini, Jegou, 2003).

Furthermore, achieving this wellbeing appears to be coherent with major guidelines for environmental sustainability, such as: positive attitudes towards sharing spaces and goods; a preference for biological, regional and seasonal food; a tendency toward the regeneration of local networks and finally, and most importantly, coherence with an economic model that could be less transport intensive and more capable of integrating renewable energies and eco-efficient systems (Vezzoli, Manzini, 2008).

Precisely because these cases suggest solutions that merge personal interests with social and environmental ones, they should be considered as promising cases: initiatives where, in different ways and for different reasons, people have been able to steer their expectations and individual behavior towards more sustainable ways of living and producing (Jegou, Manzini, 2008).

21.2.2 Creative communities

Behind each promising case of social innovation are groups of people who have been able to imagine, develop and manage them. A first glance shows that they have some fundamental traits in common: they are all groups of people who cooperatively invent, enhance and manage innovative solutions. And they do so by recombining what already exists, without waiting for a general change in the system (in economy, institutions, large infrastructures etc.). For this reason, these groups of people can be defined as creative communities: people who cooperatively invent, enhance and manage innovative solutions for new ways of living (Meroni, 2007).

A second characteristic is that they have developed out of problems posed by everyday contemporary life such as: how can we overcome the isolation that an exasperated individualism has brought and brings in its wake? How can we organize daily functions if the family and neighborhood that no longer provide the support they traditionally offered? How can we respond to the demand for natural food and healthy living conditions when living in a global metropolis? How can we support local production without being trampled on by the power of the mighty apparatus of global trade?

Creative communities generate solutions able to answer all these questions. Questions that are as day-to-day as they are radical. Questions to which the dominant production and consumption system, in spite of its overwhelming offer of products and services, is unable to give an answer and, above all, is unable to give an adequate answer from the point of view of sustainability. We can therefore state that creative communities apply their creativity and take a different perspective on mainstream models of thinking. In doing so they, consciously or unconsciously, become concrete steps towards sustainability.

A third commonality is that creative communities result from an original combination of *demands and opportunities*. Here the demands, are always posed by problems of contemporary everyday life, and the opportunities arise from different combinations of two basic elements: the existence (or at least the memory) of *traditions* and the possibility of using (in an appropriate way) an existing set of technologies (*in the form of products, services and infrastructures*) (Rheingold, 2002; Bauwens, 2007; Leadbeater, 2008).

21.2.3 Collaborative organizations

Creative communities are living entities that evolve over time. A closer observation shows that the promising cases they generate can be seen as organizations at different stages of development. In fact, when they consolidate into mature organizations, creative communities become a new kind of organization: *collaborative organizations* that, in practical terms, can operate as social services, responsible enterprises or user associations (Jegou, Manzini, 2008).

- **Collaborative services** are a particular kind of services where final users are actively involved and assume the role of service co-designer and co-producers. Some examples are: houses where elderly people of different ages live in a resource-sharing community suited to their diverse needs and lifestyles; services that facilitate house sharing between elderly and young people, where students find cheap, family-style accommodation, while giving lonely but independent elderly people help, companionship and financial support; self-organized nurseries for small groups of infants, making best use of existing resources such as parents' capabilities (social resource) and houses (physical resource).

- **Collaborative enterprises** are entrepreneurial production and service initiatives that enhance new models of locally-based activities by encouraging direct relationships with users and consumers who, in this case too, become co-producers. Examples are: farms that help clients to experience the value of biodiversity in the food chain; local enterprises that teach people how to reuse old and used materials; shops where people exchange used sporting goods; housing companies that renovate houses for more collaborative ways of living.
- **Collaborative associations** are groups of people who collaboratively solve problems or expose new possibilities (and who, again, become co-producers of the results). Some examples of this category are: groups of residents who transform an abandoned lot into a shared neighborhood garden; groups of people who love cooking and who use their skills to cook for a larger group, dining together in one of the members' houses; groups of people who exchange mutual help in terms of time and skills; groups of elderly people and teachers who organize vegetable gardens for children in elementary schools.

Creative communities and the collaborative organizations they may generate are important for us not only because they are sociologically interesting (although they do reflect a significant aspect of contemporary societies) or because they can generate potentially profitable niche-markets for new businesses (even though this opportunity too could and should be explored). They are important because they are "prototypes" of sustainable ways of living that can be implemented as viable solutions to urgent modern-day problems. And therefore they have the possibility to spread and to support sustainable lifestyles for a large number of people.

21.2.4 Scaling-up

Creative communities and collaborative organizations have been introduced here as bottom-up initiatives: actions "from the bottom" that give rise to promising cases of social innovations. However, a closer observation of their evolution from the initial idea towards more mature forms of organization indicates that their possibility of long-term existence, and often even of their start-up, depends on complex mechanisms, and that the initiative taken directly by the people concerned (bottom-up interaction) is often supported by information exchanges with other similar organizations (peer-to-peer interaction) and by different kinds of intervention from institutions, civic organizations or companies (top-down interaction).

For instance, a micro-nursery exists thanks to the active participation of the mothers and fathers involved. However, it may have been started looking to the experiences of other groups (and eventually interacting with some of them) and it may be backed up by specific top-down initiatives and enabling tools, e.g. a guide-book indicating, step by step, the procedure to be followed in starting up and managing it; local authority support in assessment (to guarantee its conformity to established standards); the support of a centralized service (in case of educational or medical problems that cannot be solved within the nursery itself). These examples, like many other similar ones, tell us that *creative communities and collaborative services should be considered as bottom-up initiatives not because everything happens at grassroots level, but because the precondition for their existence is the active involvement of people directly interested.*

Consequently their starting up, their daily life and their possible improvement usually emerge out of a complex interplay between bottom-up, top-down and peer-to peer interactions (which differ from case to case). It is exactly on this basis that we can assume that, even if the creativity and collaborative actions that are the necessary building blocks of every creative community and collaborative organization cannot be planned, something can be done to make their existence more probable and their diffusion potential higher. Therefore, the challenge is now: How to consolidate and scale-up promising cases of social innovation while trying to maintain the relational qualities of the original initiative? That is, how to increase their social and economic impact without dramatically increasing in size? A careful observation of the on-going initiatives indicates that this possibility concretely exists. In fact, if in the past century, consolidating and scaling-up small and local initiatives meant inevitably growing in dimension and bureaucratic structures. Today however, in the age of networks, there are additional possibilities. Here, two main, and complementary, design strategies are presented: (1) To consolidate promising cases enabling the active participation of a larger group of people (from "social heroes" to several "active people") and to spread the best ideas *replicating* them in other contexts (from few to many) and (2) to integrate different small projects in larger program synergizing them (from local to regional).

21.3 Enabling and replicating

The evolution from the original inventions and working prototypes towards lasting and effective collaborative organizations asks for both, a *favorable environment*, aiming at creating for them tolerant norms and positive economic and socio-cultural habitat, and *enabling solutions*, conceived to transform the original inventions in more accessible ones.

21.3.1 Favorable environment

We have already said that creative communities and collaborative organizations are living entities and that depend on the quality of their environment. At the same time, they are brand new entities with (very often) a contradictory relationship with the same contexts in which they have appeared, that can be hostile or favorable to their existence and development.

The most favorable environment for creative communities and collaborative organizations is characterized by a high degree of tolerance. Since the promising cases at issue here are by definition forms of organization that radically differ from the norm, fostering them means accepting something that will probably not fit in with existing norms and regulations. Consequently the tolerance required for them to thrive must be expressed at different levels, i.e. in social, economical, political and administrative terms.

But the tolerance we are referring to here is not a natural gift. It depends on a wide range of choices done by different social actors, in different moments and dealing with different topics. In other words, to improve a context's capacity to tolerate creative communities *new governance tools* are needed. These tools must be capable of generating a favorable social, political and administrative context and, therefore, facilitate the regeneration of specific contextual traditions or foster an appropriate technological infrastructure, to cultivate new talents (skills and abilities). How can this be done? Obviously, there is no single, simple answer to this question. However, some particular opportunities are appearing. In particular, the diffusion of the new organizational models emerging from the Internet can become the enabling technology to facilitate the shift from the present rigid, hierarchical governance models to the flexible, open, horizontal ones needed to support creative communities and collaborative services. Finally, the existence of entrepreneurs capable of recognizing business potentials generated by social innovation is another component of an environment favorable to social innovation. In fact, when they exist, a very interesting virtuous cycle may appear: new business ideas and new technologies can support social innovation, and vice versa. This represents a positive loop, in which social innovation triggers new businesses and technological innovations, can promote a new and sustainable, economy.

In my view, the clearest example of this positive loop is the one created, in the last two decades, in the food and agriculture field. Its result has been the present broad recognition of the new value and viability of new food networks based on local and seasonal food. This new model is challenging, worldwide, the dominant unsustainable agro-industrial one. It must be added that this radical, positive innovation has been triggered and supported by movements (such as the Slow Food one) operating on both the practical side, with the farmers and the consumers/co-producers, and on the cultural and political ones, with opinion leaders and policy makers (Petrini, 2007; Petrini, 2010).

21.3.2 Enabling solutions

Generating a new idea, creatively adapting and managing an existing one or even simply actively participating in an on-going venture often calls for a huge commitment in terms of time and personal dedication. Although this almost heroic aspect is one of the most fascinating characteristics of these initiatives, it is also an objective limit to their long-term existence and to the possibility of being replicated and adopted by many. So this appears to be the major limit to the diffusion of collaborative organizations: the limited number of people capable and willing to cross the threshold of commitment required to become one of their promoters, or even just an active participant. In fact, it has been verified that these initiatives, with their mix of practical results and socializing effects, appear very attractive to many people, but, in practice, for the majority of them, simply require too much attention and time, i.e., they call for too large an investment of the very resources that today are, or are perceived to be, the scarcest ones. To overcome these problems, collaborative organizations need to become more *accessible* (reducing the threshold we mentioned before), more *effective* (increasing the ratio between results and required individual and social efforts) and more attractive (enhancing people motivation to be active). In order to facilitate the positive evolution of the original ideas, a new generation of product-service systems, the enabling solutions, has to be conceived and developed.

For example: the intention of a group of parents to start up a micro-nursery could be facilitated by an enabling solution that includes, not only a step by step procedure indicating what must be done, but also a system of guarantees that certify to the suitability of the parent organizer and the house, and health and educational support for problems that cannot be solved within the nursery itself. Similarly: a solidarity purchasing group could be supported by special software designed to manage shopping and guarantee relationships with producers; a co-housing project could be facilitated by a system that puts potential participants in touch, helps find suitable buildings or building plots, and that helps overcome any administrative and financial difficulties. What these examples tell us is that, case by case, new product-service systems can be thought up which, starting from the capabilities of organizers, can supply support at the weak points, integrating the knowledge and abilities that prove to be missing.

Given the diversity of the organizations to which enabling solutions should be applied, each one of them will require specific features. Nevertheless, some very general guidelines can be outlined. For instance it will be necessary: to promote communication strategies that provide the required knowledge; to support individual capabilities in order to make the organization accessible to a larger group of people; to develop service and business models that match the economic and/or cultural interests of potential participants; to reduce the amount of time and space required, and increase flexibility; to facilitate community building; and so on (Cottam, Leadbeater, 2004, Manzini, 2010).

On these bases, we can propose the following definition of the new product-service systems: *enabling solutions are product-service systems* (Halen, Vezzoli, C., & Wimmer, 2005) *providing cognitive, technical and organizational instruments so as to enable individuals and/or communities to achieve a result, using their skills and abilities to the best advantage and, at the same time, to regenerate the quality of living contexts, in which they reside* (Jegou, Manzini, 2008). In practical terms, enabling solutions can include:

- › **Digital platforms** to connect people and to make it easier for collaborative organizations to function smoothly (such as: customized and intelligent booking and ordering systems, tracking and tracing technologies; fluid payment systems);
- › **Flexible spaces** that can be used by communities for mixed public-private functions (and as incubators for the collaborative organizations start-up phase);
- › **Logistic services** to support the new producer-consumer networks;
- › **Citizens' agencies**, acting as catalysts for new grassroots initiatives, but also as facilitators for existing ones to grow, multiply and flourish;
- › **Information services**, for example, to deliver specific advice when new procedures and/or new technologies have to be integrated;
- › **Co-design methodologies**, to conceive and develop a way to collaborate all the previously indicated artifacts.

21.3.3 Replication strategies

Until now, the diffusion of *collaborative organizations* took place spontaneously and at a relatively slow pace. Here we will discuss whether and how this movement could be accelerated by appropriate actions. That is, by applying some forms of the replication strategy.

Looking to what has been done until now in different fields of activities, we can easily discover that several kinds of replication strategies have been already proposed and developed to scale-up services, businesses and social enterprises. Even though operating in different contexts and moved by motivations, these existing replication strategies present interesting similarities and offer useful experiences. In particular, we will consider three of them: *franchising*, mainly used in commercial activities; *formats*, with reference to the entertainment industry, and *toolkits*, which is used in several application fields where the do-it-yourself approach has been adopted.

The first two replication strategies, *franchising* and *formats*, have different characters and, normally, they have been applied for commercial and business-oriented initiatives. Nevertheless, they can give an idea on how to deal with enabling the existence of small-scale enterprises (the case of franchising) and on how to actualize ideas and organizations in different contexts (the case of formats). Of course, a TV program idea is normally very far from collaborative organizations, and a commercial business under the umbrella of a big brand is even further. However, these experiences indicate that the discussion on how to enable a large number of collaborative organizations to transform a solution idea into operative programs must not start from zero.

Finally, we can consider a replication strategy based on toolkits. It is clear that the notion of toolkit could be very interesting in the discussion on how to replicate promising collaborative organizations.

A *toolkit* normally consists of a set of tangible and intangible instruments conceived and produced to make a specific task easier (and, therefore, feasible also for non-expert people).

Today, tools and toolkits are (mainly) conceived for individual self-help. In order to support collaborative organizations, these traditional "individualistic" toolkits must evolve and become community-oriented ones: sets of tools conceived to empower groups of people. That is, to help them in being active and building, in an easier and more effective way, some commonly recognized values. If and when this evolution takes place, the toolkit idea converges with the one of enabling solution. In short: toolkits become enabling solutions conceived to make a collaborative organization idea more easily replicable in several different contexts.

21.4 Synergizing

The *synergizing strategy* consists in developing local projects and coordinating and systemizing them at a larger territorial scale (neighborhoods, cities, regions) and/or in relation to larger complex systems (healthcare, education, administration, and so on).

When a territorial system is concerned (it could be a urban regeneration program, a regional food network promotion, a community-based development), a synergizing strategy permits to improve its overall social, economic and environmental quality thanks to a development process triggered by a set of synergic self-standing local initiatives. Similarly, when the challenge is transforming a complex organization (could it be a public administration, an healthcare or a school system), the process can be prepared, started and oriented launching a number of local initiatives to mobilize the whole organization and promote its transition towards more effective one.

To better understand what this expression refers to, let's consider, as an example, the *Nutrire Milano* project: an on going initiative promoted and developed in Milano by Slow Food, Politecnico di Milano, Facoltà di Scienze Gastronomiche and several other local partners (Meroni, Someone, Trapani, 2009). This project aims at regenerating the Milanese peri-urban agriculture (that is the agriculture near the city) and, at the same time, offering organic and local food opportunities to citizens. To do that implies promoting radically new relationships between the countryside and the city. That is, to create brand-new networks of farmers and citizens based on direct relationships and mutual support.

The process started from the recognition of available (social, cultural and economic) local resources and of existing best practices. Moving form there, a strategy developed considering the emerging trends towards a new possible synergy between cities and their countryside (such as the ones towards 0-mile food and proximity tourism). On this basis, a shared and socially recognized vision has been built: the vision of a rural-urban area where agriculture flourishes feeding the city and, at the same time, offering citizens opportunities for a multiplicity of farming and nature related activities.

To enhance this vision the program is articulated in local projects, which are several self-standing projects, each of them supporting, in different ways, some farmer activities and *framework* actions including indepth context analysis, scenario co-creations, communication, promotion and coordination of different individual local projects. It is remarkable that in a large project like this (a 5 year project involving a very wide regional area), thanks to its adaptability and scalability, a first concrete result has been obtained in less than one year since its launch (it has been a very successful farmers market initiative). It can be added that two new initiatives will be realized in the next two years and that several others are progressing and will be implemented in the future (keeping in account the very concrete experiences of the first three ones).

21.4.1 Acupunctural planning

As it has been said, the previous example represents a growing group of large-scale projects[13]. These projects are very diverse and context-specific. Nevertheless, they present four common characters: (1) all of them aim at sustainable social changes at the regional scale; (2) all of them express the explicit intention to achieve these results activating high level of citizen participation and (3) all of them have been started and are driven by some specific d*esign initiatives* (that is, they have been – explicitly or implicitly – led by design, i.e. by design agency and/or design schools). (Manzini, Rizzo, 2011).

These large-scale projects present a similar architecture: Multiple local projects are promoted and synergized by one *framework*. Where local projects are self-standing initiatives, highly rooted in the local specificities and capable to use at best some existing physical and social resources. And where *framework projects* are design and communication initiatives including *scenarios* (to give different local projects a common direction), *strategies* (to indicate how to implement scenarios) and specific supporting activities (to systemize the local projects, to empower them and to communicate the overall project) (Manzini, Jégou, Meroni, 2009).

Given its specific nature, the synergizing strategy permits to conceive and develop large-scale programs that, thanks to its same nature, are extremely flexible, scalable and adaptable in time. A strategy that is particularly adapt to be implemented in turbulent times (as the ones we currently live in) and when *territorial systems* or *large organizations* are involved. For this same reason, it can also be defined as *planning by projects* or, adopting as a metaphor the practice of the traditional Chinese medicine – *acupunctural planning* generating changes in large and complex systems operating with well-defined initiatives on some of their "sensible nodes". (Meroni, 2008; Jegou, 2010).

13 For instance, we can quote the ones that have been collected and analysed in the framework of an international research program on the role of design in defining, shaping and implementing social innovation initiatives: the SEE-Sustainable Everyday Explorations research, within the PERL European project. These projects are: Nutrire Milano (Italy), Dott 07 – Designs Of The Time (UK); Chongming Sustainable Community (China); Amplify (USA); Malmo Living Lab (Sweden).

21.5 Design for social innovation

Today, creative communities and collaborative organizations constitute a constellation of small initiatives mainly promoted by active local communities. Nevertheless, as we have seen, an attentive observation indicates that, if *favorable conditions* are created, these small, local social inventions and their working prototypes can be scaled-up and consolidate, replicate and integrate with larger programs and generate great sustainable changes. In other words, we have seen that, if the *original social invention can be generated on the bases of pure intuitions, to make these initiatives more effective and replicable a design approach is required* (Brown, Wyatt, 2010; Manzini, 2009).

It comes that scaling-up social innovation is a particular kind of design process: a design process in which those who "design" are very diverse social actors (including "ordinary citizens"), and in which a new field of activities emerges for the "design experts". We will refer to it with the term: *design for social innovation*, and intend: *"whatever expert design can do to trigger and support social innovation"* (here, the term "expert design" refers to the whole design community, including, as we will see later, whoever is using design knowledge in an expert way: from professional designers to researchers and theorists, from design schools to design journals and publishers).

21.5.1 Creative people and design experts

Given the previous very general definition, let's consider what it means in practical terms. We can take, as examples, two well-known solution ideas; *co-housing* (family living nearby, sharing some residential services and collaborating in facing some everyday life problems) and *car-pooling* (people using the same car in order to share the journey expenses and reduce the traffic). They are examples of social innovation we can find in Europe and world-wide. Of course, other and very diverse examples could be chosen. But these ones seem quite clear and sufficiently well known to be effectively used for our discussion.

Both co-housing and car-pooling have been started by "ordinary citizens" capable of imagining something new, that is, something radically different from the mainstream way of thinking and doing. In fact: the co-housers formulated a concept of housing based on a original mix of private and community spaces and services; the car-poolers had the idea of using private cars as a quasi-public service (and to become, as car owners, quasi-public drivers). Further to this, all of them have been able to move from these visions to reality, setting up the appropriate processes and becoming active agents in the delivery of the imagined results. Now, given that to imagine something that does not exist yet and to make it happen is, by definition, a design activity, it results that these co-housing and car-pooling solutions are, by all means, the results of successful design processes.

These specific observations can be generalized saying that, as anticipated, all the social innovation processes are design processes. And all the involved actors, adopting a design approach, are (consciously or not) designers.

Given that, the question is: if all the social innovation actors – "ordinary people" included – are de-facto designers, what is the role of the design experts and their design community? To make a long story short, we could say that the design experts' role is to use their expertise (that is, their specific design knowledge and skills) to empower the other social actors' design capabilities.

21.5.2 Design knowledge

The previous statement asks for some explanations. The starting point is the observation that adopting a design approach corresponds to the use of basic human capability (that is, a capability that every human being has). This potential human capability, as every other capability, from creativity to music sensitivity, can be cultivated or not. In particular, it can be applied in a naïve way or in an expert way. And here we are with the specific issue raised by our original observation: the human capability to adopt a design approach can be applied inventing, or re-inventing, what to do – from zero. Or, it can build on existing knowledge (previous experiences, appropriate methods and skills, cultivated sensitivities). This specific knowledge, to which we can refer with the term *design knowledge*, is what design experts, and in general the whole design community, can bring to social innovation.

It comes, in conclusion, that design for social innovation is what the design experts can do to trigger and support more effective co-design processes.

Let's return to the co-housing example. In Milano, some years ago, the DESIS Lab of the Politecnico di Milano developed, with other partners, an enabling system dedicated to groups of people willing to realize co-housing initiatives. This system included a digital platform (to create a large community of interest regarding co-housing). Several specific services were also included to help potential co-housers in the co-housing realization process: from the search for suitable areas to the co-housers' group building, and from real estate experts' services to the specific technical expertise needed in the co-design of shareable services and spaces. Parallel to that, a communication strategy (to make the co-housing advantages more evident and attractive) was developed. The first result of these design initiatives was the creation of a dedicated company (Cohousing.it) which is still promoting, several cohousing initiatives in Milano. The second, and probably most important, result was that this experience generated a design knowledge that, successively, has been adopted, and further developed, by the Fondazione Housing Sociale (Social Housing Foundation) – an important institution dedicated the support of the social housing in Italy. The Fondazione Housing sociale now integrates the notion of *collaborative housing* in its programs and utilizes several design ideas and tools coming from the previous co-housing experience.

By generalizing this specific experience, we can say that if it is true that cases like these have historically and frequently been started by ordinary but highly committed people, to last in time and to spread they had to be reinforced by appropriate top-down interventions. It is in this delicate interplay between bottom-up and top-down initiatives that design for social innovation can play a major role.

The mainstream way of doing it is, for design experts, to facilitate existing cases of social innovation, helping them to become more effective, accessible, pleasurable and, potentially, replicable. But designers can also act as activists, triggering, or even initiating, new collaborative organizations (replicating good ideas or starting-up brand new ones). In parallel to this, as we have seen in the previous paragraph, design experts can also promote large systemic changes synergizing a variety of local initiatives and developing specifically conceived *framework projects*. Finally, they can feed the social conversations with *scenarios* and *proposals*, aiming at building shared visions of the future.

21.5.3 A new design field

Traditionally, designers were asked to recognize technological innovation and translate it in socially acceptable products and services. This activity, of course, remains valid. But now, to support social innovation, something else has to be done. The bridge between technology and society has to be trodden in the opposite direction too. In fact, to promote social innovation, design experts must use their design skills and competences to recognize promising cases when and where they take places and to reinforce them. That is, to make them more visible and to support their scaling-up conceiving and developing sets of "appropriate technologies" (i.e. specifically designed products, services and communication programs). Doing that, a new field of design activities (design for social innovation) appears.

This new field of design activities doesn't create a brand new design discipline. What it does is to ask for new approaches, sensibilities and tools that can be transversal to, and impact on, all the (traditional and new) design cultures and practices: from product design to service design, from communication to interior design, from interaction design to strategic design. Nevertheless, dealing with design for social innovation, two of these design disciplines are particularly relevant: service design (to conceive and develop solution ideas considering the quality of these interactions) and strategic design (to promote and support partnerships between the different involved actors). It comes that, to promote and support social innovation, all the design skills, capabilities are to be used, blending them in different ways, case by case. But in all of these cases, some strategic and service design components will be included.

Finally, it has to be underlined that design for social innovation requires also, and maybe most than all, a different idea of the designers' role and position among other social actors involved. Traditionally, designers have been seen, and have seen themselves, as the only creative members of the interdisciplinary design processes. Dealing with social innovation this clear distinction blurs, and they become professional designers among many non-professional ones. But, as it has been previously anticipated, even if this distinction blurs, it does not mean that design experts' role is becoming less important. On the contrary, in this new context, design experts may have a lot to do in bringing very specific design competences in these co-design processes. That is, they become a particular kind of process triggers and facilitators who use specific design skills to empower the other actors' capability to be, themselves, good designers (Thackara, 2005; Manzini, 2009; Manzini, Rizzo, 2011).

21.5.4 Empowering people's capabilities

If designers must learn how to work with other non-professional designers, an important step to be done is to redefine the profile of the people for whom and with whom they – the design experts – design: to look at the "final users" for their capabilities, rather than their needs. That is, to consider them neither as consumers nor as passive users, but as active subjects, endowed with resources and, if the conditions are right, ready to put them into play.

This approach, that can be defined as the *capability approach*, per se, is not new: more than 2.500 years ago Lao Tzu's wrote: *"Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime"* (Tao Te Ching). It means that, to give people long-lasting well-being we must make it possible for them to deal with problems themselves. And, to do so, they may need access to appropriate knowledge and tools. Moving to the present, we can find Amartya Sen who says that what determines well-being is neither goods nor their characteristics, it is "the possibility of doing things with those goods and characteristics …" (Nussbaum, Sen, 1993). In fact, it is this possibility that enables people to approach their own ideas of well-being and feel able to "be" what they wish to be and "do" what they wish to do. And this is what design can do: to focus on people's capabilities and to conceive and develop the solutions to increase them.

Coming back to our main topic of design for social innovation, we can state that the Sen's capability approach could (and should) offer it a solid theoretical basis. By adopting it, the fundamental question of what to design and how, could have a very simple but challenging answer: *design to expand the capabilities of* *people to lead the kind of lives they value. And to do it in a sustainable way.*

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Anamika R Dey & Anil Gupta

22 Empathetic climate resilient frugal innovations for sustainable communities

22.1 Introduction[14]

For more than two decades, Honey Bee Network has been trying to scout, spawn and sustain grassroots green innovations and outstanding traditional knowledge. Several institutions were created to link formal and informal science, technology and policy institutions. India is the first country, which has made unleashing the potential of grassroots innovators an essential part of the National Innovation System. Ideas, innovations and institutional initiatives for turning around economic development and fair distribution of wealth generated will not depend upon actors in formal sector alone. Lessons from Honey Bee Network are also influencing corporations both national and international besides public policy makers with in India and abroad. Many companies like Volvo, GE, HP, Philips, Microsoft, JSW etc. have also tried to learn from the insights gained from grassroots innovators. However, given the increasing uncertainty in the environment and the need for frugal quick time solutions, there is no choice but to learn from the communities for whom this kind of adaptation is the only choice.

In part one, creative and innovative coping strategies of knowledge rich-economically poor people are summarized. Part Two deals with the contours of emergent inclusive innovative ecosystem in India over the last 25 years of Honey Bee Network. Part three lists emerging inclusive models of innovations having bearing on creativity at the grassroots level. Trends in innovation literature, particularly from an open innovation perspective are reviewed in part four followed by a summary of key points at the end.

22.1 Part One: Creative and innovative coping strategies with Climate risks

Dealing with risk and uncertainty has contributed to the evolution of local knowledge, institutions and culture among farming, pastoral and artisanal communities at grassroots level. The traditional institutions, practices and ways of finding contemporary innovative solutions to emerging problems still remain relevant even if some of the indicators or specific practices may have lost their relevance (Leonard, Sonia, et al 2013, Corinne Valdivia, D. Green and G. Raygorodetsky, 2010, Coleen Vogel et. Al., 2007). Institutional adaptation plays no less important a role through collective action (Daivi Rodima-Taylor, Mette F. Olwig, Netra Chhetri, 2012, also see www.sristi.org/cpri). The resilience requires not just actor based study but also the role of entire socio-ecological system (Gupta, 1984, Donald R. Nelson, W. Neil Adger and Katrina Brown, 2007). This paper focuses more on technological adaptation and innovation (Gupta, 1992, 1995, 1989, 2006, 2012). The grassroots innovations emerging in a materially constrained environment invariably leverage knowledge, ingenuity and local resources in a very frugal and empathetic manner. Not all innovations at grassroots are designed to solve one's own problems. Many of these are inspired or triggered by internalization by the innovators of some third party's problem including community unmet needs (through *samvedana*). The adjustment with risk at a time and adaptation over time may take place thus through collective institutions, individual responses and market and state level interventions. Studies have shown that among various household risk adjustment (HHRA) strategies for 'survival under risk' (Gupta, 1989), local communities can cope at intra and inter household lev-

14 Authors are grateful to Prof Gurdeep Singh, ISM, Dhanbad, for very useful suggestions and Pooja Tole for bibliographic help, R Baskaran for processing the text. The insights presented here are entirely due to the lessons learnt from green, grassroots empathetic and frugal innovators.

el, community and common pool resource institution level and though public interventions (see Table one, Gupta, 1984, 1995, Dey, 2015).

Intra-HHRA includes reordering existing plans for managing natural resources such growing eco specific crops, varieties, managing drainage, etc. When stress increases, households may take recourse to non-farm, socio economic adjustment strategies such as disposal of assets, migration or even modified consumption. When either intra-HHRA does not work enough, or some times depending upon the strength of kinship or social network structure, households may resort to exchange or borrowing or purchase of natural resources, seeds, seedlings, or other inputs to tide over the climate change induced crisis. But these exchanges may also involve borrowing loans in cash or kind, labor contracts, or tenancy, land being leased-in or leased out to adjust with risks. There are very few communities, which can really manage the risks without some collective measures. These could be reliance of indigenous common property resource institutions (see sristi.org/cpri), common pooling of resources, or labour to manage a lake, pond or grazing land, community nursery, weeding, water management etc. Public interventions become imperative when the crisis is so deep that HHRA fail or prove inadequate. At such juncture government and some times philanthropic organizations create public support for affected population. The availability, accessibility and affordability (Gupta 2014), of these strategies lone or in combination influences how the new innovations are triggered and what combination of private, public and common resources they draw upon.

Technological innovations can emerge through collective need identification but may be pursued both individually as well as collectively. Double decker tree Root Bridge across a river in Nogreat village of Cherrapunji distt, Meghalaya, north eastern India is a good example of how technology, institution, and culture mediated the evolution of a sustainable, frugal innovation. Thats why, Gupta (2009), has argued that *if technology is*

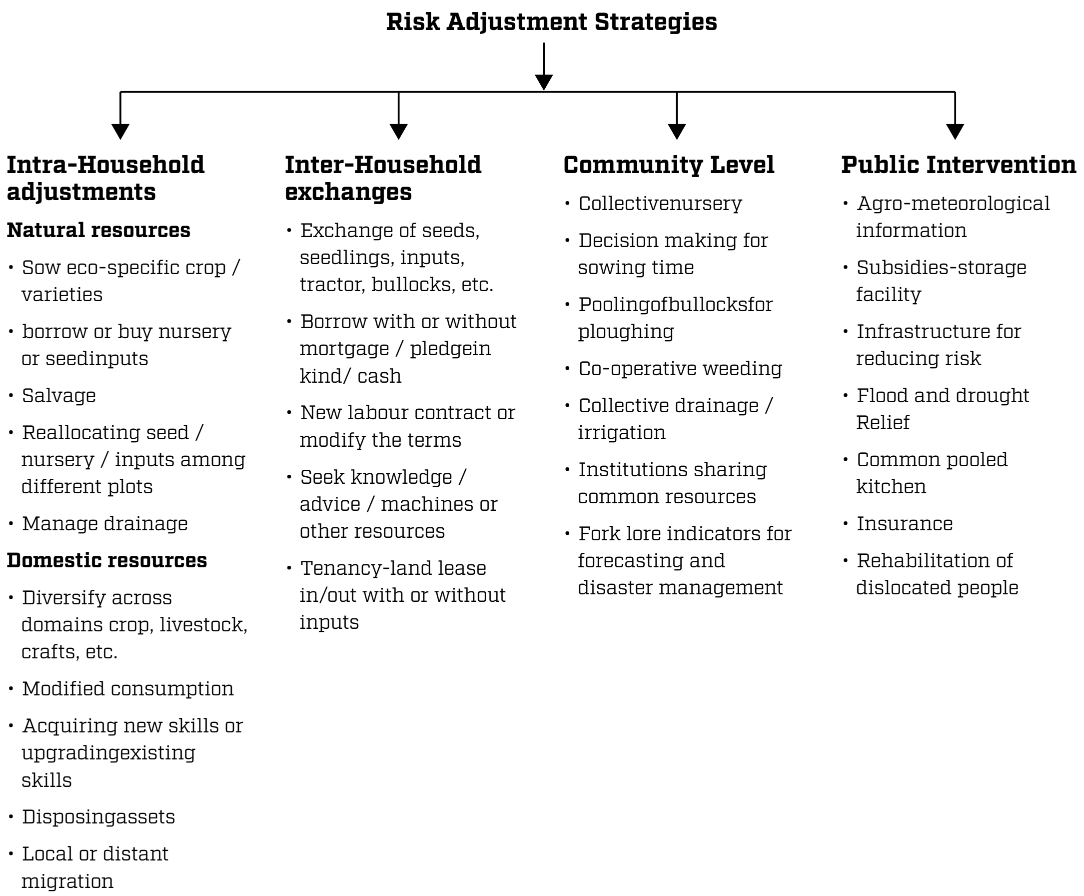

Figure 1: Risk Adjustment Strategies

like words, institutions are like grammar and culture is like thesaurus. Climate change induced risks require access, assurance, ability and attitudes of both, the local communities and institutional support providers, towards ecological resources, technologies, institutions and cultural norms in a given region to be modified to enhance resilience. Unless these changes are circular in nature, that is cradle to cradle, these will not be sustainable.

One of the drivers of frugal innovations is the use of second hard parts for mechanical innovations. These parts have a lot of material strength and life left though the main machine or the vehicle of which these were part originally may have exhausted theor useful life. Thus frugal innovations are circular in nature and reduce, delay or slow down environmental footprint.

22.2 Part Two: Towards inclusive Indian innovation ecosystem

Tapping green grassroots knowledge from different parts of the country was not easy task. A journey begun 25 years ago through the new social movement, viz., Honey Bee Network paved the way for combining eight Es, *"Ethics, Equity, Excellence, Empathy, Efficiency, Environment, Entrepreneurship and Education"*.

The National Innovation Foundation (NIF, www.nifindia.org 2000), Grassroots Innovation Augmentation Network (GIAN, www.gian.org 1997), Society for Research, Initiatives for Sustainable Technologies and Institutions (SRISTI, www.sristi.org, 1993) and recently techpedia.in, (a portal by SRISTI pooling 187,000 engineering projects pursued by 550k students from over 600 institutions) etc., are some of the initiatives of the Honey Bee Network which are transforming the inclusive innovation eco-system in India. NIF has mobilized more than 200,000 ideas, innovations, and traditional knowledge practices, of course not all unique, from over 500 districts in India. More than 745 Patents filed for these creative students, innovator, mechanics, farmers and others institutions have triggered and supported a social movement with the help of volunteers in which many private sector institutions, such as intellectual property protection firms, marketing companies, designer firms etc., are coming forward to join forces.

Several models of innovation have emerged which either reduce risk, improve access or provide support to take risk (ecological, climatic, economic and social). Empathetic innovations are triggered when an innovator internalizes the pain of others, by considering a third party problem as one's own. The Inverted Innovation model applies when children ideate, and innovate; engineers and fabricators design and large companies commercialize these innovations. Deviant (New Scientist, 2007:56, Gupta, 2006) researchers in the formal and informal sector are joining hands to transcend new frontiers of affordability and accessibility through what Prahalad and Mashelkar (2010) call, Gandhian Engineering i.e. getting more from less for many, MLM). Grassroots innovations are unaided, developed by people having no formal training and often no experience from, or affiliation with the organized sector. Given scarcity of material resources, it is inevitable that most grassroots innovations leverage local knowledge resources, which is what they may have in abundance.

When household portfolios are characterized with low mean-low variance (vulnerable) or low mean (or average) income – high variance (most vulnerable) due to inherent socio-ecological characteristics and climatic uncertainties (Gupta, 1981, 1984,1989), they have to compulsively innovate because survival otherwise seems so difficult. The hope is that large and small corporations, public policy makers and R and D institutions will learn new heuristics from the distributed, diversified and developmental nature of such innovations at the grassroots level and trigger, what we call, a G2G (Grassroots to Global) model of reverse globalization.

New pedagogies in management education have to emerge such as courses like ShodhYatra, taught at IIMA for over a decade, reinforcing learning from *within, each other, nature and common people*. A paradigmatic change is in the offing when many large corporations are recognizing that the majority of ideas for the future will come from outside organizations through mass sourcing or crowd-sourcing processes. Forbes made this evident when it used Honey Bee Network's experience to crowd-source content for its January 2011 issue and thus created a new journalistic tradition. It is for this reason that the search for the so-called Fortune at the Bottom of Pyramid (by selling things to poor) was a misplaced paradigm, since it did not consider the Innovative potential at the Tip of the Iceberg. Unless we expand the purchasing power of the poor through this inclusive innovation model articulated by Honey Bee Network, we may continue to sow the seeds of social instability through the systematic exclusion of creative communities from the market (Gupta, 1992, 1995, 2012, 2013).

22.3 Part Three: Emergent Models of empathetic and frugal innovations

Among various motivations and triggers for innovations studied by Sinha (2009), one of the important drivers is empathy (Gupta, 2010). An innovator does not generally take initiative to solve a problem because they personally suffer from it. It is the internalization of problems faced by somebody else, as ones own that becomes a prime driver for an empathetic innovation. Amrutbhai, an innovator who began his life as a farm labourer developed several innovations such as a wheat sowing plate or box, a blade for groundnut harvesting and later a tilting bullock cart to distribute manure in the fields (Honey Bee, 1992). Similarly, Khimjibhai from Sabarkantha district, Gujarat was approached by women tired of carrying water on their heads and thus, having pain in their neck to find a solution. A device to shift a load from the head to the shoulders was developed as a result. Later, he developed a device for scraping gum from thorny acacia plants, which used to cause tremendous inconvenience to the women (Honey Bee. 2000).

Amrutbhai also developed a pulley that drastically reduces the risk of buckets falling into the well while lifting water due to loosening of grip or fatigue. Virendra Kumar Sinha (2009) had a mechanical welding and repair workshop situated opposite a primary school. The noise and the air pollution caused by the 12 HP generator used in his workshop disturbed the children in the school. Neither the school nor his workshop could be relocated. He therefore, invented a pollution control device to improve the learning environment for the children and reduced the smoke and noise pollution for neighbours. Gupta, Patel and Patil (1992) have reviewed more than hundred plants which have been used by local communities for pest control without using chemical, thus making solutions open source, extremely affordable, without negative externalities and highly climate change resilient.

Empathetic innovations can be mediated by several triggers such as articulation of the problem by the people suffering, noticing the third party oneself or, feeling responsible for those affected. Sometimes, a teacher or other intermediary can impress upon an innovator to recognize the need to solve a problem. I had been sharing the problem of tea leaf pluckers in tea gardens for many years. Not many got moved until this problem was posed to the students of CEPT University in Ahmedabad, where students were, a part of their course taught by Astad Pastakia, a former student of mine, required to develop a solution to an unsolved local problem. Later, two groups got motivated through the internalization of the tea worker's problem and developed interesting prototypes. There is a widespread realization that the classical innovation system, based on R&D in the organized sector (corporations and public systems) has failed to take note of many unsolved problems of common people. With rising aspirations and increasing media exposure, a lot of local communities are becoming restive and are not willing to wait indefinitely for their problems to be solved either by local innovators or an external agency. Inclusive or harmonious innovation models require considerable stress on empathetic innovations, although several other motivators may have to be mobilized where empathy alone does not trigger action.

The *Inverted Innovation Model* builds upon the imagination of children to become intolerant with the myriad of problems around them. They may not have the technical competences to solve a specific problem but they can imagine a creative solution. Such ideas have been mobilized by Honey Bee Network for a long time but specifically focus in recent years under the IGNITE Competition. NIF has developed a new model in which children imagine and innovate, engineers and designers fabricate and corporations commercialize. For a long time, the task of innovation has been far too systematized and thus relegated to a professional and specialized group or set of individuals. The experience of triggering innovations not only in India but several other countries such as UK and Malaysia has revealed numerous examples of the Inverted Innovation Model. Let us illustrate. Mayank Walia, a grade nine student thought of an innovation which should have occurred to the specialists in the field years before. The problem was how to expand the reading potential for visually impaired people. A technology of pen-based scanners, which convert printed text to digital text, already existed. So did a public domain technology for converting digital text into speech. Mayank thought of combining these two technologies to enable blind people to read practically any book. This sweep of imagination shows an element of empathy but also a very clever juxtaposition of available solutions. Eighth grader, Nisha Choubey noticed many that, due to overcrowding, there are often not enough places for travelers to sit while waiting at bus stops, airports and railway stations. She thought of integrating a folding seat into a stroller and thus gave rise to a multi functional stroller.

There are numerous other examples where children of class one and higher levels have imagined solutions to the problems with which, we the adults have learnt to live with. This is a trend, which portends well for the future. There can be nothing more reassuring for a society than to have children who are no longer willing to live with inefficiency or inadequacy. Much, of course, depends upon the favourable eco system required for nurturing such ideas. In Malaysia, a similar quest led us to visit a school along with the officials of the Ministry of Science, Technology and Innovation. On the spot competitions for ideas generated numerous examples of children developing new ideas to solve contemporary social and personal problems. Likewise, through a teacher who was walking with us in Shodh Yatra (learning journey), we talked to the young kids in her class who all invented one or another peculiar solution and surprised everybody with their creativity. While children's ideas have long since been scouted, treating kids as potential inventors and innovators for solving social problems is a recent development.

Deviant research (Gupta, 1984, 1998, 2007) has been argued as the process of breaking out of the boundaries of conventional research paradigms both in terms of methodology as well as purpose. Innovations emerging from deviant research follow unconventional methods and approaches. This has now become popular as crowd sourcing, mass sourcing and user driven innovations were conceptualized initially as deviant research by practitioners who realized the limitations of then available methods for discovering new ideas. Honey Bee Network itself began as deviant research more than two decades ago. The importance of deviant research as a precursor for innovations lies in recognizing the limits of disciplinary and sectorial boundaries of innovation organizations. Many large corporations today are acknowledging that majority of the new leads for innovative products and services are likely to emerge from people outside the organization. These may be users, non-users, just observers, supply chain members or even those excluded from the use phase. The concern for frugal, flexible, friendly and extremely affordable innovations arises on account of majority of the poor people having remained excluded from the purview of various commercial and developmental policies, programs, products and processes. The concepts of *reverse globalization* (or g2G, Grassroots to Global) and *innovation insurgent* are offshoots of concern for the excluded.

The much abused term profit at the bottom of the pyramid (BOP) triggered a mindset in which the little savings and purchasing powers available to economically poor people had to be tapped by the large corporations by selling things to them, as Prahalad famously said, even if it meant a one rupee ice cream. Whether the children born in the poor families needed milk to meet their nutritional gaps or eat ice cream became a moot point. It is not surprising such a mindset has led to a situation where almost 40 per cent of children in one of the fastest growing states of India, i.e., Gujarat are found to be malnourished as per the official surveys. This approach did not consider that economically poor people could be at the top of pyramids dealing with ethics, knowledge, institutions or innovations. As we well know, language shapes the habit of thought. By using the BOP framework, we will inevitably discover only the inadequacies of economically poor people and not their strengths. Honey Bee Network was a departure in this context. It focuses on the ideas, institutions, initiatives and innovations in which economically poor people were rich i.e. at the base of economic pyramid (BoEP). That is how a huge database of innovations and traditional knowledge emerged in the last two decades. The fact that thousands of these practices and innovations could help in climate risk adaptation and resilience at individual and community level was ignored. For instance, Harbhajan Singh, a farmer from Hisar, Haryana was recognized by NIF for developing an innovative climate resilient practice of alternate row irrigation in cotton. The water requirement was reduced by half without reducing productivity. The reduced succulence in the plant also led to reduced pest attack and thus the cost of pesticide application.

Reverse globalization and g2G (grassroots to Global) imply creating global markets for grassroots products. Fair trade organizations and companies like the Body Shop did try to pursue such a path with various limitations and potential. In most cases, the poor were the provider of raw materials and seldom of knowledge and ideas. Instead of treating poor as receivers of aid, assistance and help, thinking of them as provider of new ideas, traditional knowledge and creative institutions can change what I refer to as from Sink to Source (Gupta, 2006, 2013). NIF has facilitated the commercialization of several grassroots innovative products around the world. SRISTI has filed patents for such innovators in US with pro bono help from patent firms. If proof of the potential of reverse globalization was needed, it has been provided in abundance. The performance of this potential however remains to be fully tapped. The model of reverse innovation (Govindarajan, 2009; Trimble, 2009; Immelt, 2009; Prahalad, 2009) suggests that innovations developed in resource-starved conditions in developing countries may find applications and market in developed countries as well. Reverse globalization not only implies that innovations developed in the informal sector in developing countries have relevance in global markets in western countries, but also other developing countries.

Within developed countries, there is a scope of grassroots innovations by common people outside the formal sector and this is one potential, which has not been tapped in most developed countries. There are examples where attempts were made to learn from the margins within developed countries. Hiscox and Connor (1939) wrote a book, "Fortunes in Formulas for Home, Farm & Workshop" illustrating numerous examples of local knowledge in grassroots innovations made by farmers, fishermen and women, artisans, etc., for solving local problems. Unfortunately, this did not continue in most developed countries.

The concept of *innovation insurgent* (Gupta, 2007) implies harnessing the qualities of an insurgent for a positive transformative end. The insurgents are irreverent, don't respect the order, establishment or a dominant paradigm, are risk takers, courageous, and do not often care about social approval (though peer approval is still relevant) before embarking upon a new mission. In most developing countries, where the development process is not inclusive enough, youth in marginalized communities become influenced by extremists and may resort to violence prone leftists ideologies. Their choice of violent means is wrong but their ends, i.e., desire for fair and just social order may be valid. It is in such a context, that an eco system for supporting social and economic entrepreneurship based on local creativity and innovation can translate the concept of non-violent, *collaborative innovation insurgents into a peaceful order*.

The socio ecological model of transforming organizations through innovative self-design also needs to be taken forward. Ecological conditions define the range of enterprises whereas the access to factor, product markets, kinship and other non-monetary exchange relationships determine the scale and scope of economic activities. The inherent risk in various enterprises generates the portfolio of choices having high risk - high return, high risk – low return, low risk – high return and low risk – low return (Gupta, 1981, 1984, 1989, 1992, 1995). The implications of household choices for the design of resource delivery system are obvious. Stationary organizations will not be able to serve mobile communities such as pastoralists, fish workers, forest workers, etc. Similarly, organizations designed for high population density regions will inevitably fail to serve the communities in low population density regions. Such fundamental disjunctions in the theory of organizational design and creative aspirations of local communities have begun to receive attention lately (Kate Hanisian & Shiloh Turner, 2015). It is time to ask questions about innovations in the research on innovations. Anderson, Dreu and Nijstad (2004), in fact after reviewing research during 1997-2002, suggested need to "Study innovation as an independent variable, across cultures, within a multi-level framework, and use meta-analysis and triangulation." Most of the studies are focused on innovations in organizations at different levels that occur due to varying motivations. The triggers could be stress, conflicts or hope of positive outcomes. The authors are focused on distress related triggers, which motivate individuals to innovate so as to alleviate distress in the organizations.

22.4 Part Four: Open innovations for enhanced resilience

The review of research by Anderson, De Dreu and Nijstad (2004) also revealed that more than 80 per cent of studies dealt with the replication of extension of existing lines of research and only about 13 per cent could be said to be theory driven. The majority of these studies were field based and not lab based and relied on questionnaire survey. The authors did not find any intervention study during 1997-2002. The search for inducing climate resilience through bridging knowledge of formal and informal sector in open innovation literature poses even a bigger bigger challenge.

22.4.1 Incentives for innovations

The role of prize as a motivator for innovation has received renewed interest in the recent past. Lohr (2011) reviews the experiences of X Prize Foundation, famous for announcing a prize for a low cost private space flight, and Qualcomm for announcing a 10 million dollar competition for a smart phone that could diagnose human health problem as accurately as medical doctors. The US Federal Government passed the America Competes Act in December 2010 authorising government agencies to sponsor prize competitions valued up to 15 million dollars. The US government had listed various challenges at www.challenge.gov with and without prizes to tap the innovative ideas of common people. This is a natural extension of the concept of crowd sourcing and open source softwares within the broad domain of an open innovation model. Lohr recalls a prize of 20,000 pounds being offered by Britain in 1714 (today approximately 4.5 million dollars) to anyone who could develop a device to accurately determine the longitude of a ship. That is how the marine chronometer emerged as an invaluable tool for sea navigation. In 1929, Mahatma Gandhi announced a competition with a 7,700-pound prize to anyone who could improve the design of the spinning wheel. He outlined six criteria of efficiency and cost. The winner was supposed to assign the intellectual property rights of the improved design to the organizers. It is a different matter that such prizes have not subsequently been offered for solving social problems. There is very little research on how different incentives work to promote innovation by common people.

Terwiesch and Xu, 2008 suggest that the potential of an open innovation system generating appropriate solutions through a promise of reward is linked to the type of innovations to be generated. When potential solvers are many, there could be some under investment of effort but with appropriate incentives and multi level or multi round screening systems, effort can be maximized. Mahatma Gandhi set the bar far too high by offering one of the best prizes at that time to intuitively eliminate the chances of under investment of effort. He had also specified the output parameters to prevent frivolous entries. Even without a multi round screening effort, one can offer a substantially large award and get challenging problems solved. In the recent past, a private space flight came about through such an award system. The irony is that such awards are seldom offered for persistently unsolved socio-technical problems.

22.4.2 Open innovation model

In a recent review of users as innovators, Bogers, Afuah and Bastian (2010) built upon the work of von Hippel (1988) about the role of users as innovators. They referred to the earlier example of this kind given by Adam Smith (1776/1999: 114-115) illustrating how a boy who was employed to run a fire engine tied a string from the handle of engine to automate the system and thus got *time to play around*. Enos (1962) illustrates user driven innovation in the oil sector, Freeman (1968) in chemical industry. And Shah and Tripsas (2007) explore the potential of user innovators becoming user entrepreneurs. There are various reasons why users innovate. However, none of the paper indicates the producers of the products sharing the benefits derived from the deployment of user driven innovations in their products with the innovator users. The role of acknowledgement, reciprocity and respect has remained grossly under studied. The issue of intellectual property rights of the users has also been ignored. The authors suggest that the theoretical underpinnings of why users innovate has not been systematically articulated. The role of tacit knowledge triggering user-based innovations is also not adequately discussed. Incentives through enhanced performance are suggested as one of the major drivers of user driven innovation (Riggs and von Hippel, 1994: 459 - 460 in Bogers, Afuah and Bastian, 2010).

There are several questions that this literature review leaves unanswered: Why has the role of non-users but passive observers in generating innovations not been studied? Will the role of a user who continues with the usage vis-à-vis the one who discontinues the use of original device or practice be similar or different in triggering derivative innovations? Why should benefit sharing with the users not be pursued on the grounds of ethics and efficiency? The process of seeking innovations from common creative people who may not be users of the manufactured goods or services but identify the need gap among available technologies has been ignored almost completely. Honey Bee Network tried to bridge this gap since the late 1980's and has spawned a whole new framework of seeking innovations from untrained, often unschooled minds in rural and urban areas with varying motivations.

22.4.3 Crowd sourcing

The concepts of crowd sourcing and mass sourcing were part of outsourcing in open innovation models emerging in the west (Howe, 2006, Chesbrough, 2003, Piller and Ihl, 2009, Hippel and Jong, 2010). The literature, however, remained focused on the need of a corporation or an organization to seek ideas for improving existing products and services. Piller and Ihl (2009) gave an example of the Danish government using user-centered innovation as a national policy (2005). The Indian government had announced the establishment of the NIF (National Innovation Foundation) in the budget speech of the Finance Minister in the 1999 parliament. The Foundation was actually established in 2000. In 2010, it became an integral part of the Government of India's Department of Science and Technology as an autonomous institution. India is perhaps the only country where grassroot innovations and outstanding traditional knowledge practices are part of the National Innovation System since then. With the help of volunteers and institutions such as SEVA (Sustainable – agriculture & Environment Voluntary Action), SRISTI *(Society for Research and Initiatives for Sustainable Technologies and Institutions)*, Hitalgida, etc., by 2000 Honey Bee Network had mobilized about 10,000 innovations and ideas. Over the next decade and a half, supported by a strong volunteer network, NIF (National Innovation Foundation) established a database of 200,000 ideas, innovations and TK practices. While not all of these are unique, a large number are very distinctive and extremely affordable. The Memorandum of Understanding NIF has with the Indian Council of Medical Research and the Council of Scientific and Industrial Research, Indian Council of Agricultural Research etc., facilitate the blending of formal science with informal technologies developed by common people.

Gemunden, Salomo and Holzle (2007) extend the works of Schon (1963) and Howell and Higgins (1990) to stress the role of innovation champions in projects or programs possessing different degrees of innovativeness. They conclude that more than the champions, the open innovators willing to learn from outside the organization, take risks and identify valuable options play an important role in promoting innovations. However, these cases focus primarily on the organized sector.

Wiggins (2010) narrates an interesting model of research collaboration. He referred to it as citizens' science, in which people are involved in scientific research to deal with real world problems. Millions of volunteer participants from around the world can be motivated for distributed knowledge production, as witnessed in open source software. Schenk and Guittard (2009) continue the discussion on crowdsourcing from an organizational perspective using web2.0 and other social network platforms. In fact, in 1998 Eli Lilly company had used the concept of crowdsourcing at InnoCentive drawing upon the knowledge of the crowd for offering solutions to the corporate problems.

Minin, Frattini and Piccaluga (2010) describe the process of open innovation helping a firm during and after the downturn. Laursen and Salter (2005) linked the degree of openness of a firm to its absorptive capacity. By implication, there could be occasions when people's knowledge does not get recognized by public and private organizations because of their lack of absorptive capacity and perhaps ability to share benefits and win trust of the knowledge providers.

Bughin, Chui and Johnson (2008) noticed tension in open innovation model and asked the question as to who owns the intellectual property in the co-created products and services. The McKinsey research suggests that a variety of incentives would be needed for co-creation with customers. Trust in the company is a vital factor. They recognized that the limits of individual voluntarism might be reached sooner than later. A whole variety of licensing models emerged. Earlier work by Honey Bee Network (Gupta, 1997, 2000) advocated a portfolio of incentives combining material or non-material benefits targeted at individuals and communities to fructify in the short- and long term, upfront after commercial realization.

Terez-Luno, Medina, Lavado and Rodriguez (2011) analysed the effect of social capital and the tacitness of the knowledge on the emergence of medical innovations. By itself, social capital does not guarantee higher radical innovations indicating an important role for trust apart from reciprocity.

Dahlander and Gann (2010) look at the openness of the open innovation model. They traced much of the literature beginning with von Hippel's 1988 book but noticed far more citations for Chesbrough's (2003) publication. They recommend that the cost of openness needs to be figured out more thoroughly. The incorporation of external actors for generating innovations within the firm needs to be studied in terms of various processes used to cope with openness as well as competitive environments. They also suggest that management of relationships with variety of sources from which ideas are taken needs to be factored while conceptualizing the open innovation model. A variety of combination of openness, offers seal will need to be evaluated for their respective effectiveness. Gupta (2010) discussed this issue from a slightly different perspective of accessibility of knowledge and opportunity to common people who may only communicate in local language and sometimes only through oral means. In such cases, their participation in the innovation chain will be contingent on the availability of multimedia and multi language tools as articulated by Honey Bee Network at the first Global Knowledge Conference in Toronto in 1997.

Schaffers, et al., (2007) and Marita Holst, Anna Ståhlbröst and Birgitta Bergvall-Kåreborn's (2010) share the view that Openness in Living Labs–Facilitating Innovation deals with the concept of the users, researchers, companies and other stakeholders engaging in voluntary agreements for solving problems. This represents an early stage collaboration for generating systemic innovations involving people in rural areas in a specific domain. It is still an engineered process highly purposive in nature and this purpose is not always autonomously decided but could be steered by specific stakeholders.

Dean [2011] traces the sources of technological innovations in China and highlights the role of mass innovations in the early years of industrialization, particularly in agriculture and decentralized industries. The role of workers for suggesting improvements was clearly identified. The innovations by workers were focused as a legitimate mode of improvement in productivity. The role of design in improving processes and product features began to be stressed in the late 1960's. Currently, innovations by grassroots workers are again being stressed and the design is no longer focused on adaptation but also the local generation of solutions suitable for Chinese conditions (Li Hua, Yu Jiang, Ye Lin, 2010, Zhang Liyan 2013). It is useful to mention that the China Innovation Network [CHIN] was modeled on the basis of the Honey Bee Network based out of the Tianjin University of Finance and Economics [TUFE]. In China, there is a renewed emphasis on harmonious development, which in India is labeled as inclusive development. The exact degree of inclusion or harmony may remain a matter of interpretation but there is a conscious attempt.

The research on knowledge and innovative potential of workers in and out of organizations has remained grossly understudied though various authors have drawn attention to this lacuna from time to time. Yanow (2004) articulated this very sharply:

In principle, these workers develop knowledge in interaction with clients and customers that could be valuable to the organization, were it but to learn from them. Instead, the 'local knowledge' they learn in acting across these peripheries *is discounted, if not disparaged (emphasis mine)*, by more centrally-located managers and executives. The article theorizes about the nature of translating local knowledge concerning organizational practices and about the structural character of local versus 'expert' knowledge.

She sums up the tension as:

The problem appears to be old, recurrent, and structurally entrenched. Given the extent to which the language of 'organizational learning' has caught on in recent years, it is possible that describing the problem of the disparagement or disregard of local knowledge in these terms may work to change the nature of management practices in this regard. If the problem is located in the societal value attached to expertise, changing the situation will require a change in the working definition of 'expert' and expertise and a re-privileging of local knowledge. Such an approach would engage questions of power and the hierarchical structuring of work and the workplace, a source of potential resistance. If the problem is located in the societal value attached to 'Science' and technical rationality made through rhetorical argumentation, then change may require a counter-rhetoric of value. Here, perhaps, is where there might still be a role for 'culture' in talking about organizational learning, in that it enables an argument for the values of experience and local knowledge as sources of expertise.

Earlier, Nilsson [1995] highlights the process through which the scattered knowledge accumulated by the workers in the process of solving local problems, often learning-by-doing, was organizationally neglected but informally networked by the workers themselves. It was so vital for their continued efficiency. It is argued that in several specific circumstances, “skill innovations by workers can be an important source of technical advance.”

It is apparent from the review that there are several factors which have led corporations to look outward in seeking solutions to their problems. The fact that most of them did not explicitly involve workers in the solutions seeking process implies continued neglect of the potential the workers have for developing ‘expert knowledge’. Many times, this expertise evolves through innovations. Stuart McDonald [1983] had shown through a study of sales notices of slaves during the 19th century England that some owners of slaves highlighted their highly skilled status and innovative potential while advertising them for sale. It is ironic that when workers were treated as a commodity, their creativity found value but after their incorporation as colleagues, the explicit attention towards their creative potential declined. Open innovation models have improved the ability of corporations and public systems to seek ideas and innovations far more easily and in a more diverse manner than before. But the limitations of such models are: [a] attribution, reciprocity and benefit sharing with the idea providers remain a contentious issue; [b] while looking outward, the degree of openness has been subject to access to tools, techniques, platforms and other kinds of knowledge domains.

The asymmetry in access invariably makes the so-called open systems less open; [c] the methods of incentivizing the common people and experts to share their solutions has yet to be empirically tested so as to produce a body of knowledge that can link formal and informal systems of knowledge productions, exchange and augmentation; and [d] the focus is far too much on seeking solutions to the predefined problems instead of treating open source or proprietary solutions developed at the grassroots level as indicators of problems being faced by the society [and thus worthy of solution]. The design of similar platforms for sourcing climate resilient grassroots innovations has led SRISTI to collaborate with UNICEF around UReport (as HoneyBeeReport) and RapidPro platform, to promote horizontal real time interactions among knowledge producers innovators, children, students and eventually other commercial and non-commercial organizations. It is hoped that corporations and other formal sector systems will see in open innovation system, a need for reciprocity towards the common people from whom climate resilient innovations are sought and learned from.

22.5 Summing up

Grassroots innovations have triggered several fundamental changes in the way national systems of innovations are viewed, articulated and conceptualized. It is no longer possible to characterize national systems of innovations as dealing with formal sector Research & Development only.

Open innovation models influenced by early models of user driven or user centric innovations still retain focus on problems defined by the organizations at it’s managerial level. The involvement of workers as problem solvers or as mobilisers of social insight might have brought about greater connect between organizational strategies and the ideas of unorganized workers. Similarly the idea of involving climate change affected people in generating new solutions has not picked up a great deal though attempts in that direction have started[15]. But this has not happened as yet to a significant extent. Several models of innovations have emerged which warrant further work to test their empirical validity in different cultural and institutional contexts. The available evidence from Honey Bee Network’s activities in China and other countries indicates some potential

15 http://www.wfp.org/climate-change/innovations downloaded on Nov 3, 2015, provides the efforts of world food program but one can not find many examples of technological or informal institutional innovations at the site. Rockefeller Foundation issued a call launched in 2014 for livelihood innovations for building resilience. If it had built upon the learning from Honey Bee Network, the results could have been not only more extensive but also achieved more frugally. https://www.rockefellerfoundation.org/blog/exploring-innovative-solutions-to-resilience-building/ downloaded on Nov 3, 2015. USAID launched a partnership with three NGOs including SRISTI to share the experience of grassroots innovators from India to enable Kenyan farmers to cope with risk better and use resource more efficiently; see www.sristi.org/cms/sristi-usaid and ‘USAID announces three partnerships for low cost agricultural innovations’, http://timesofindia.indiatimes.com/business/india-business/USAID-announces-three-partnerships-for-low-cost-agricultural-innovations/articleshow/24982827.cms, Oct 31, 2013

for these ideas and philosophical foundation to work cross culturally.

The inverted model of innovations, particularly empathetic innovations generates a new idea of involving young children as a source of ideas about the world they want to live in. Sustainability is likely to be higher in models that take into account the aspirations of future leaders of our society. The empathetic innovations emerge in socio-ecological contexts and can be a powerful source of generating climate resilient solutions for communities prone to risk. A model of inclusive or harmonious development in which the focus is far too much on one's own problem as a valid trigger for innovations needs to be tempered by a samvedansheel dimension so that innovations are triggered by internalizing others' problems as one's own.

The slowdown in economic growth in the recent past has further underlined the need for rethinking developmental approaches. The conventional models of corporate social responsibility or philanthropic approach to address problems of social iniquity, continued drudgery by women and other workers and lack of fair opportunities for developing one's talent will not work any more. It is borne out by the fact that there is almost total disconnect between the largest database of green grassroots innovations and such pursuits of larger organizations and public policy makers in various fields including climate change resilience at local level.

Absence of certain linkages speaks volumes about the chaasm between philosophies of dominant foundations/bodies and policy structures and their accountability and assimilation of the perspectives from the grassroots. I have argued that linkage between formal and informal science and organizations of knowledge, innovation and practices can spawn a huge new ground of creativity, compassion, and collaboration for dealing with increasing climate, market and institutional risk and uncertainty in the lives of economically-poor but knowledge-rich poor people.

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Daniel Barcza & Bori Feher

23 Design for Disasters

“The most important ability that a designer can bring to his work is the ability to recognize, isolate, define, and solve problems” Viktor Papanek

23.1 Introduction

As this chapter is being written Typhoon Haiyan, a category 5 storm, has reached the central islands of the Philippines and destroyed almost all cities and villages in the region killing more than 6 thousand people and forcing 4 million to leave their homes.[16] Some experts estimate that this was the strongest storm ever making landfall.[17] Two months before that Cyclone Phailin a category 4 storm swiped through the coasts of India and at the same time Typhoon Wipha triggered severe storms and landslides in Japan. Pictures and video footage of destroyed villages, collapsing houses and grieving people quickly reached us through media channels, sometimes even faster than first response teams and relief organizations got on the site. In front of our TV screens we are confronted with more and more disasters both by in numbers and in scale. Is it a real trend, and if so what can be done and how could design help to resolve these issues?

Statistical evidence shows that the number of disasters has been dramatically rising in the last forty years and this trend is closely related to global climate change. With the growing trend of natural disasters humanity is facing a huge challenge for the future. Global population growth, rapid urbanization and increasing urban poverty – key factors increasing vulnerability – also worsen the impacts of disasters. We might think that the hundreds of humanitarian organizations and the billions of development funding are sufficient resources to tackle the issue. However, according to many international organizations such as WHO, IFRC, Oxfam and others traditional disaster prevention and relief approaches many times fail to give complex, long-term solutions to the affected communities. In the last decade a certain aspiration can be experienced in the field of humanitarian affairs to regard disasters as an opportunity window to improve life standards, resiliency and sustainability of a given community and introduce new development oriented practices.

So why and how can design be relevant in the issue? Do we really need more futuristic rescue vehicle concepts and another transformer-like disaster shelter that can be unfolded from a Swiss army knife with the price tag of a luxury apartment? Surely not. But new and complex challenges require approaches that are able to step out of the traditional framework, give new perspectives and provide holistic and human-centered solutions in the long run. And this is exactly what design is good for.

23.2 General trends of natural disasters

Disaster is defined as “a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering”[18] by the Centre for Research on the Epidemiology (CRED). Two categories are generally distinguished: natural and technological disasters. Although technological disasters can also be related to sustainable design, this chapter focuses on natural disasters from the aspects of climate change. EM-DAT, the International Disaster Database, categorizes natural disasters like earthquakes, landslides, storms, floods, extreme temperature, drought,

16 CRED, (2014) CRED Crounch: Disaster Data, A Balanced Perspective, Issue No.34. January 2014.
17 OCHA (2013) Phillippines: Typhoon Haiyan, Situation Report No.23, as of 13 December 2013.
18 Guha-Sapir D., Hoyois P., (2012) Measuring the Human and Economic Impacts of Disasters, Brussels, Centre for Research on the Epidemiology of Disasters

wildfire and epidemics in five sub-groups: geophysical, meteorological, hydrological, climatological and biological.[19] Almost all types of natural disasters can be triggered by climate change.

General statistics tell us that in the last decade natural disasters had huge human, infrastructural, economic and social impacts around the world. In 2012 alone, 357 natural disasters were registered, killing almost 10.000 people, leaving more than 100 million victims behind and causing an estimated economic damage of US$ 157 billion.[20] In the last fifty years the number of disasters has increased six-fold, 90% of which were hydro-meteorological events such as storms, floods and droughts.[21] It is hard to link a specific disaster to climate change but based on strong scientific evidence and statistics we can assert that climate change will further increases these trends. The IPCC 2012 Special Report (SREX) points out that "a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events."[22] In the future we can expect more frequent and more severe rainfalls, storms, floods, landslides, glacial lake outburst floods, heat waves and droughts. Glaciers will further retreat, arctic sea ice will shrink, the permafrost will melt and sea level will continue to rise.[23] All of these contribute to the growing number of natural disasters.

It is not only the increasing number and intensity that determines the impact of a natural disasters but also the exposure and vulnerability of the affected community. Substantial growth in global population, rapid urbanization and growing urban density increase exposure to risks.[24] Today more than half of the world's population lives in cities and by the mid of the 21st century this proportion will reach 70%, as projected by the World Bank.[25] It is enough to remember New Orleans, New York or Port-au-Prince to realize that our expanding cities are not particularly planned and designed for natural disasters. Most of our megacities located near to oceans or river estuaries and will be increasingly exposed to hurricanes, cyclones, sea surges and sea-level rise in the future. According to the projection of the World Bank, population of large cities exposed to natural disasters will double by 2050.[26]

Besides growing population and density, poverty is also a strong factor that increases vulnerability. In most cases low-income people can only afford to live in lands that are undesirable for others, the cheapest marginal locations and wastelands like flood plains, steep hillsides where risk of disasters is much higher.[27] In Indonesia, every year quarter million people move to the slums of Jakarta, located near to canals, rivers and low lying lands, exposed to annual floods. These communities live in constant threat and in lack of proper income, adequate urban infrastructure and basic services; therefore are extremely vulnerable to disasters.[28]

Despite the international efforts to eradicate urban poverty, the number of slum dwellers is increasing. By the end of this decade every seventh person will be living in slums neither with sufficient sanitation, water or electricity supply, nor proper health care, child

19 Guha-Sapir D, et. al., (2012) Annual Disaster Statistical Review 2012: The Numbers and Trends, Brussels: CRED
20 Guha-Sapir D, et. al. (2013)
21 Guha-Sapir D., Hoyois P. (2012)
22 IPCC (2012) Summary for Policymakers In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, Field, et al., Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA
23 IPCC (2013) Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Stocker et.al., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
24 Sendai Report (2012) Managing Diasaster Risks for a Resilient Future, The World Bank, Washington D.C., USA
25 Daniel Hornweeg et.al. (2011) Cities and climate change: responding to an urgent agenda, The World Bank, Washington, USA
26 The World Bank and The United Nations (2011) Natural hazards, unnatural disasters: The economics of effective prevention, The World Bank and The United Nations. Washington D.C. USA
27 Baker, J. L. et.al. (2012) Climate Change, Disaster Risk and the Urban Poor: Cities Building Resilience for a Changing World, The World Bank, Washington D.C., USA
28 The World Bank (2011) Jakarta, Urban Challenges in a Changing Climate, Mayors' Task Force On Climate Change, Disaster Risk & The Urban Poor, The World Bank, Jakarta, Indonesia

care, education or other basic services.[29] Their number is expected to double by 2030.[30] When subsistence in everyday life is already a struggle there is little hope that a community can tackle a disaster and reduce its impacts.

It is not a question that the biggest impact of a disaster is always the loss of human lives. Since 1970 natural disasters caused 3.3 million deaths around the world.[31] Due to different factors discussed above, human impacts are disproportionately higher in poor countries. While the average number of disaster fatalities in developing countries is around 1,000 this number barely exceeds 20 in rich countries.[32] In 1998 Hurricane Mitch a category 5 storm in Central America claimed more than 11,000 lives by catastrophic flooding and landslides, mostly in Honduras, Guatemala and Nicaragua.[33] By contrast Hurricane Katrina in the United States with the same size and strength as of Hurricane Mitch caused five times less fatalities.[34] These numbers represent general trends that many reports point out: lower economic development and higher rate of vulnerability result in higher human impact in a disaster. As the SENDAI report of World Bank asserts: "Disasters discriminate against the most vulnerable".[35] But there is good news, the number of deaths has decreased in the last ten years thanks to international humanitarian effort in disaster risk prevention, management and relief.[36]

In contrast to the trend of human impacts that is slightly improving, economic and infrastructural damages show worsening trends: in the last decade economic costs of natural disasters has increased eightfold. The costliest year was 2011 so far, when the Japanese earthquake and tsunami generated US$ 216 billion damage. In comparison Hurricane Katrina accounted for US$ 146 billion, Hurricane Sandy for US$ 50 billion and the devastating earthquake in Haiti for US$ 8 billion damage.[37] These numbers cannot be assessed without the context of the national economies. While the Japanese tsunami, the biggest ever registered economic loss was responsible for only the 4% of the country's GDP, the relatively low price of the Haiti earthquake accounted for more than the 100% of the GDP.[38] [39] Many reports point out that in poor regions lack of assets, in rich countries sufficient resources prevent the costs of disasters climbing high. Economic impacts are often the worst in the middle-income economies, where lack of sufficient financial resources prevent the country to save the relatively developed infrastructure and assets.[40] [41]

There are many more incremental impacts of natural disasters besides immediate, direct, human and economic loss such as epidemics, increased water and air pollution, soil contamination, water and food shortages, disruption of basic services, loss of livelihoods, fragmentation of communities and families. These secondary impacts often trigger other problems such as local conflicts, internal displacement, migration, disruption of local economies and local culture that have strong and long lasting implications.

23.3 Disaster relief approaches

Disasters and their impacts are determined by many factors and impose complex and multi-faceted challenges both in the short term and in the long run. So how can these ever-unique emergency situations be tackled? There are many different approaches how relief organizations react to such challenges. Traditional hard relief approaches focus on saving lives, reconstructing physical infrastructure and providing basic services in a centralized top down method. By contrast, recent soft

29 UN-HABITAT (2010) State of the World's Cities 2010/2011, Bridging the Urban Divide, Overview and Key Findings, Nairobi, Kenya
30 Baker, J.L. et al. (2012) Climate Change, Disaster Risk, and the Urban Poor - Cities Building Resilience for a Changing World, The World Bank
31 The World Bank and the United Nations (2009)
32 OXFAM (2009) Right to Survive, Oxfam International
33 Pilke, Jr. R.A. et.al. (2003) Hurricane Vulnerability in Latin America and The Caribbean: Normalized Damage and Loss Potentials, National Hazards Review
34 Knabb R.D. et.al. (2005) Tropical Cyclone Report Hurricane Katrina 23-30 August 2005, National Hurricane Center
35 SENDAI report (2012)
36 Guha-Sapir D., et.al. (2012)
37 Guha-Sapir D., et.al. (2012)
38 SENDAI report (2012)
39 Cavallo E., Noy I. (2012) The Economics of Natural Disasters, A Survey, Inter American Development Bank
40 SENDAI report (2012)
41 The World Bank and the United Nations (2011)

approaches emphasize prevention, involvement of local communities in reconstruction and increasing local resilience.

These two approaches can be demonstrated in the case of the 2010 Haiti earthquake, during which 70% of the houses have been destroyed in the capital and almost half of the country's population has been directly affected.[42] The massive scale of the destruction demanded the largest international humanitarian response in history, involving 140 countries and more than 500 organizations.[43] The day after the first shockwaves joint US Forces launched their military relief operation. In the next five months they took charge of air traffic control, coordination of all rescue operations, technical and medical assistance with a top-down military protocol.[44] Although the operation called Operation Unified Response did a great job to stabilize the emergency situation in the short term, many reports have criticized its short sighted wartime logic. In the case of medical assistance for example, the principle of efficiency demanded a large number of limb amputation among victims. The estimated 200.000 amputations will have a massive long-term impact in the recovering economic and social structure of the country.[45] [46]

In contrast to the top-down military approach, Architecture for Humanity, a US established international humanitarian NGO has initiated an open source, community based relief project focusing on designing and rebuilding community facilities such as schools, clinics, community centers and small businesses. These facilities can help to restore and strengthen local communities' social, cultural and economic resilience both in the mid and long run.[47] Obviously, lifesaving and physical recovery is always top priority, but as Oxfam emphasizes: restoring is not enough, the goal has to be to rebuild a better, more equitable and resilient Haiti.[48]

The goal of the traditional hard approach is to secure the basic standards of human existence in a situation when victims and community cannot secure it themselves. It prioritizes saving lives, restoring physical infrastructure and providing basic goods and services such as clean water, sanitation, food, nutrition, and shelter.[49] As life standards differ from place to place, Sphere Project an extensive collaboration of many NGOs defined the universal minimum standards that relief operations have to achieve when responding to an emergency, including strong design standards.[50] This normative approach is essential in short term stabilization efforts, but might have a lock-in effect in socio-economic terms, conserving poverty and vulnerability in developing regions. Besides that, most relief organizations operate in a top-down method, where victims are regarded as passive beneficiaries of the procedure and are excluded from the process, many times resulting in inadequate solutions for the affected communities.

Parallel to traditional technical oriented approaches, new development focused paradigms have appeared in the last decade. The building back better models see disasters as opportunity windows for long-term positive change and development in socio-economic terms, based on the involvement of the local community.[51] [52]

42 SENDAI report (2012)
43 Cecchine, Gary, et. al. (2010) Rand Aroyo Center, The U.S. Military Response to the 2010 Haiti Earthquake
44 Cecchine et. al. (2010)
45 Medicins Sans Frotieres (2011) Haiti One Year After, Medicine Sans Frontiers
46 Phillips, Tom, (2010) Haiti earthquake creating a generation of amputees, doctors warn, The Guardian Retrieved from: http://www.theguardian.com/world/2010/jan/21/haiti-doctors-warn-amputee-crisis, 11.02.2013

47 Sinclair, C. (2010) Haiti Quake: A Plan for Reconstruction, Architecture for Humanity, 2010 http://architectureforhumanity.org/updates/2010-02-18-haiti-quake-a-plan-for-reconstruction, Web, 10.02.2013.
48 Oxfam (2010) Briefing Paper 136., Haiti: A Once-in-a-Century Chance for Change Beyond reconstruction: re-envisioning Haiti with equity, fairness, and opportunity, OXFAM International
49 United Nations High Commissioner for Refugees (2007) Handbook for Emergencies, Third Edition, Geneva
50 The Sphere Project (2011) Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response, Geneva
51 World Health Organisation (2013) Building Back Better, Sustainable Mental Health Care after Emergencies, WHO
52 Gupta, M. et. al. (2010) Build Back Better for Next Time, UNISDR Secretariat Asia and Pacific, Bangkok

Some of the key tools of this are owner driven reconstruction and community based reconstruction, two decentralized participatory process promoted by IFRC and Practical Action.[53] [54] Target groups and beneficiaries can be even more specific to improve social inclusion of minority groups. Women's Refugee Commission and the World Bank promote incorporation of gender aspects in the recovery process as women are often underrepresented in post disaster reconstructions.[55] The World Health Organization has recently issued a report focusing on mental health aspects of post disaster situations and it points to the underlying opportunity of mental health reform through building back better practices.[56]

After Hurricane Sandy affected New York in 2012, Architecture for Humanity's New York Chapter (s) started a detailed assessment to understand the post-disaster context of each neighborhood. The Post Sandy Neighbourhood Assessment Project focused primarily on owners' and communities' needs, which is a different approach to the traditional post-disaster assessment of physical infrastructure damage. Before starting their user-centered, collaborative rebuild project, the NGO aimed to get a clear understanding of the human and community aspects of the situation. Representatives of AFHny, such as one of the writers of this chapter and trained volunteers interviewed residents and community leaders in the affected areas and collected data. Based on the information, ideas and pilot programs were initiated for a human centered neighborhood reconstruction process that keeps resilience in focus: building retrofits, adaptation, soft infrastructure redesign and most importantly capacity building of local communities for future disasters. AFHny in collaboration with other organizations created a Q&A platform the Sandy Help Desk, which is ran by architects voluntarily. Here homeowners can ask professionals about resilient building reconstruction practices.

Different disasters and different phases of relief call for different priorities, tools and approaches. But in the heart of each situation there are communities and individuals who need solutions for problems. These solutions are more likely to be appropriate and accepted by local communities, when local people are involved, and are based on a bottom-up procedure, as the Refugee Study Centre at the University of Oxford argues: "This approach can foster sustainable solutions based on self-reliance".[57]

23.4 The relevance of design

"The most important ability that a designer can bring to his work is the ability to recognize, isolate, define, and solve problems"[58] wrote Viktor Papanek in his famous book, Design for the Real World in 1971. During the second half of the last century the work of Papanek and others like the American architect and inventor Buckminster Fuller or the economist Ernst Friedrich Schumacher demonstrated that design is much more than styling and creating more appealing products, it is primarily to provide solutions for the real needs of people. They demonstrated how simple and affordable technology combined with innovation and design thinking can help to resolve global challenges like environmental issues, poverty or humanitarian crises, and thus change millions of lives.

Despite Paul Polack's assertion at the turn of the century, that the "90% of the world's designers spend all their time working on solutions to the problems of the richest 10% of the world's costumers"[59] a certain change can be experienced in the field of design. In the last two decades there is a growing number of designers, architects and artists taking social and ecological responsibility. The focus is slowly shifting from mainstream issues towards new problems like rural and ur-

53 IFRC (2010) Owner-Driven Housing Reconstruction guidelines, International Federation of Red Cross and Red Crescent Societies, Geneva
54 Ruskulis, Otto, et.al. (2010) People-Centered Reconstruction: An Introduction, Practical Action, IFRC
55 World Bank (2011) Integrating Gender Issues in Recovery and Reconstruction Planning, Guidance Note 5.
56 WHO (2013) Building Back Better Sustainable Mental Health Care after Emergencies, WHO
57 Betts, Dr. A., Bloom L. (2013) The two worlds of humanitarian innovation, Working Paper Series No. 94 Refugee Studies Centre, Oxford Department of International Development, University of Oxford
58 Victor Papanek (1971/2011) Design for the Real World: Human Ecology and Social Change, Thames & Hudson, London
59 Paul Polak (2008) Out of Poverty – What Works When Traditional Approaches Fail, Berrett-Koehler Publishers, San Francisco

ban poverty, environmental destruction and from traditional methodology towards new approaches. As Kigge Hvid, CEO of INDEX: Design to Improve Life says, there is no need for designing more white teacups.[60] Since 2002, the INDEX Award has been showcasing products and services that can change the life of millions, many of them designed for the case of an emergency and disaster. In America, Smithsonian's Cooper-Hewitt National Design Museum has organized the Design for the other 90% exhibition in 2007, focusing on addressing the basic needs of the global population, showcasing many design solutions for disasters. The same year Singapore Design Festival chose Design&Disasters as its central topic.

By now, many design and architectural books are available with design for disaster and design for poor communities in focus. Design Like You Give a Damn 1-2 from Architecture for Humanity[61] [62], Design revolution from Emily Pilloton[63], Beyond Shelter by Marie J. Aquilino[64], and Worldchanging from Alex Stephen, just to mention a few, collect fine examples how architecture and design can help in disaster situations. There are also many online platforms to share information, projects and knowledge like design4disaster.org developed by Econcept and Ecosense or Uniting Designers in Disaster, an initiative for open dialogue between designers and humanitarian professionals by ICSID. This online platform has been launched after the devastating earthquake in Haiti and is still functional in the form of a Facebook page. It has been used during recent large disasters like the Chilean Earthquake, the Japanese Earthquake and Hurricane Sandy.

Obviously the public and professional attention is always higher after large disasters. Following the devastation of the Indian Ocean tsunami in 2004 and Hurricane Katrina the next year, Architecture for Humanity (AFH) announced a series of design competitions and started many reconstruction projects. Since then AFH responded to all of the major natural disasters including Cyclone Nargis 2008, Haiti earthquake 2010, Japanese earthquake 2011, Hurricane Sandy 2012 just to mention a few. In the wake of the earthquake and tsunami in Japan many professionals from architects to graphic designers took action. Milton Glaser, a graphic designer of the enigmatic I love NY logo, has initiated the Rise for Japan poster campaign in collaboration with AFH, in parallel to the fundraising campaign called Ventilate Japan by Michael Brown for the Red Cross. Shigeru Ban architects helped to design multi-story temporary housing made of containers and a paper tube partition system for evacuation facilities. After the 6.3 magnitude earthquake in New Zealand in 2011 the Japanese architect's office created a temporary Cardboard Cathedral in Christchurch that replaced the collapsed cathedral of the city.

As the risk of tropical storms is increasing in New York, in 2008 the NYC Office of Emergency Management, in partnership with the Department of Design and Construction, the Rockefeller Foundation, and AFH announced the "What If New York City …" design competition in search of innovative design solutions for post-disaster provisional and temporary urban housing in case of a fictional storm disaster. Four years later the storm that has been imagined struck: it was called Sandy. In 2013 the American Institute of Architects (AIA), in partnership with the Make It Right Foundation and AFH announced its Designing Recovery ideas competition for rebuilding sustainable and resilient communities.

But designing improved shelters, community centers, more efficient rescue tools, cheap water purifiers, better communication systems and other products for disaster is not the only way that design can contribute to disaster prevention, relief and recovery. The ways and methods how these products are created can be equally valuable for non-designer professionals in social and humanitarian innovation. In his book in 1971, Papanek examines different ways of thinking. He compares for example the routine thinking of engineers when the correct answer is looked up in some technical manual, to the creative thinking of designers which is a "systematic, solution-directed search for a new way

60 Index, Design to Improve Life, Retrieved from: http://designtoimprovelife.dk/history/, 07.11.2013.
61 Architecture for Humanity, ed. (2006), Design like You Give a Damn: Architectural Responses to Humanitarian Crises, Metropolis, New York
62 Architecture for Humanity, ed. (2012) Design Like You Give a Damn [2]: Building Change from the Ground Up, Abrams
63 Pilloton, E. (2009) Design Revolution: 100 Products that Empower People, Metropolis Books, New York
64 Aquilino, M. J. (2011) Beyond Shelter: Architecture and Human Dignity, Metropolis Books, New York

of doing things."[65] It is not a question that in the case of an emergency routine thinking and protocols are key elements of efficient response. However, new and complex challenges require more holistic and outside-the-box approaches. As Papanek describes: "the number of problems, as well as their complexity, have increased to such an extent that new and better solutions are needed."[66] As we saw in the first part of this chapter it applies to natural disasters as well. The number and complexity of disasters is increasing and that requires humanitarian organizations to break out of the traditional frameworks. This is where design thinking can play a major role.

In the last ten years design thinking has become a buzzword in the business sector as a highly efficient method to generate innovative business models, services and strategies. In an article in the Harvard Business Review Tim Brown, CEO of IDEO, explains how design thinking helped to redesign strategies and services for large banks or health care providers.[67] However, this method is not only successful in the for-profit sector but also in the non-profit sector. In collaboration with the Bill and Melinda Gates Foundation and the International Development Enterprise, IDEO developed the Human Centered Design Toolkit for NGOs and social enterprises working in developing countries to help them understand the needs of local communities in different parts of the world and provide viable and innovative solutions for complex challenges.[68]

In the last decade the innovation turn has reached the humanitarian sector and design thinking can be a key component of change, argues a recent research from the Refugee Study Centre at the University of Oxford. Reinventing whole organizational structures, changing methodologies, shifting focus from top-down to bottom-up approaches and practices, require different way of thinking and working. As authors of the research assert: "design thinking [...] offers a holistic methodology to combine skills from multidisciplinary teams and to consider local systems in the design of a whole process".[69]

23.5 Teaching Design for Disasters

Natural disasters impose a growing challenge around the world. They have so complex impacts both in short and long terms that traditional problem solving techniques and approaches sometimes fail to give complex answers to them. We have seen in many examples that design can have a strong relevance in tackling the issue.

Design can help to create better tools, products, buildings, systems and services for affected people or professionals working on the site. It can help to explore and answer the human aspects of a situation. It can help to raise awareness and mobilize people to help. It can help to reinvent old strategies, methodologies and workflows within professional organization. It can help to innovate when resources are scarce. It can help to give a holistic problem solving methodology in extremely complex challenges with many stakeholders and priorities. These are just a few of the potentials of how design and design thinking can contribute to solving disaster challenges.

If it is so clear that design is a perfect tool to tackle this issue, and clear, that the issue is urgent and relevant, then why Design for Disaster (DfD) education is not a fundamental part of general design education? Design universities have departments for Contextual Design, Interaction Design, Service Design, Information Design and many other specialized programs that reflect to the contemporary challenges of our decade. But what is the case with DfD? Anyone who taught at a design university knows that drawers are full of idealistic design concepts for fictitious disaster situations. Students embrace those projects that have a sense of save-the-future idealism and design departments happily introduce such topics to ornament their curriculum. However these short courses, diploma works and competitions are most of the time just ad-hoc projects

65 Papanek, 1971/2011.
66 Papanek, 1971/2011.
67 Brown, T. (2008) Design Thinking, Harvard Business Review, June, 2008. p. 84-92
68 IDEO, Human Centered Design Toolkit, Retrived: http://www.ideo.com/work/human-centered-design-toolkit/, 10.11.2013 Betts, Dr. A., Bloom L. (2013) The two worlds of humanitarian innovation, Working Paper Series No. 94 Refugee Studies Centre, Oxford Department of International Development, University of Oxford
69 Betts, Dr. A., Bloom L. (2013) The two worlds of humanitarian innovation, Working Paper Series No. 94 Refugee Studies Centre, Oxford Department of International Development, University of Oxford

without any precedent or connection to the core studies, without proper theoretical and practical knowledge transfer and without collaboration with other disciplines or professional organizations. Luckily there are some rare and refreshing exceptions. Every year the Harvard Graduate School of Design runs courses with urban resilience and urban disasters in focus[70]. Pratt Institute also included DfD and Resilience in their curriculum.[71] MIT has been running numerous research projects like, Tsunami SafeR House project[72] that has tangible and usable outcome. Shelter Project, an extensive research on transitional shelter design, has been initiated and developed by Cambridge University, now operating as the Sheltercenter organization[73].

One of the most interesting initiatives is the recently started MA program of Universitat Internacional de Catalunya in Barcelona called Master of International Cooperation: Sustainable Emergency Architecture in collaboration with Technische Universität Darmstadt, Università di Roma Tor Vergata, Université Pierre-Mendès-France Grenoble and with many relevant relief organizations. The one year program focuses on how to rebuild communities after disasters, conflicts or economic crises, and is dedicated primarily to architects and urbanists.[74]

So how to start Design for Disasters education? Moholy-Nagy University of Art and Design Budapest (MOME) initiated an interdisciplinary research group called MOME EcoLab four years ago, to start project based research in sustainable design. Experiencing local challenges in Hungary, MOME EcoLab developed a Design for Disasters working group, where architects, landscape architects, product designers, textile and fashion designers, graphic designers, photographers work together with disaster experts, development NGOs, sociologists, economists and educators to build a solid pool of knowledge, competence and run projects. In collaboration with the UNHCR global refugee agency MOME EcoLab is now working on redesigning some of the basic relief items that UNHCR provides in refugee camps: tents, sleeping mats, kitchen sets, stoves, semi collapsible jerry cans, water buckets and solar lanterns.

Parallel to that, MOME EcoLab is working in the Bódva valley, a remote part of Hungary, where first negative impacts of climate change can be experienced, natural disasters like floods and droughts cause more and more damages. Students and young professional from MOME coupled with local people to strengthen the resilience of the local communities living in extreme poverty. MOME EcoLab is now working to create a community center, called Cloud Factory, where both designers and local people can learn from each other, work and act together. After many dead ends with that traditional teaching methods, MOME EcoLab and the Cloud Factory now seem to be right platforms for interdisciplinary and multi-stakeholder dialogue, capacity building and knowledge transfer in the field of design for resilience and design for disasters. For MOME the true challenge is now to integrate this parallel running program in the curriculum and develop an interdisciplinary Design for Disasters or Humanitarian Design master program with international partners.

The World is rapidly changing and new problems confront us. Disasters and their impacts impose a growing challenge to designers, architects and creative professionals too. Are they ready for the challenges? Are they equipped with the sufficient background knowledge, competencies, methods and experience? Design provides powerful tools to resolve extremely complex problems, however there must be competent people behind those tools. We need to stop seeing Design for Disaster (DfD) as an eccentric pastime activity of idealistic students or burnt out creatives.

We need to stop considering DfD as a sexy and exotic topic to shake up the dusty curricula of academic programs. Instead DfD needs to be regarded as integral part of the design profession. Design universities must take the role and start systematic DfD education, research and innovation. Disasters are not local issues any more, international joint courses and programs need to be started whit the collaboration of different profile universities and organizations. Design programs and designers must recognize that DfD is not a privilege

70 Retrieved from: http://www.gsd.harvard.edu/#/academics/courses/ses-05404-fall-2013.html, 11.08.2013.
71 Retrieved from: http://prattpspd.com/ramp/, 11.08.2013.
72 MIT Senseable City Lab, Harvard GSD (2005) Safe(R) House Project, Retrieved from: http://openarchitecturenetwork.org/node/375, 11.07.2013.
73 Retrieved from: http://sheltercentre.org/about/team, 11.07.2013.
74 Retrieved from: http://masteremergencyarchitecture.com/, 11.07.2013.

of designers and architects, it must be a collaborative and integrative process of many different professions. Design thinking which is now a hot topic in business has to be taught to humanitarian professionals, disaster management professionals and development economists too. There are strong and certain needs for design in this growing challenge. Now design universities and designers need to act.

Jose Gamboa

24 Craft based Design for Sustainability: "The Pejibaye Project"

"Pejibaye was present in my life since childhood. I remember often eating pejibaye fruit, heart of palm in salads and in picadillo. But my most vivid memory comes from my first experience with the wood.

I wanted to buy a knife, but I was too young to have one and my parents didn't allow it, so I decided to make one myself. I asked my father for a very strong piece of wood. He gave me a piece of pejibaye wood and proceeded to tell me stories about how the native people of Costa Rica used it to create bows and arrows, which made it seem like an incredibly interesting material for my knife.

It was a very dense and strong piece of wood and I probably spent half a day shaping the basic form of my knife against the concrete slab in my grandfather's backyard. I remember this day well because it was the first time that my grandfather allowed me to use his workshop and his tools, perhaps moved by my persistence in shaping the knife against the concrete.

This experience motivated me to explore in detail the potential of this material and discover the versatility of this palm tree, opening the door for new industries and business opportunities based on this plant."
Jose Gamboa

24.1 Summary

This chapter describes a strategy to foster ecological practices and economical development for the communities of Costa Rica. Pejibaye, or bactris gasipaes, is a palm tree commonly used in Costa Rica for the production of fruit and heart of palm. The plant has a productive life of ten years, usually from its seventh to seventeenth year. After that, the fruit production drops considerably and old plants are abandoned or cut down in order to plant new palm trees.

The new strategy suggests to utilize old pejibaye palm tree trunks as raw material for the creation of a new industry. It also investigates the use of environmental strategies in order to create a new export of raw material that expands and promotes Costa Rica's reputation for ecological dedication. Finally, the project demonstrates, through the design of new products and artifacts, how design can generate profit and new job opportunities that improve people's lives. Conservation and green design is more than just a trend; it is a vision of how to face problems that affect the environment, nature and humanity.

Designers must be aware of eco-friendly design tools in order to minimize the pollution and destruction that some materials and manufacturing processes are inflicting on the environment. Additionally, designers must try to reduce the waste of natural materials used in the creation of new products. We must find a way to enjoy nature without destroying it. We are responsible for making life better and more enjoyable for all people.

The goal of the project is to diversify the use of the pejibaye palm tree while minimizing waste in order to stimulate the creative process of the Costa Rican agricultural and artisan communities. Through the new use of this material, positive economic development will occur in the artisan's quality of life and communities in general.

As a tool to exemplify the possibilities of the pejibaye project, GAMA, a design firm that designs prod-

ucts with awareness of environmental issues (this will be referred to as the first cycle of opportunity) has been created.

The design firm will donate 10% of its profit to support environmental efforts in Costa Rica. The waste material that comes from the first cycle of opportunity will help to develop a second cycle of opportunity that will use a compound material as the basis for the creation of new and different products. This will extend the possibilities of creating new job opportunities and increase resource efficiency.

24.2 The Starting Point

A few decades ago, Costa Rica had serious deforestation problems. "Until the late 1980s, the small country, the size of West Virginia, had one of the world's highest deforestation rates" (Daily/Ellison 2002). Costa Rica changed directions. The country started creating conservation areas and changing laws, making deforestation of the rain forest illegal.

With the help of international organizations and private contributions, Costa Rica modified the means of gaining profits from nature. Daniel Jenzen, a biologist from the University of Pennsylvania, created the concept of selling carbon credits in Costa Rica; since 1998 the country has continued to sell carbon credits to industrial countries in Europe.

This progressive approach by the Costa Rican government has helped to save and recover the natural resources of the country, creating a perfect opportunity to develop the concept of this project. The pejibaye project investigates the viability of developing an industry created around the bactris gasipaes (known as pejibaye palm tree or peach palm). This industry will bring new job opportunities and revenue to the underdeveloped communities of Costa Rica and may foster the creation of new companies in the design, crafting and manufacturing fields.

24.3 The Plant

The peach palm (bactris gasipaes krunth), or pejibaye, as it is referred to in Costa Rica, is also known by many other common names; these include pupunha (Brazil), chontaduro, cachipay (Colombia), chontaruro (Ecuador), pijuayo (Peru), gachipaes (Venezuela), peach palm, and pewa nut (Trinidad).

The Amerindian domesticated the peach palm and distributed it throughout much of the Amazon Basin, Northwestern Andean region and Central America, producing in the process a genetically rich palm tree (Mora Urpi 1993; Clement 1995). They valued the pejibaye because the plant is easy to cultivate in traditional agroforestry systems and has a high yield in infertile soil. The fruit can be prepared as a variety of nutritious foods, and other parts can be consumed or used for construction and other household needs.

The palm tree grows upright, with a single slender stem, generally armed with black spines in circular rows from the base to the top. The pejibaye reaches heights of 65 to 100 feet (20 to 30m) and usually grows suckers freely. The leaves are generally 8 to 12 feet (2.4-3.6m) long (Fig 1). The fruit hangs in clusters of 50 to 100, with as many as 300 fruits to a cluster; clusters may weigh 25 lbs or more. The fruit is yellow and reddish-brown at first, turning purple when fully ripe (Mora Urpi et al. 1997).

Dr. Jorge Mora Urpi describes the fruit as an ovoid, oblate, cylindrical or conical shape, 1 to 2 inches long. Each palm can produce 5 to 6 clusters at the same time (Fig 2). The skin of the fruit is very thin and the flesh is yellow to light orange or red. Some fruits can be found without seeds and are called machitos (males) by the local Costa Ricans.

24.4 New Design Opportunities

The characteristics of the pejibaye palm provide new opportunities for an industrial designer to create an en-

Figure 1: Bactris gasipaes palm

Figure 2: A 10 kg fruit bunch

tire industry centered on this unique material and its physical characteristics. Some of these characteristics are listed below.

- **Fruit:** Excess fruits and peelings from the pejibaye are used as feed for poultry and pigs.
- **Leaves:** Leaflets stripped from the tree are fed to livestock; the leaves themselves have been important in making huts.
- **Sap:** The trunk of the pejibaye tree may be tapped for sap, which is fermented and used to make an alcoholic beverage.
- **Bark:** The bark of the tree is peeled off in one piece and used like canvas to make a substitute for springs in crude beds or bunks.
- **Wood:** The dark brown wood is very hard but elastic and takes a good polish. It has been used for spears, beads, bows, arrowheads, staffs and walking sticks. More modern uses include siding for houses, veneer and tool handles. Small pieces are fashioned into spindles and other parts used in weaving. Split trunks are used as water troughs.

Enormous possibilities exist to create entirely new industries in Costa Rica based on this abundant and underutilized material.

According to Forestry Engineer Rafael Cordoba Foglia, pejibaye is a conglomerate of thorns that resemble wood. He agrees with Dr. Mora regarding pejibaye's wood properties: "It has qualities of great beauty, hardness, duration and great polish".

When asked if he was aware of any companies in Costa Rica utilizing the wood, he responded, "Nobody utilizes this 'wood', I don't know why." Very few people use the palm to decorate furniture or as a construction material. "This was an investigation that we made years ago exploring the potential of the material." (See figure 4)

When Mr. Cordoba Foglia was asked what he thought about using the abandoned materials to create a new industry in Costa Rica, he responded: "You would be rich; that's a really good idea and it would help many people by creating new job opportunities." He also commented that using pejibaye as timber is a great idea because it takes just 10 to 15 years for the tree to reach maturity.

During field research at the Technology Institute of Costa Rica's wood shop (TEC) it was confirmed that the palm does not possess the abrasive oils that other trees contain; these oils provoke harmful corrosion in the expensive machinery. However, the hardness of the palm is such that it damages the sharpness and performance of the machines. A new process to handle the material has been developed as shown in figure 5.

Figure 6 shows the aesthetic qualities of the pejibaye compound material. The new material possesses highly polished qualities. There is no need to add color to the mixture, because pejibaye residues have a natural brown dye.

24.5 A New Industry Model

Central to this project is the analysis of the pejibaye harvesting process, focusing on methods to utilize the cut-off waste in order to create a new industry, which will ultimately benefit the country of Costa Rica and its citizens. The project studies the process and identifies methods to take advantage of the largest possible percentage of this wasted material. The opportunities created involve economy, ecology and social development.

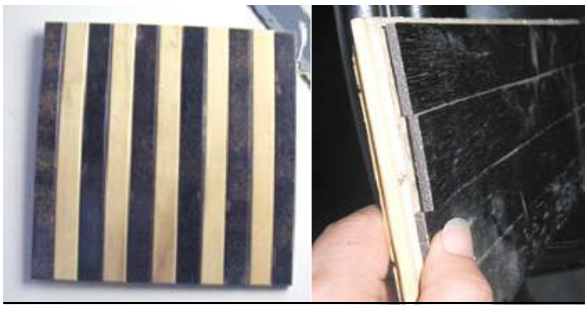

Figure 4: Samples of other uses (Gamboa)

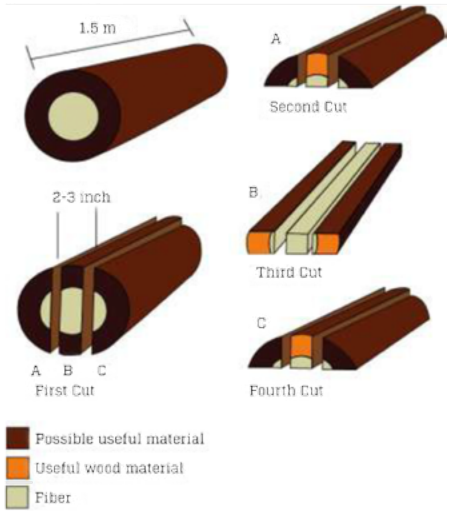

Figure 5: Procedure of Cutting the Pejibaye Trunk / Initial aspect of the Trunk.
First cut: segmenting the trunk into three parts (A, B and C). **Second cut:** from the first segment (A), we obtain a piece of usable wood; two other pieces are created that should be rejected due to reduced dimensions. **Third cut:** from the second piece (B) we obtain two pieces of usable wood and one piece formed by the fibrous center of the trunk. **Last cut:** from the piece (C) we obtain the last usable piece and two small pieces that will be rejected. All the rejected pieces will be used as part of the second cycle of opportunity to maximize efficiency.

This project attempts to create a sustainable industry that will benefit nature and humans at the same time. It promotes the creation of two cycles of opportunities that will increase the benefits that could be obtained from this unused material. (See figure 6).

The first cycle of opportunity consists of using old pejibaye trunks as raw material for the creation of a new industry. The waste material that comes from the first cycle of opportunity will be used to develop a second cycle of opportunity that will use a compound material as the basis for the creation of new and different products. This compound material will be comprised of environmentally friendly resin and waste material such as sawdust and small pieces of wood from the first cycle of opportunity, maximizing the use of abandoned resources (Figure 7).

Figure 6: Aesthetic qualities of pejibaye compound material

24.6 How to implement the new industry model and improve local economy

The new industry model aims at improving the economy and ecology of a country and creating new job opportunities by harvesting abandoned and unused natural sources. This industry would fit in perfectly with the Costa Rican market. In Costa Rica, the Small Grants Program has been helping to create a correlation between environmental issues and the development of the local communities. It supports the communities by helping them create self-sustainable projects, getting profit from nature without damaging the ecosystem.

The government in Costa Rica is well known around the world for paying special attention to basic education, health and ecology. Environmental protection is a national priority in Costa Rica. Kids in elementary schools learn how to take care of nature. Using the dedication that this country has to the environment, this project will develop a creative tool represented by a design firm to promote the concept and gain critical support for trial programs in existing communities. GAMA Design, created to support eco-design, is an example of a new industry with awareness of ecology, economy and social development. This design firm works as a prototype in order to demonstrate the potential of the project.

The goals at GAMA Design are:

› To generate profit from abandoned and unused materials.

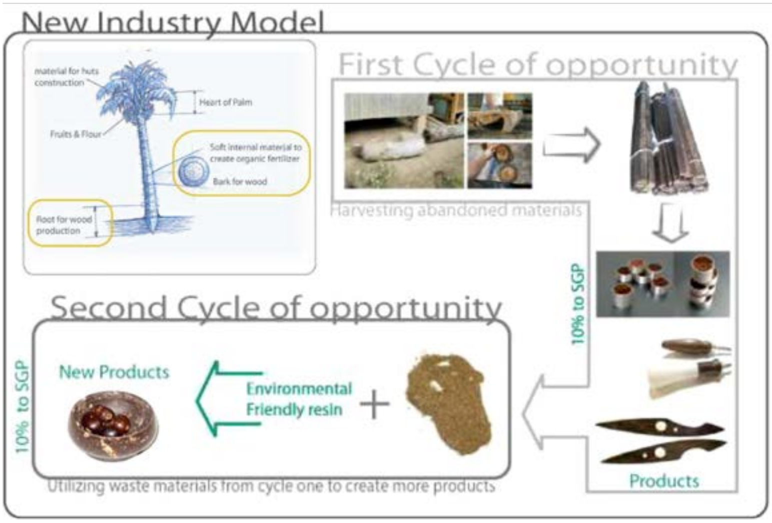

Figure 7: “New Industry Model” creates new job opportunities and minimizes waste of natural sources

- To extend the life cycle of the bactrics gasipaes, minimizing waste.
- To stimulate the creative process of Costa Rican artisan communities.
- To support ecological and environmental projects.
- To create an environmentally friendly conscience in Costa Rica, acting as a prototype for a new industry.
- To prepare and help other industries to minimize waste.

GAMA products mainly combine metal and wood. The GAMA line of products is made from pejibaye wood that will be combined with aluminum, silver or gold in order to enhance its natural beauty.

GAMA design focuses on using every part of the plant to reduce the amount wasted. Figure 9 describes the different uses of the palm following the ideas of this project. Using this method of harvesting the old trunks, GAMA will lengthen the productive palm tree life cycle. With the two cycles of opportunities described above, this project optimizes resource efficiency and creates a profitable resource from waste. The first cycle of this project harvests abandoned and unused material directly from the old palm trees in order to benefit people and the environment in Costa Rica. In the second cycle, the products will be created by using environmentally friendly resins or corn-based plastic mixed with waste and scraps of pejibaye wood from the first cycle, creating a natural compound material.

An extensive analysis of the research conducted over three years in Costa Rica shows the great potential of this idea in becoming a reality, thanks to the huge variety of uses that this palm tree offers.

Figure 8: Jewelry boxes. Materials: pejibaye wood and aluminum. Ring for men. Sterling silver and pejibaye wood

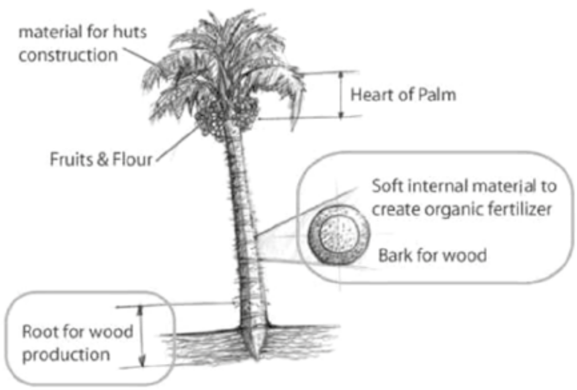

Figure 9: Diagram of possible uses for the bactris gasipaes

Figure 10: Possible products made from the bactris gasipaes

24.7 References and further reading

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Part 3

Student Case Studies of Sustainable Design

Student/s:

Massimo Cantarelli, Pietro Chiera, Virginia Grandi

ABCommunity

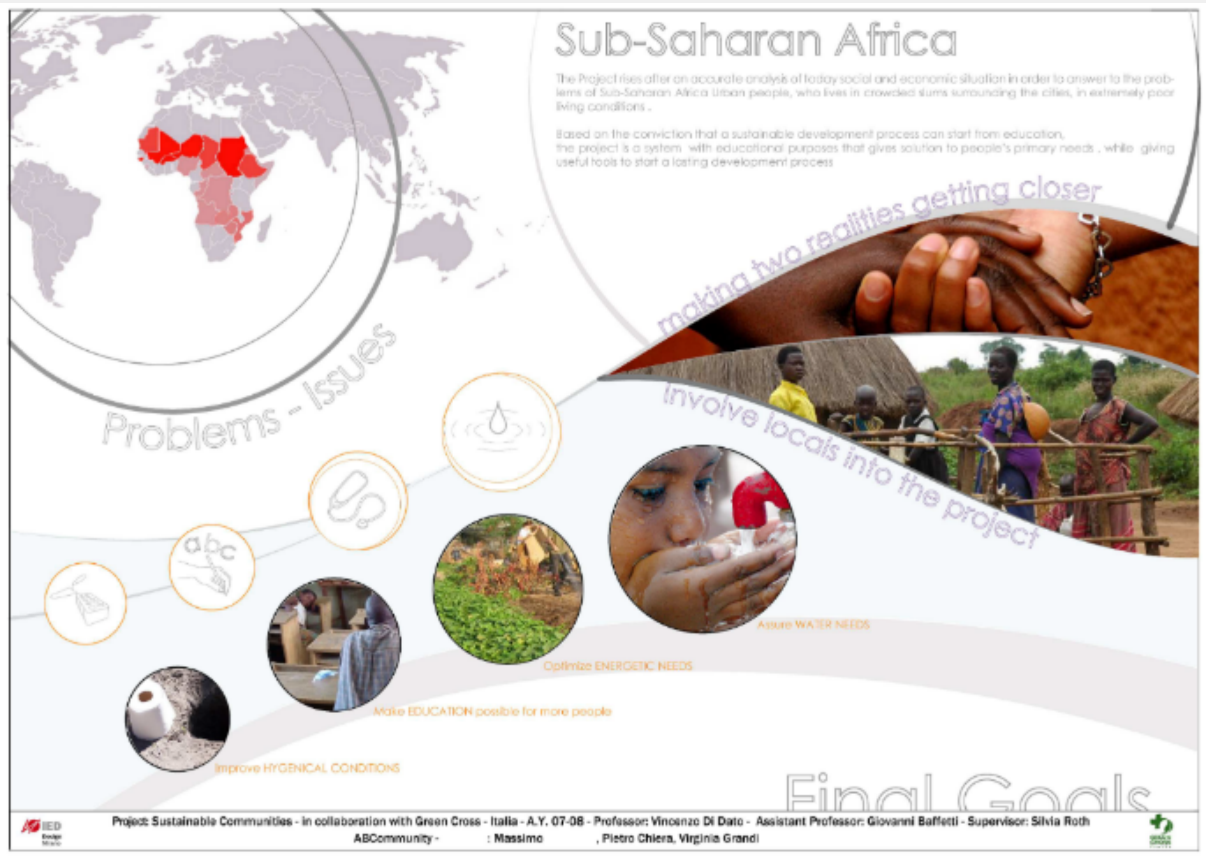
Tutor/s: Vincenzo Arduino Dora di Dato, Baffetti

Contact details: chierapietro@gmail.com

Design School: IED Istituto Europeo di Design – Milano – Italy

Theme Abstract: The Project developed after an accurate analysis of today's social and economic situation to answer to the problems of Sub-Saharan Africa Urban people, who live in crowded slums surrounding the cities, in extremely poor conditions.

Aim: The Project is an educational system that gives solutions to people's primary needs (shelter, water and food harvesting and sharing-socialization) while providing useful tools for a lasting sustainable development process.



Project description & Sustainability aspects:
ABCommunity changes its structure based on its location, whether it's close to a big settlement (Periurban area) or in the urban centre (Urban area).

In both cases the aims are to:

- Assure water and energetic supply thanks to a tensostructure that collects natural water and to cultivable areas
- Improve hygienic conditions using compost toilet
- Use the saved time for education and creation of lacking structures.
- Finally, involve locals in the whole project and encourage new relationships between urban and periurban areas.

Duration & Date completed: 8 months, from October 2007 to June 2008

Results & Photos:

Student/s:
Donna Cleveland

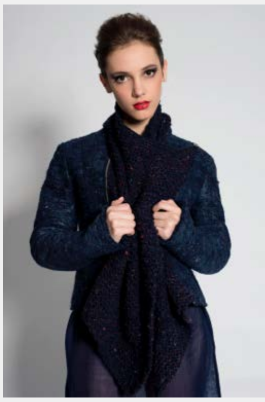
Sustainable Fashion: Translating Awareness into Action

Supervisor: Frances Joseph (PhD supervisor) and Angie Finn (Honours Supervisor)

Contact details: donna@donnacleveland.co.nz

Design School: Auckland University of Technology

Theme Abstract: Sustainable fashion design is a topical issue for contemporary fashion designers. One current challenge for sustainable designers is the perception that sustainability compromises design aesthetics. Designers brave enough to 'give it a go' face barriers that can mean prejudice and polarization. A stigma surrounding the majority of sustainable design approaches still exists. Intellectual awareness has not changed this. Exposing perceptions through raised awareness could reduce stigmatization. Whilst research and documentation has raised awareness of sustainable fashion practices there remains a gap between the 'how to', based on existing theories, and the 'doing it'; the lack of implementation of these methods in practice is evident, specifically within a university educational environment. This research explores fashion design practices and emerging textile technologies in the context of developing awareness of pre-consumer designer textile waste. This study addresses the question: Is it possible to highlight the gap that exists between sustainable fashion theory and sustainable design practice by developing pre-consumer studio waste into a relevant fashion or textile product with an unexpected design aesthetic?


Aim: The aims of this research are twofold; firstly to profile the gap between awareness of sustainable design practices and the action of utilising these practices within an educational environment, secondly to challenge that the action of applying these practices results in an expected 'sustainable design aesthetic'.

The potential outcome is an innovative approach to developing a solution to unsustainable workroom practices through textile innovation.

Project description: This research is limited to the microcosm of textile waste collected from an AUT University fashion studio so that this collection provided a snap shot sample, which formed the data mapping profile that was collated. At the time of this study there was no pre-consumer textile waste data available within New Zealand for comparison. Therefore a fundamental aspect of this research is the original nature of this broad based statistical analysis of designer textile waste. My practice led research aims to raise awareness and start an active conversation about possible future directions for textile waste and offers insight into contemporary thinking that may provide tangible commercially viable solutions to divert the waste away from landfill.

Sustainability aspects: This project is entirely concerned with sustainability both in terms of challenging an expected recycle aesthetic and of innovative solutions to the management of textile waste, both pre and post consumer. It looks to explore an entirely closed loop system that diverts textile waste from landfill.

Duration & Date completed: One year Postgraduate Honours (First Class) 2013

Results & Photos: This research has been successful in profiling the existing gap between awareness of sustainable design practices and the action of employing these practices within an educational environment, secondly it has challenged the notion that applying these practices automatically results in an expected sustainable design aesthetic which has no fashion context and which, to many, is undesirable in itself. This research demonstrates a solution in which the recycled pre-consumer textile waste destined for landfill, can be manufactured into an innovative, commercially viable, recyclable textile product. ReFabric offers a true closed loop system that is entirely regenerative. This innovative textile development has resulted in an unexpected aesthetic and draws no reference to its first life as rubbish. The development of a contemporary capsule collection emphasises the ability for sustainable practice to result in products, which have a clear fashion context.

Student/s:

Sara Greenfest

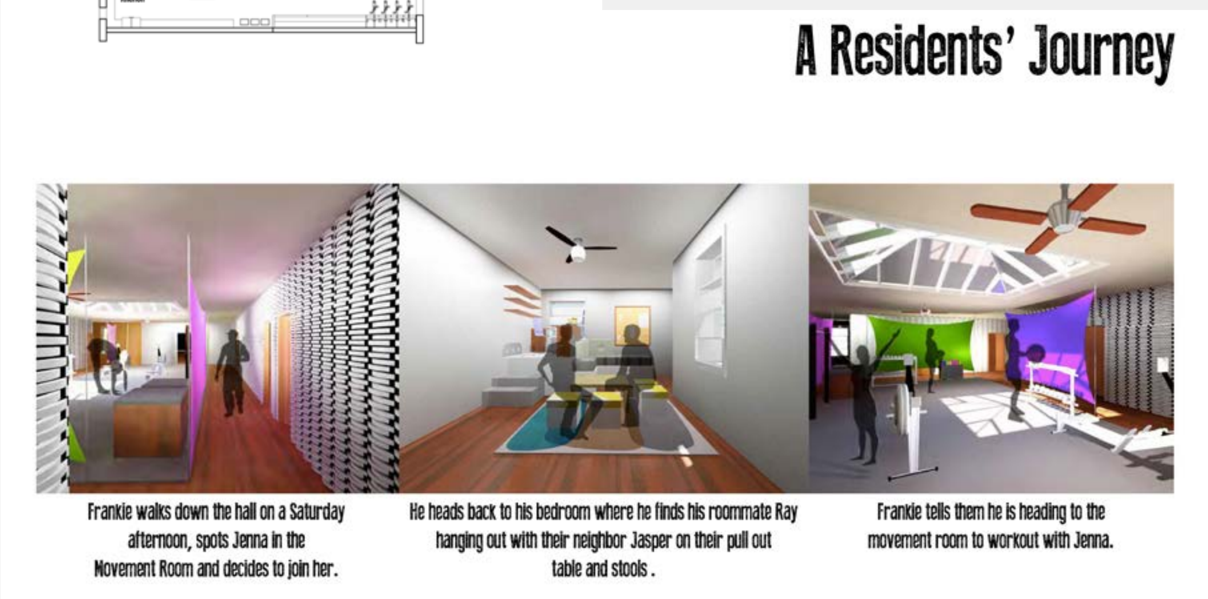
Living More With Less – The Habitat

Tutor/s: Nadia Elrokhsy, Assistant Professor of Sustainable Interior Design, studio faculty; Cary Ng, digital modeling faculty

Design School: Parsons The New School for Design, School of Constructed Environments

Aim: redefine role of interior design in designing for sustainability, efficiencies and beyond

Project description: Students of the Interior Design 2 course responded to the city of New York's call for innovative ideas in housing models to serve the city's growing small household population. They challenged the city's competition goal to provide examples of "compliant and livable" units in the smallest possible size. Given the civic focus of this interior design course, students were guided to explore innovate solutions that redirected housing models away from the predominance for more compact insertions in favor of supporting trends that build a more socially connected lifestyle, such as shared and collaborative existences – designing for an urban co-housing model.



"In my design I have chosen to push the boundaries of residents' creativity.

By creating open spaces such as a Movement Room instead of a gym, an Interactive Forest instead of your typical lounge, and modular furniture style bedrooms instead of your average sleeping quarters - residents think outside of the box on a daily basis. This type of environment will foster the innovative, artistic and resourceful thinking needed to educate a new generation of young adults on sustainable and collaborative living." Sara Greenfest.

Sustainability aspects:

1) explored existing stories of various shared and collaborative conditions and integrated them into the design of an urban co-housing model
2) studied environmental design strategies and increased efficiencies, as well with sharing items, as compared with individual housing units for the equivalent number of households and the requisite number of individual items for each household served
3) develop stories that indicate how alternative behaviors, modeled in the urban co-housing units, could be leveraged to design for change in the adjacent individual housing lifestyles, overtime.

Duration & Date completed: 8 weeks, May 16, 2013

Results & Photos:

While signing up for a skill share class in the lobby one day, Ivan bumps into his friend John. "Join me to a skill share class tonight and we can catch up," he tells John.

Ivan meets John off the elevators on the 6th floor. "What's this ipad on the window?" John asks. Ivan explains that it's used to help keep the community organized — residents can sign out equipment, volunteer to cook dinner, check what their chore for the week or register for a skill share class. Ivan also points out the rolling community news ticker above the coat hooks.

Ivan and John wait for their class to start on the multi-color modular couches. Ivan tells John the pieces can be arranged however he likes!

A Visitor's Journey

It's time for the class! John and Ivan are pumped to learn about wilderness survival skills from expert hiker, Louise.

After the class John takes Ivan to the Interactive Forest to hang out and catch up.

John and Ivan catch up while watching football on the graphic grassy patch. John is memorized at all the fun places there are to hang out around the floor. "This place rocks!" he tells Ivan

Student/s:
Shinhye Kim

Carbon Footprint

Tutor/s: Juhyun Eune

Contact details: shye20@gmail.com

Design School: Seoul National University

Theme Abstract: Understanding what carbon footprint means, & Finding the better way to reduce carbon emission in our daily life for the environment.

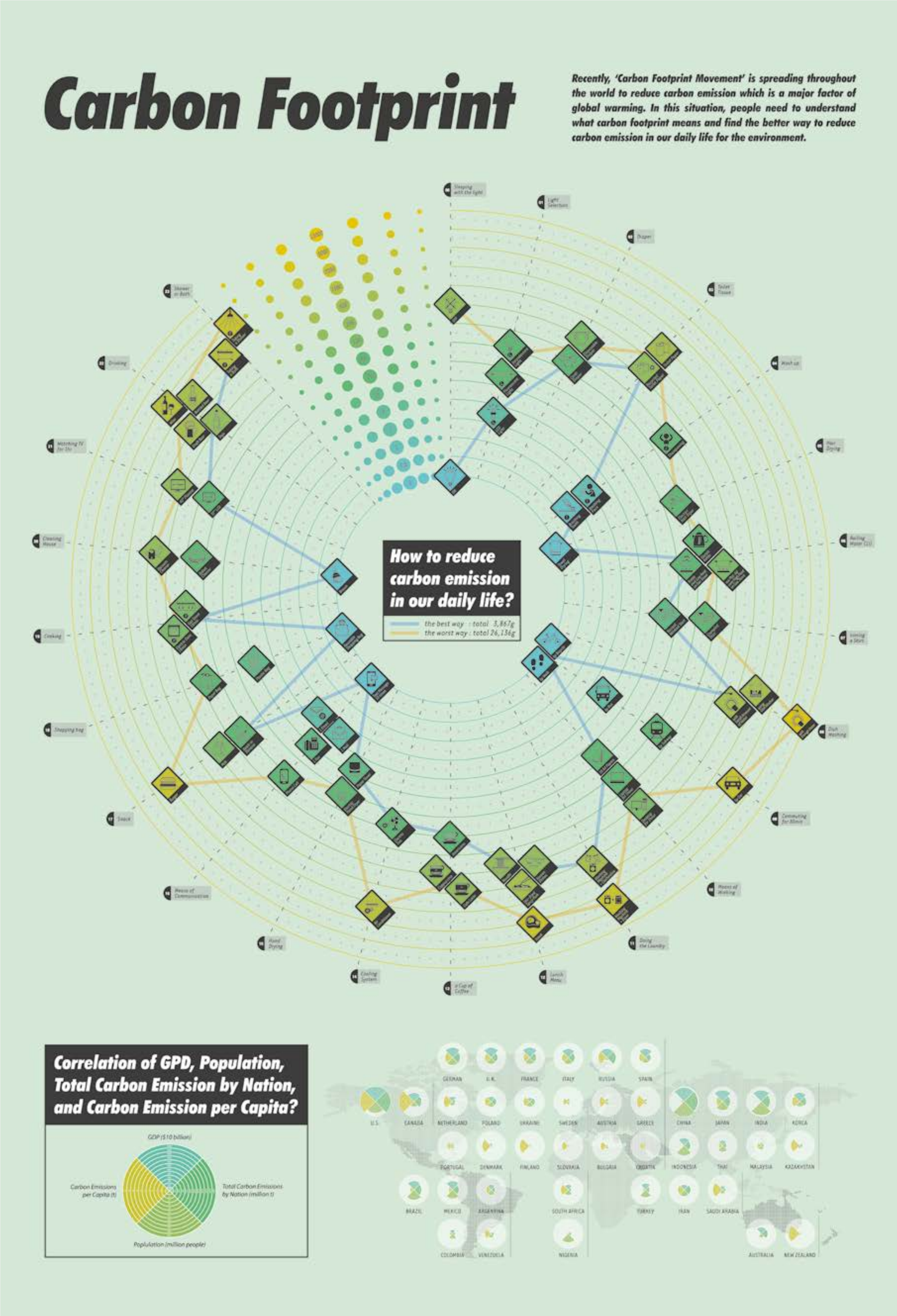
Aim: Recently, 'Carbon Footprint Movement' is spreading throughout the world to reduce carbon emission which is a major factor of global warming. In this situation, people need to understand what carbon footprint means and find the better way to reduce carbon emission in our daily life for the environment.

Project description: This Infographic is interpretation and visualization of 'How Bad are Bananas?: The Carbon Footprint of Everything', a book by Mike Berners-Lee. I picked some items and matched them with 24 hours, and layed them out by the orders of magnitude in circle-shaped time table. In addition, I visualize correlation of GPD, Population, Total Carbon Emission by Nation, and Carbon Emission per Capita of 40 countries.

Sustainability aspects: This infographic can encourage people to consider which way is helping to reduce carbon emission, and lead to the better decision for our environment.

Duration & Date completed: 2 months / Completed on 29th Apr.

Results & Photos:


Carbon Footprint
Recently, 'Carbon Footprint Movement' is spreading throughout the world to reduce carbon emission which is a major factor of global warming. In this situation, people need to understand what carbon footprint means and find the better way to reduce carbon emission in our daily life for the environment.
How to reduce carbon emission in our daily life?
the best way : total 3,867g
the worst way : total 26,136g
Correlation of GPD, Population, Total Carbon Emission by Nation, and Carbon Emission per Capita?
GDP ($10 billion)
Carbon Emissions per Capita (t)
Total Carbon Emissions by Nation (million t)
Poplulation (million people)
GERMAN
U.K.
FRANCE
ITALY
RUSSIA
SPAIN
U.S.
CANADA
NETHERLAND
POLAND
UKRAINE
SWEDEN
AUSTRIA
GREECE
CHINA
JAPAN
INDIA
KOREA
PORTUGAL
DENMARK
FINLAND
SLOVAKIA
BULGARIA
CROATIA
INDONESIA
THAI
MALAYSIA
KAZAKHSTAN
BRAZIL
MEXICO
ARGENTINA
SOUTH AFRICA
TURKEY
IRAN
SAUDI ARABIA
COLOMBIA
VENEZUELA
NIGERIA
AUSTRALIA
NEW ZEALAND

Student/s:

Juliane Lanig

Das Recto-Verso der Gestaltung – Über Paradoxien des Wachstums und gestalterische Qualitätswerte

Tutor/s: Prof. Gabriele N. Reichert, Prof. Dr. Dagmar Rinker

Contact details: mail@juliane-lanig.de

Design School: HfG Schwäbisch Gmünd

Theme Abstract: The recto-verso of design is broaching the necessity to degenerate the prosperity from material growth and encourages to start of an economical, creative and social rethinking.

Aim: The book is supposed to conribute to a new understanding of design. The marked quality features provide knowledge as well as appeals for designing sustainable lifestyles.

Project description: The paradox assumption of being able to measure the wealth of a society by its economic growth flies in the face of logic that an increasing consumption of raw materials and increasing environmental pollution are destroying the ecosystem earth. To protect this system is the basis of life and therefore the fundament of all prosperity.

The vision of this paper is to create lifestyles, which ensure the quality of life without the constantly growing claim of consumption. The phenomena of this form of society and their importance for designing will be introduced. The challenges, but also the chances, which lie in this change will be discussed in detail. From this vision you can deviate quality values, which are thought to be guidelines and orientation and in addition motivate to start acting energetically.

Sustainability aspects: content related

- Resons for a release of a material force of growing
- Definition of sustainable lifestyles
- Definition of quality features in designing
- Information and encouragement for designer in order to change their practice

Sustainability aspects: physically related

- FSC certificated paper grades
- Electricity out of water power in the print office
- Use of print colors that are free solvent-free

Duration & Date completed: October 9th 2013 until February 15th 2014

Results & Photos:

Student/s:
Lydia Humphries

The Urban Crate

Tutor/s: Caroline McCaw, Kerry Ann Lee, Leyton Glen, Martin Kean

Contact details: caroline.mccaw@op.ac.nz

Design School: Otago Polytechnic School of Design

Theme Abstract: A portable urban vegetable patch, for distribution via food banks, including branding, fundraising, product re-use design and distribution.

Aim: To communicate and experience the value and benefits of growing your own food.

Project description: The Urban Crate miniature food gardens are aimed at developing interest and competencies in back-yard food gardening. While these gardens are designed to meet the needs of impoverished families, the project extends through fundraising and tool donations, to include a wider community. The student designer developed initial research and subsequent branding, fundraising and communication strategies, the portable crate gardening system, instruction and recipe booklets. These compact and portable vegetable gardens, pre-planted with vegetable seedlings come with simple gardening instructions, a set of basic gardening tools, and some tasty recipes.

The gardens were then delivered to a social support agency, who distributed them to needy families through their food bank.

Sustainability aspects: The Urban Crate project aims to encourage the growth of sustainable communities in the Dunedin region giving families the chance to learn, through self-help strategies about affordable nutrition and sustainable living. The project brought together a wide range of community members, who do not always work together including students, gardening enthusiasts and social work agencies.

Duration & Date completed: This prototype was developed, and crates were delivered between May and October, 2012.

Results & Photos:

Student/s:

Lakshmi Murthy

Taking the cue from grandmother and making menstruation management safe and sustainable

Tutor/s: Dr Anirudha Joshi

Contact details: ellemurthy@gmail.com

Design School: Indian Institute Of Technology, Bombay

Theme Abstract: Poor women have always lived sustainable lives, recycling, reusing and never throwing away, using a product or its parts until end of life of the item. They managed menstruation in the same way - harvesting cloth from old garments, using this as a pad, washing and reusing until the piece of fabric riddled with holes, was no longer fit to absorb body discharge. This scenario changed as industry matured, when one time use and throw products were born. The sanitary napkin was one such invention.

There is no longer dignity in reuse; migration toward disposable napkins is swift. Many brands of napkins are available today for the menstruator! Advertisements reinforce the notion that disposable is good. But this is questionable. What is hidden from the user is what goes into a disposable pad: polyethylene layers, non woven fabric and super absorbent polymers. This adds to menstrual debris as none of these materials biodegrade. They only break down into microscopic pellets after many years (estimated 200 years) and enter the water ways. One time use and throw is a system unsuited for both health and environment as a woman discards 150 napkins at the end of 12 menstrual cycles. Working further we realized that some users present with rashes, itching and boils, but continue using pads as there are no other available options. Taking the cue from earlier generations of women, we realised all these issues could be addressed by bringing "reusable" to the centre. We consulted with Eco Femme at Auroville in Tamil Nadu, India, pioneers in reusable cloth pads. We developed Uger Sanitary Napkins. These pads made of layers of cotton fabric, styled to button down under the underwear, can be washed a minimum of 60 times. Uger users in our product trials discarded 6 Uger napkins at the end of 14 menstrual cycles. Not only had Uger pads brought down the environmental load, no health problems were reported.
* Uger - "New Beginning" (language of Southern Rajasthan)

Aim: Make menstruation safe and sustainable for the community.

Project description: The design of a pad alone is not enough to ensure menstruation safety and sustainability. The product needs to be a part of a larger sustainable system. The Surakshit Mahwari Abhiyan or Safe Menstruation Campaign was started in partnership with Jatan Sansthan and NGO. This campaign holistically addressed the issues of menstrual health.

Sustainability aspects: The campaign followed the four pillars of sustainability

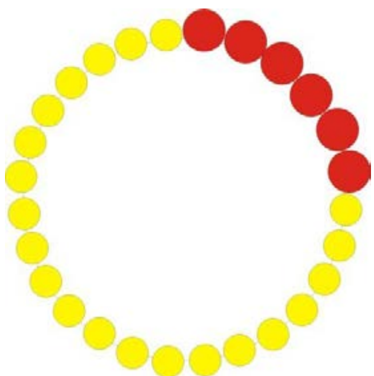
- Social: We designed workshops for young women to address issues of safety and menstruation, following this up with scientific information and together taking oath to improve women health
- Economic – Introduced Uger Pads – that bring back concepts of reuse reducing costs to the user
- Health - Uger pad – a better health option as compared to a disposable synthetic pad
- Environment – Uger pads reduce load of menstrual debris on environment – bio degrading in 6 months.

Duration & Date completed: Prototypes Completed: August 2012
Safe Menstruation Campaign: Ongoing since August 2012
Further research on Uger Pads: Ongoing since August 2012

Results & Photos:

Uger Pads – button down pads – to be worn with underwear
Left: Insert pads / Right: Plain Pad

A fact book on menstruation – *Seedhi Sachi Baath* (The Simple Truth)
given at workshops



The bracelet has 28 beads, representing the 28 days of the menstrual cycle. Period days are red beads, other days are yellow beads. Woman wear the bracelet and together take an oath improve their own and others menstrual health.

Student/s:

Nur Sakina Najib

Ease Gourmet

Tutor/s: Duarte Sousa, Thomas Tow

Contact details: http://www.tp.edu.sg/

Design School: Temasek Polytechnic, School of Design

Theme Abstract: Ease Gourmet is a student project based on the approach of Benjamin Greene's innovative sustainable agriculture project called The Farmery. The Farmery is designed to eliminate the processes green produce go through, such as distribution and segregation of produce which prolongs the time it takes before reaching the consumer. All these stages result in inventory loss and subsequently a decline in quality and a drop in produce quantity (produce go bad due to the extensive journey). The innovative approach addresses this issue by growing, harvesting and selling fresh produce all in one location thereby allowing for greater efficiency and savings in operation costs.

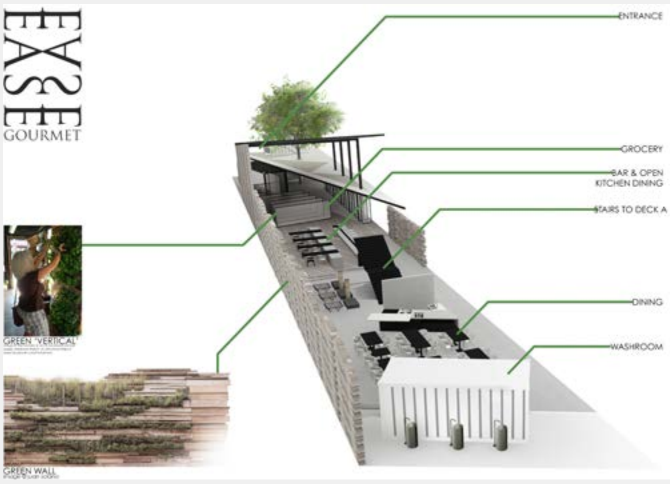
Aim: The design intent of Ease Gourmet is derived from its specific site context of being situated in a linear open site with minimal vegetation and devoid of any shelter from Singapore's hot and humid climate. From these parameters, linear spaces are created to provide shelter and physical comfort to passers-by and local residents. They also act as spaces where the user is able to pause, slow down and experience calming of his/her mind. Ease Gourmet provides an opportunity for the users to enjoy and to savour healthy and fresh foods with ingredients obtained directly within the building itself.

Project description: Nurturing the growth of true foods, Ease Gourmet will have an urban grocery accompanied by a vegan bar and dining facilities. Being a rendition of The Farmery, it features self-pick green vertical gardens (where customers can themselves pick off their produce) and experience the timeless ambience. The aim is to select the produce at its freshest state possible for purchase or for dining at Ease Gourmet.

Sustainability aspects: One of the features of The Farmery is its use of recycled shipping containers. It functions as a spot for growth and its containers form a design language that is used through the spaces. Its recycled nature means there is not a need to specifically produce certain new materials for the facility (the shipping containers are also given a new life/ function). Ease Gourmet's design features also supports sustainability as the green vertical garden uses recycled wood (green wall) and reused steel and wire mesh (self-pick grocery's green 'verticals') from scrap yards. Sections of floors are in green concrete, which uses recycled materials that replace fine aggregates. This will reduce the overall carbon footprint. The space is also designed to be naturally ventilated and this will contribute towards the promotion of health and wellness for its users.

Duration & Date completed: Mid October '13 – February '14

Results & Photos: Floor Plan



Student/s:

Mariette Breton, Koyal Chengappa, Bidisha Das, Joshua Iype, Meghna Jaswal, Sanika Sahasrabuddhe, Varda Schneider, Naomi Shah, Ananya Singh, Shambhavi Singh

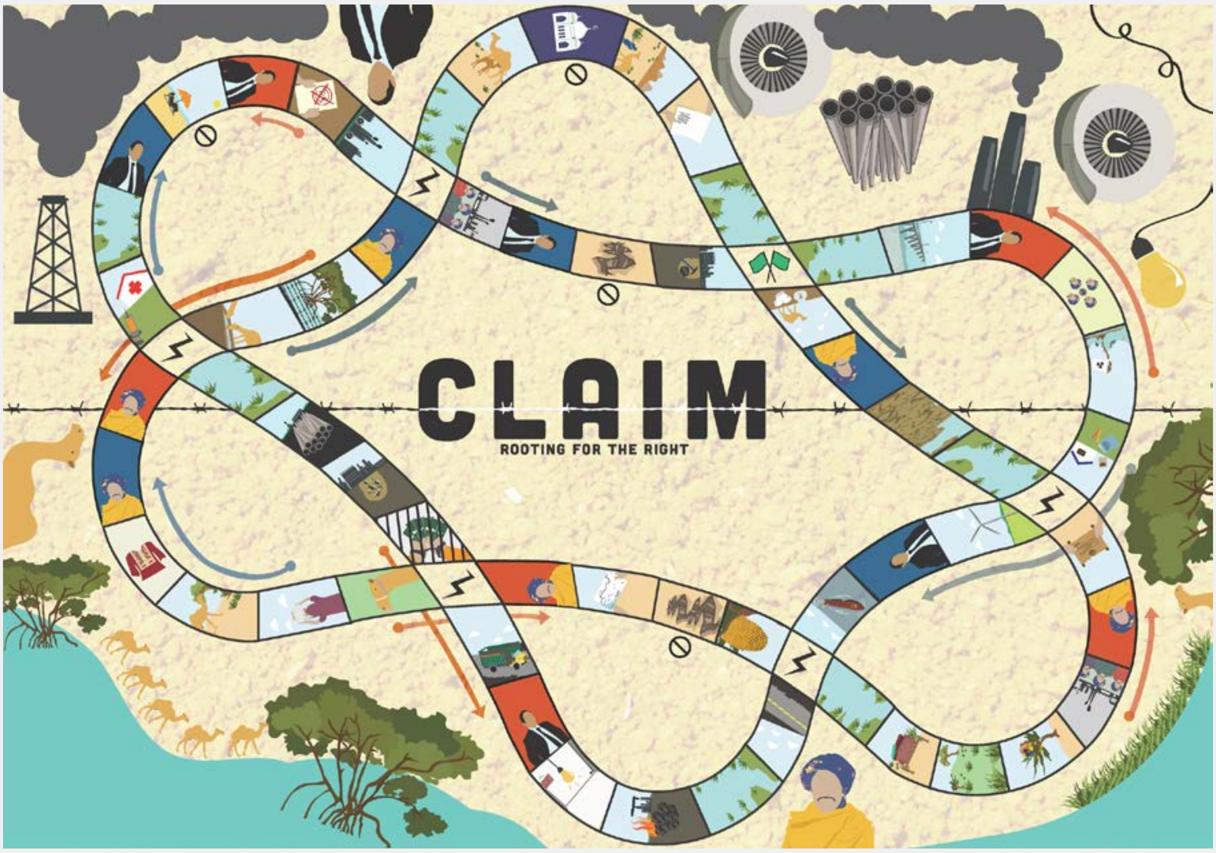
ROOTS Project – Design terrains in legal domains

Tutor/s: Deepta Sateesh (Srishti), Arpitha Kodiveri (Natural Justice)

Contact details: ledlab@srishti.ac.in

Design School: Law+Environment+Design Laboratory (LEDLaboratory) – collaboration between Srishti School of Art, Design and Technology, and Natural Justice

Theme Abstract: In this project we look at the role of interdisciplinary thinking and design tools, in unpacking complex enviro-legal contexts, through design pedagogy and legal thinking. In the pilot project called 'ROOTS', design students worked closely with indigenous communities, in Gujarat and Rajasthan, India, who are unaware of the threat of violations of their rights to land and grazing under the Forest Rights Act, 2006. Design enabled a way of thinking to address the nature of these issues, and understand the depth of the communities' biocultural relationships with their environments. The project focused on awareness and empowerment for the communities, and offered an extraordinary context for students to become perceptive to the intricate systems of ecologically sensitive regions and the laws that govern them.



Aim: The ROOTS Project was created to explore the gap between the legal framework and its implementation through an interdisciplinary approach, using design thinking and creative communication, bringing together law and design in the context of socio-ecological issues in two regions – Sariska Tiger Reserve in Rajasthan, and Kutch, Gujurat.

Project description: The world as we see it is rife with large global 'wicked problems' that stem from complex local issues of social, ecological, economic, political and cultural issues, and new patterns of consumption that impact human values and practices. The divides between government and citizen, man and nature, development and sustainability, economy and wellbeing, are widening at a rapid pace, while our ability to view the complexity of these issues are limited by current systems of education, communication and engagement.

At the Law+Environment+Design Laboratory, we believe the key is to use an interdisciplinary design approach to understand, interpret, communicate and engage with the complexity of these issues, to catalyze change, by democratizing information, and promote empowerment, decision-making and changing practices, that can contribute to resilience and adaptation.

The ROOTS Project begins to acknowledge these gaps, and looks at the complex interconnectedness and interdependencies, through deep understanding of the contexts, and the legislations that govern these places.

The Forest Rights Act, 2006, India, is a landmark legislation that seeks to correct historical injustice that tribal communities in India have suffered due to exclusionary conservation practices. The law though in effect since the passing of the Rules in 2008 has not yet been successfully implemented in the intended areas. This lack of implementation has been attributed to the following factors:

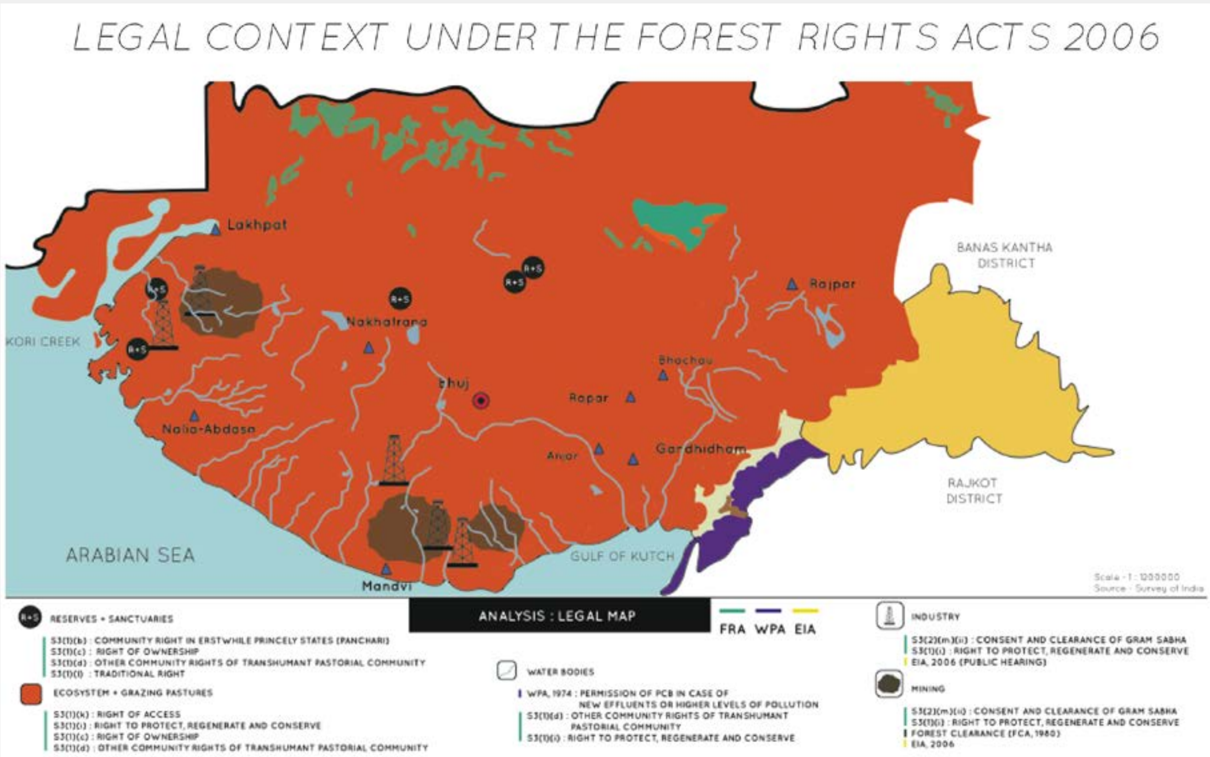
- The lack of political will on the part of the Forest Department to facilitate its implementation as it challenges the present set of powers that are vested through earlier laws and policies;
- The lack of mobilization of communities on the ground for ensuring organized implementation of this law;
- Lastly, it is also the lack of awareness of this law, within the communities it impacts, that has resulted in such poor implementation.

All these factors intermingle to create barriers in the effective implementation of the FRA. If one looks closer at these factors it can be seen that the underlying questions of translating legal recognition and legitimacy into action. Herein lies the mystery of progressive legislative advancement and its inability to rectify asymmetrical power relations on the ground. Using the power of design and an interdisciplinary approach, with a capability to embrace complexity and communicate issues through creativity, is an opportunity to re-examine this issue of translating law into action. It was with this intention that the ROOTS Project sought to experiment in using creative interventions for communicating the law which is often inaccessible and convoluted in its specialized vocabulary.

Sariska Tiger Reserve is facing degradation of the ecosystem due to forest-dweling community activities such as grazing, extractive industries and tourism. Sariska is also a politically volatile region at the local level. The Gujjars, a pastoralist community, are one of the largest indigenous communities living in the protected forest, and are facing pressure from the Forest Department to relocate outside the forest, but have not been given adequate information to make informed decisions for themselves, or to come to any kind of consensus amongst themselves, nor with other communities living within the forest. The challenge here was to communicate the Forest Rights Act, 2006, to empower them to claim their rights through an informed process. Students designed a paralegal toolkit to enable better communication and decision-making processes on the ground. The toolkit included an infograph to share the rights, responsibilities and evidences needed to claim these rights, a puppet theatre that shares and demonstrates various scenarios that the Gujjars may face, and the processes to overcome them.

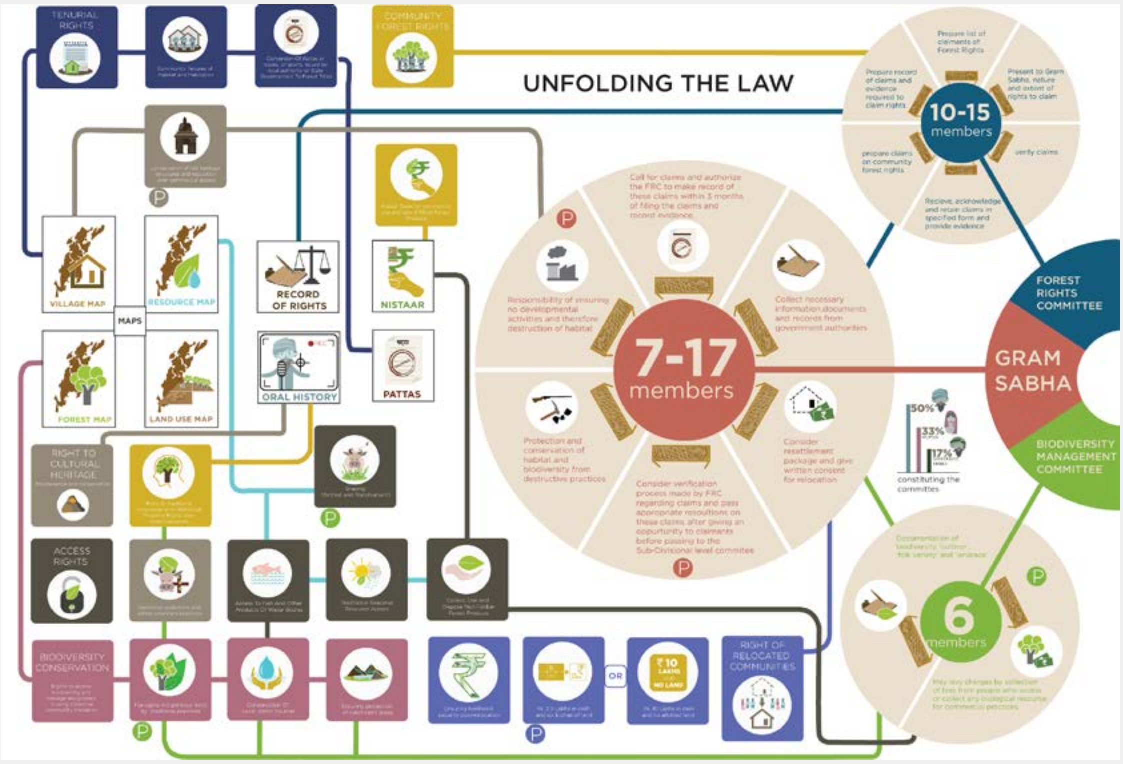
In Kutch, the Camel Maldharis, a nomadic pastoralist community, are facing similar pressures, not only form the Forest Department but also from the increasing numbers and sizes of industries that are locating in the region and along the coast. The Maldharis depend on the Kutchi and Kharai camels for their survival and livelihoods, but due to development pressures, the environments that the camels depend on is shrinking considerably fast. Students designed “Claim”, a board game that uses a visual language to engage the Camel Maldharis, a nomadic pastoralist community, in understanding their rights and evidences they need to collect to claim these rights. The board game players either represent the Maldharis or their current largest threat, extractive industries in the region; and is based on chance and strategy. In November 2013, a team of environmental lawyers from Natural Justice took the board game to Kutch, and tested it with various members of the the Maldhari community. The LEDLaboratory is currently in the process of incorporating feedback from the field testing, to refine the board game so that it may be used by the local communities and the NGOs that work with them.

Sustainability aspects: The project is situated in two environmentally protected regions – Sariska Tiger Reserve and Kutch – both being governed by environmental legislations including the Wildlife Protection Act, 1972, Biodiversity Act, 2002, and the Forest Rights Act, 2006. The aspects that were explored, interpreted and represented were looking at socio-ecological relationships within the regions, traditional knowledge systems and sustainable practices of the communities, their abilities to adapt to climate and geographies, changing seasons and limited resources. Students also began to critique our current notions of development and progress that are largely driven by national and global economies, and paid attention to interdependencies among people, culture, economy and ecology. Empathy played a significant role through the project, particularly through the experience of the field visit where they deeply engaged with the people and places.



Duration & Date completed: January 2013 – April 2013 (4 months).

Results & Photos:



Student/s:

Tongtong Zhao, Delan Shi, Ruiying Zheng, Gang Miao

The museum of bicycle parts

Tutor/s: studio 5 of visual communication major Shan Hu

Contact details: 651908490@qq.com

Design School: China Central Academy of Fine Arts

Theme Abstract: use broken parts to design

Aim: creat a brand / help all the bicycle repair shops come into being a new business model

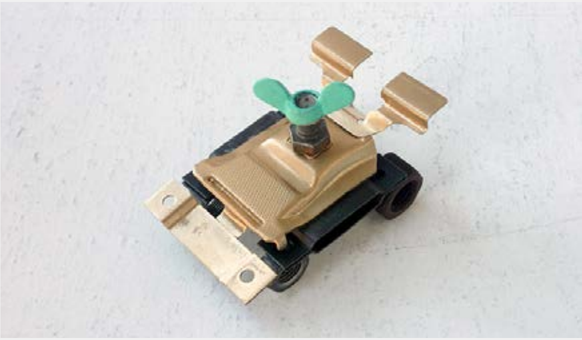
Project description: Our cooperator is a bicycle repair shop at No. 49 Yingtao Hutong, which has been there for more than 10 years. Through the research of their present live situation, we discover the value of this kind of " time-honored brand ", put emphasis on its advantages and characteristics. We renovate the shop space, use broken parts of bicycle and other mechanical parts to design new products and furnitures to be shown and sold, redesign the visual identity of the shop and products, to make it as a brand. We hope it could still service its customers and reap value-added, thus could influence more designers to help small business in this area to upgrade themselves.

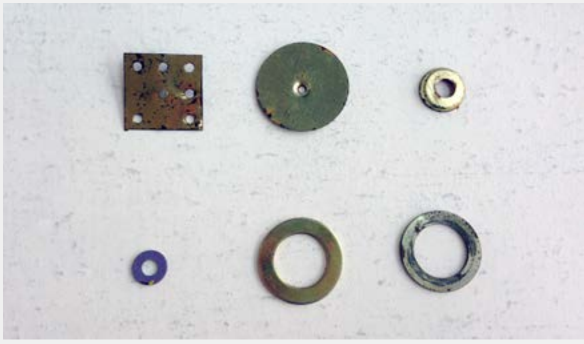
Participation Methods: Research + Concept design (VI design / Space renovation / Product design) + Program implementation

Sustainability aspects: use broken parts to design and create diverse products.

Duration & Date completed: from 2013 to 20-- (we will keep on doing it)

Results & Photos: We took part in Beijing Design Week in 2013, then the project is doing as final design.





Student/s:

Asma Al-Sulaiti & Maryam Abdulrahman

My Mai: My Water, My Change

Tutor/s: Denielle Emans, Assistant Professor of Graphic Design

Contact details: djemans@vcu.edu

Design School: Virginia Commonwealth University in Qatar, http://www.qatar.vcu.edu/

Theme Abstract: "My Mai (ماء)" is a culminating installation from a semester-long graphic design collaboration that explores the subject of water sustainability using multiple formats, interactive media, and the elements of both 2-D and 3-D space. Each area of the exhibition centers on a different water-related theme, encouraging visitors young and old to explore issues of consumption, personal habits, and desalinization within the MENA Region. Through poetic and pragmatic approaches, the exhibition delivers the poignant message that community awareness and involvement is needed to respond to the water crisis in a timely manner.

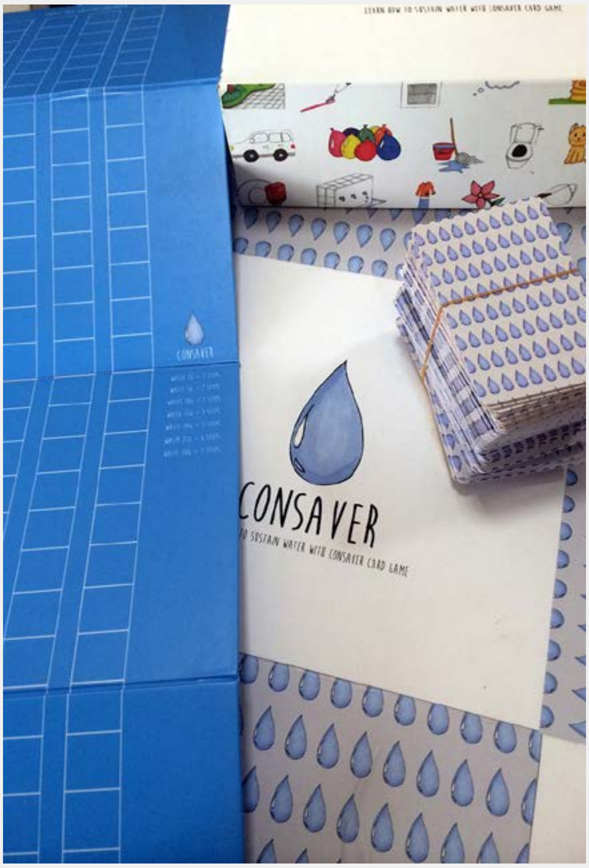
Aim: The primary aim of this project is to encourage a critically engaged application of design craft and design thinking to current and future water challenges through a process of research, conceptualization, construction, and presentation in an exhibition context.

Project description: The "Consaver Card Game," helps raise awareness about personal consumption habits of one of the most precious resources in the MENA region: water. The player's goal is to learn how to 'conserve' and 'save' by matching water-cards with activity-cards to move fewer steps on the board. If a player reaches the end of the board he/she loses and the game ends. The winner of the game is the player that moves fewer spaces on the board, representing how a player is able to sustain water and consume less in one day.

Sustainability aspects: Water is one of the planet's most valuable resources, and one of its most imperiled. In dry regions of the world such as Qatar, issues of consumption, conservation, and utilization are key issues at the forefront of discussion and debate. Qatar is among the top water-scarce countries in the region and at the same time has one of the world's highest per capita water consumption rates at 500 liters per day. In 2011, the World Bank indicated that over the next decades, the region will face drastic water shortages, owing about 20% of the scarcity to climate change and 80% to a steep increase in demand, based on population growth and fast economic development. As Qatar's population continues to rise and the demand for water supply grows, creative and community based approaches are needed to achieve sustainable development.

Duration & Date completed: Spring 2014

Results & Photos: Game play video displayed in the exhibition space: https://vimeo.com/93382306



Student/s:

Alanoud Alattiyah & Sara A Al Kuwari

My Mai: My Water, My Change

Tutor/s: Denielle Emans, Assistant Professor of Graphic Design

Contact details: djemans@vcu.edu

Design School: Virginia Commonwealth University in Qatar, http://www.qatar.vcu.edu/

Theme Abstract: “My Mai (ماء)” is a culminating installation from a semester-long graphic design collaboration that explores the subject of water sustainability using multiple formats, interactive media, and the elements of both 2-D and 3-D space. Each area of the exhibition centers on a different water-related theme, encouraging visitors young and old to explore issues of consumption, personal habits, and desalinization within the MENA Region. Through poetic and pragmatic approaches, the exhibition delivers the poignant message that community awareness and involvement is needed to respond to the water crisis in a timely manner.

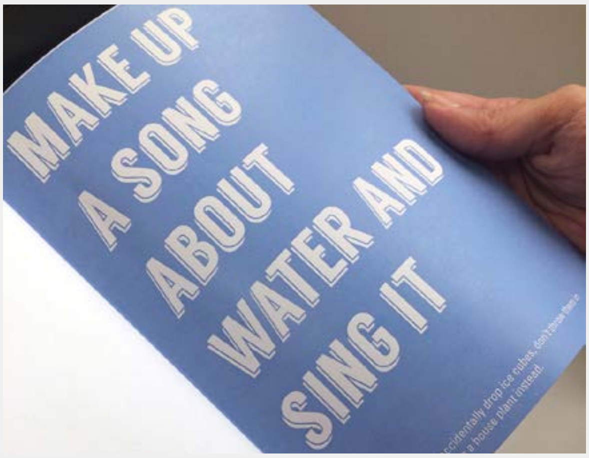
Aim: The primary aim of this project is to encourage a critically engaged application of design craft and design thinking to current and future water challenges through a process of research, conceptualization, construction, and presentation in an exhibition context.

Project description: To teach people about how time and water use are related, this interactive time-line displays the amount of water used when taking a shower based on a series of durations ranging from 5 to +60 minutes. This installation contains five pedestals that display methods of measuring water, including 1 cup, 1 liter bottle, 1 gallon bottle, bucket and container with a poster of the measurements. The interactive posters surrounding the pedestals provide the audience with simple tips on how they can improve their water habits with appliance in the home.

Sustainability aspects: Water is one of the planet’s most valuable resources, and one of its most imperiled. In dry regions of the world such as Qatar, issues of consumption, conservation, and utilization are key issues at the forefront of discussion and debate. Qatar is among the top water-scarce countries in the region and at the same time has one of the world’s highest per capita water consumption rates at 500 liters per day. In 2011, the World Bank indicated that over the next decades, the region will face drastic water shortages, owing about 20% of the scarcity to climate change and 80% to a steep increase in demand, based on population growth and fast economic development. As Qatar’s population continues to rise and the demand for water supply grows, creative and community based approaches are needed to achieve sustainable development.

Duration & Date completed: Spring 2014

Results & Photos: Alanoud Alattiyah's animation projected on shower curtain in the exhibition: http://vimeo.com/92012446



Student/s:
Alex Cabunoc

Safe Agua Peru: Giradora

Tutor/s: Penny Herscovitch, Dan Gottlieb

Contact details: designmatters@artcenter.edu

Design School: Designmatters at Art Center College of Design, http://www.designmattersatartcenter.org/

Theme Abstract: GiraDora addresses the burdens of hand-washing clothes for the nearly 1/2 of the world population without running water.

Aim: To create products to alleviate water poverty in the slums of Lima, Peru - for real-world implementation and potential scalability up to 1 million people.

Project description: GiraDora is the product of rigorous exploration, beginning with a 10-day intensive field research trip to Cerro Verde, a 30,000 person slum perched on the hills surrounding Lima, Peru, without access to running water or basic services.

PATTERNS & OBSERVATIONS: Following the research trip, we took our findings and began to analyze the data to discover patterns in both behavior and consumption. Where these two patterns intersected provided opportunities for design. After establishing the largest opportunity in hand-washing clothes, we proceeded with trend analysis on a macro, meso and micro level, to benchmark the current washing product landscape.

FIELD TESTING & CO-CREATION: After initial rounds of design exploration, we sent an early washing prototype along with a drying prototype to Cerro Verde for field testing by the same community where we conducted field research. The families in Peru responded to these working prototypes and shared their own ideas. Immediately, the women identified the highest value in combining our washing and drying prototypes into a single device. This level of interaction with end users afforded for insights that fundamentally shifted our design goals and drove the final design of a combined washer+spin-dryer.

ITERATIVE PROTOTYPING: Based on lessons learned from our own testing and user feedback from the field, we are continuing to improve the function, ease of use, and aesthetics of our working prototype.

PILOT TESTING: The revised prototype is currently undergoing a second round of testing in the slums of Chile, with support from our NGO partner's Santiago, Chile office. Our surveys focus on qualitative and quantitative design feedback, as well as pricing and market segment info.

VISUAL APPEAL: To align with Peruvian aesthetics, we combined modern clean form language with rugged, functional elements from water barrels common in slums. We based the color palette on Peruvian “Cultura Chicha,” known for by its bright colors and folk-inspired patterns.

MANUFACTURING & AFFORDABILITY: Social innovation though leader Paul Polak's principles guided our target price of $40, equivalent to 1/5 the cost of an electric spin dryer in the developed market. We minimized costs by repurposing the drive pedal mechanism from an existing product, sources for $3 from an overseas manufacturer. Following another round of field testing, we will determine the most appropriate manufacturing strategy: overseas manufacturing with drop shipping to target country, or in-country manufacturing with local distribution.

Sustainability aspects: Social, cultural, environmental

Duration & Date completed: 14 weeks, completed December 2011

Results & Photos: GiraDora's comfortable and ergonomic operation more than doubles productivity & increases health. Saves water compared to hand-washing laundry by eliminating a rinse cycle & facilitates re-use of water with drain. GiraDora reaches a wide market with a product designed specifically for underserved consumers. It is assembled in country to create local jobs. GiraDora's innovative business plan provides a user with 3 revenue streams to supplement income.

Student/s:
Sabina Brägger

STÖR – fischleder swissmade / STURGEON – Swiss-made fish leather

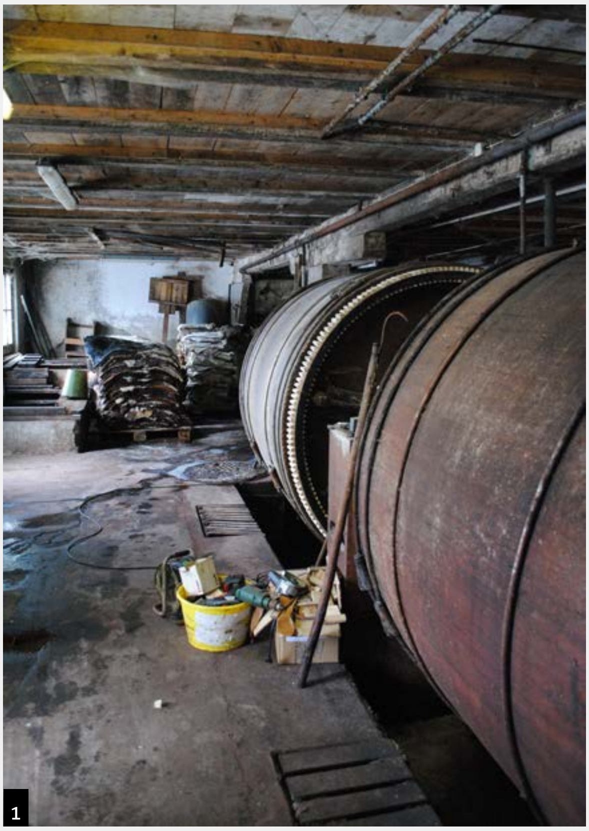
Tutor/s: Tina Moor, Marion Becella, Ursula Hersperger

Contact details: sabinabraegger@gmail.com, www.sabinabraegger.ch

Design School: Hochschule Luzern Design & Kunst, Textildesign, www.hslu.ch

Theme Abstract: Fish leather – 100% Swiss design. At the beginning of 2013, an experiment was carried out on sturgeon fish skin (a by-product of the tropical greenhouse in Frutigen). The outcome was successful - for the first time in Switzerland - a leather has been produced from fish skin. The potential for utilising this new material in high-end lifestyle products within a sustainable context is broad and varied. Applications range from interior screens to eyeglass frames. Anything is possible.


3


1

Aim: Almost all production results in surplus waste materials. These are often dismissed as worthless and consequently disposed of. My work attempts to give value to these waste materials by investigating their potential and transforming them into usable materials. Like other young designers, I am faced with the challenge of contributing products to an already oversaturated market. One solution to this problem is to focus on the development and processing of waste materials.

Project description: The sturgeon farm, Tropenhaus Frutigen was the catalyst for this project. As a producer of caviar, they are left with a large quantity of redundant sturgeon skins, which are burned at a bio-gas plant. During the course of my textile design studies, I developed an interest in the untapped potential of waste materials. Tropenhaus Frutigen eventually became the focus of these inquiries when I began to question whether this rare form of fish skin could be converted into a natural leather. After much experimentation, and with the cooperation of Zeller (a Swiss tannery), a method of producing sturgeon leather was finally achieved using a vegetable tanning process. While its acknowledged that the production of fish leather is not itself innovative (Siberian and Icelandic traditions have existed for centuries), introducing the process to a Swiss context has the potential to breathe new life into its production.

During my Bachelor Thesis I was able to extend my experiments beyond the tanning process. Out of these investigations a range of surface designs emerged that transported the leather from its more familiar traditional folk applications to a fresher urban context. This shift opened up the possibility of adapting the sturgeon leather for lifestyle products. The next step was to produce designs that would be able to complement the distinctive qualities of the sturgeon leather: its appearance is reminiscent of tree bark and it has texture similar to cork. Because this is such a versatile material, it can be utilized in a wide range of accessories. It also appeals to a broad range of users (both male and female) who are ethically aware and appreciative of high-end Swiss production.


2


4

Sustainability aspects: Preserving and expanding Swiss know-how through sustainable practices is a priority of this project. Every stage of production, from hatchery to tanning process to fabrication of design, is carried out in Switzerland. The Tropenhaus Frutigen is a respected leader in sustainable uses of energy, so it is crucial that the products which are made from their waste material are both durable and 100% natural to reflect the same level of integrity. Unfortunately, due to economic pressure from foreign competition, few tanneries remain active in Switzerland. This also means the disappearance of valuable craft knowledge. Zeller is presently the only tannery equipped to produce fish leather. During our collaboration, Zeller developed new tanning processes specifically to meet sustainable practice criteria.

Duration & Date completed: six months (January 2013 - June 2013)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7

Results & Photos: 01 rotating tanning cylinder used in production

02 work in progress at Zeller tannery

03 fishleather clamped for drying

04, 05 samples of sturgeon leather enhanced by using various techniques

06 weekender

07 bicycle/belt purse

08 block-heel sandals with sturgeon leather uppers for Tokushuu

9 trouser strap with cat's eye


9


8

Student/s:
Caitlyn Charniga, Tyler Somers, Zachary Bokuniewicz, Hunter Haubert, Rachel Mitrano

Save Ritchie

Tutor/s: Kelly Murdoch-Kitt, “Advanced Web & Interactive Design”

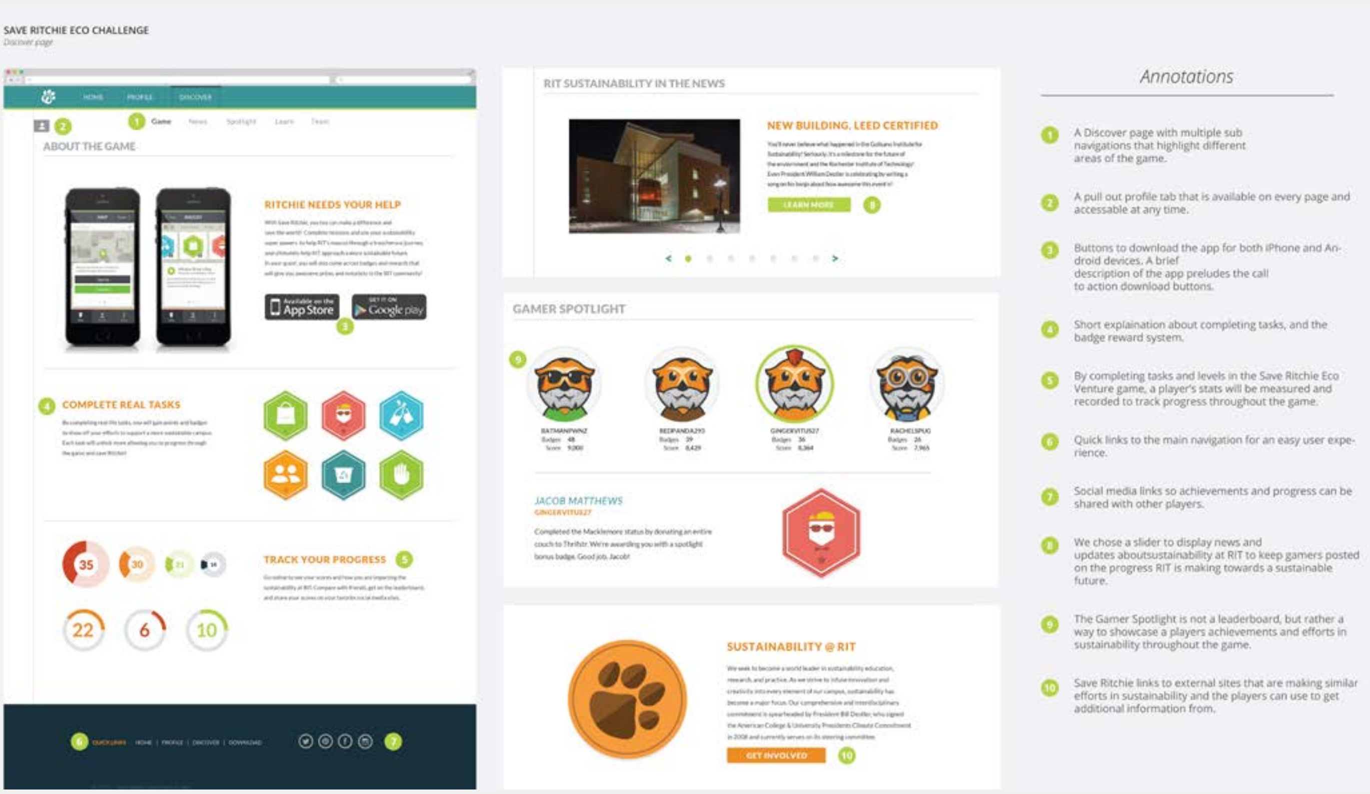
Contact details: kmmfaa@rit.edu

Design School: Rochester Institute of Technology

Theme Abstract: Save Ritchie, A mobile game that merges virtual and physical campus communities, encourages a large variety of sustainable habits though a game environment, which in turn allows for these habits to become much more fun, attractive, and appealing. These practices are mainly framed as activities and challenges, while tying in different campus events and organizations, acting as a hub for motivation and bringing different people within a campus community together.

Aim: The aim of Save Ritchie is to promote “sustainable” behaviors on campus and beyond through clever challenges that are woven into a mobile game. Effective and successful design impacts decision-making, and aids in creating certain social norms focused around sustainable practices.

Project description: A class assignment during our senior year as Graphic Design majors at Rochester Institute of Technology (RIT) challenged us to make sustainability more interactive and attractive to students while simultaneously addressing behaviors that reinforce the university’s sustainability initiatives. After we developed our concept for a mobile game (called “Save Ritchie,” after RIT’s mascot), we continued our work the following semester as an independent study. The current state of the project represents the culmination of seven months of research, design and development. Though our initial concept was designed with RIT in mind, our mobile game concept could be adaptable to college campuses nationwide.

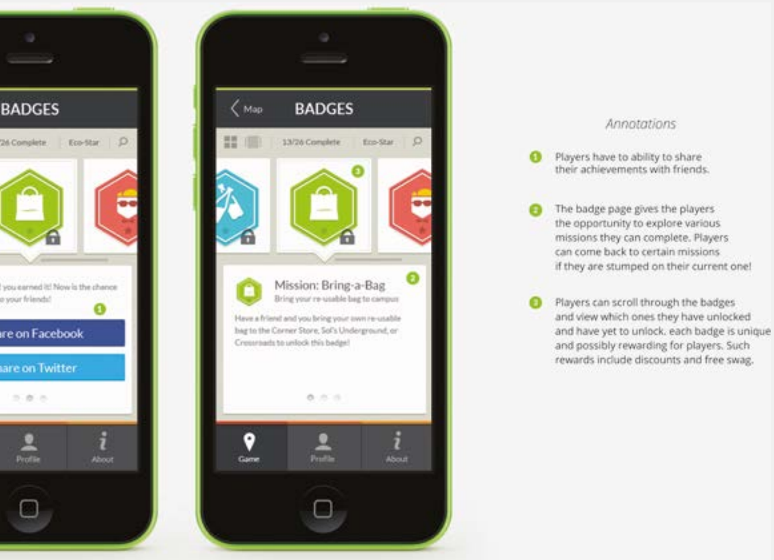


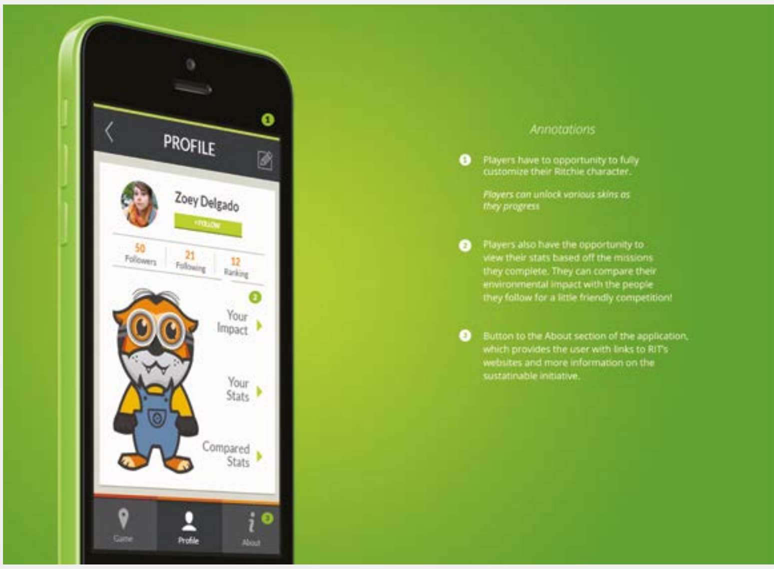
A fun-filled interactive game that bridges the gap between physical and virtual environments, Save Ritchie incorporates real-life challenges involving sustainable practices such as recycling, waste management, energy use, water consumption, and community engagement. Users can complete tasks not only to improve their game score, but also to track their progress in terms of a comprehensive eco-footprint. While completing challenges, players will learn more about how they can act on sustainable practices and help spread awareness about the campus' sustainability initiatives. The experience comes in two parts: an app where tasks and achievements can be completed and a website where players can track their scores and progress. There is some crossover in the features of both the app and website. With a university login, each player will be given a customizable mascot avatar that will help show their progress through the game. Advancing in the game will unlock new challenges and customizations that they can use to personalize their avatar.

Sustainability aspects: By providing positive interactions and success, game players will be encouraged to learn and build on their sustainable practices, adopting sustainable behaviors on campus and beyond. The game focuses not only on individual behavior change, but looks at change from a systemic level and strives to create new social norms through game play, so that simple actions such as bringing one's own shopping bag, using a reusable mug at the campus coffee shop, and donating used goods to be reused or recycled instead of sending them to a landfill become second-nature.

Duration & Date completed: October 2013 - May 2014

Results & Photos: This project was selected to be shown on campus as part of Imagine RIT, the 2014 campus-wide creativity and innovation festival. (May 2014)





Student/s:
Leah Mersky, Sunnie Yun, Rachel Anderson, Gentry Demchak, Keira McGee, Kyle Brady, Kate Wallace

Stay bag for resilient futures

Tutor/s: Jamie Kruse

Contact details: krusej@newschool.edu

Design School: Parsons, The New School for Design

Theme Abstract: A reinterpretation of the NYC Office of Emergency Management's "GO BAG." Students designed a "STAY BAG," reflecting the reality that we (all humans) have nowhere to "go" to in relation to emerging planetary futures. We are all charged to meet, engage, and respond as resiliently, and creatively, as possible to changing environmental conditions wherever we are.

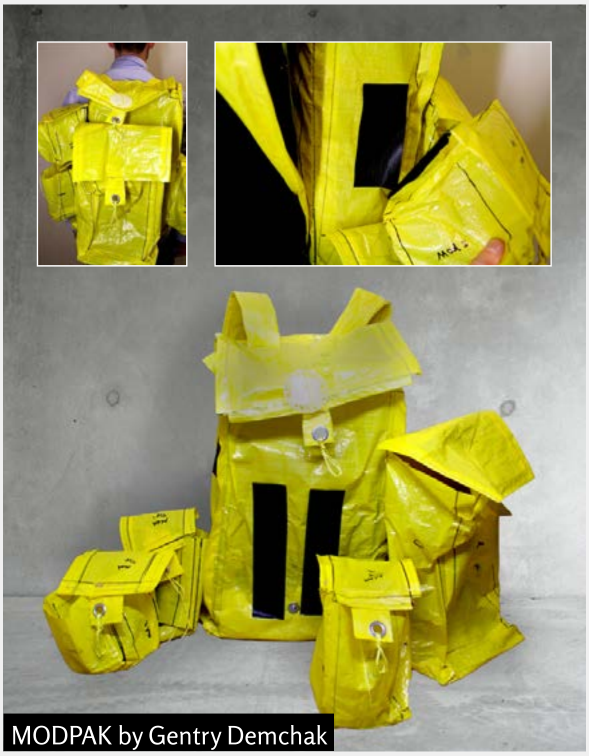
Aim: To respond resiliently and creatively to uncertain environmental futures.

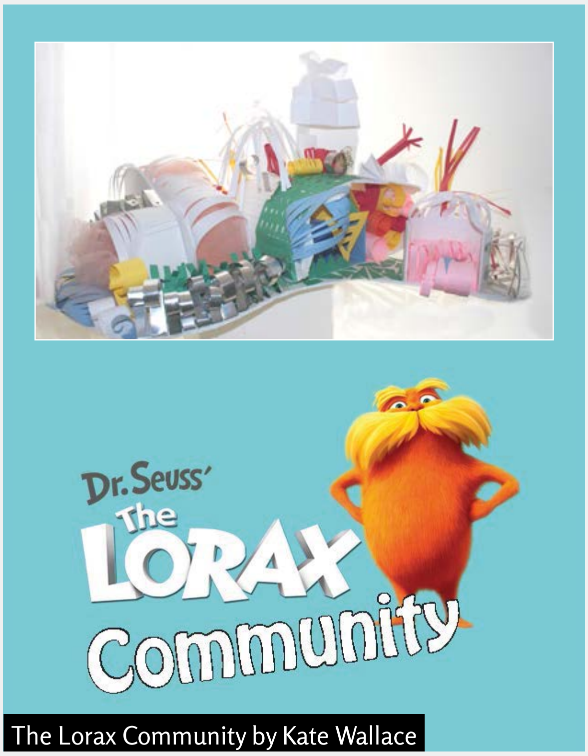
Project description: Each student was charged with designing a Stay Bag and including elements inside the bag that synthesized the semester's work in relation to our core themes of WATER, ENERGY, MATERIALS and AIR.

Sustainability aspects: Resiliency is the capacity to be flexible and adaptable in relation to complex events. Rather than striving to "recover" (return to what was) or "endure rigidly," we instead aim to navigate change responsively, while attempting to keep future actions open to reconsideration and augmentation and invite flexibility of response in the future.

Duration & Date completed: Fall 2014

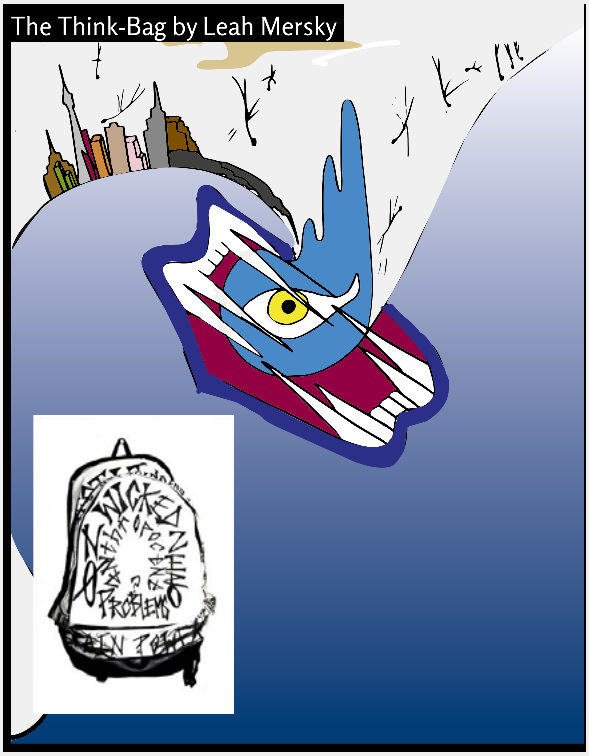
Results & Photos:


MODPAK by Gentry Demchak



The Lorax Community by Kate Wallace

HabiSuit by Kyle Brady


The Think-Bag by Leah Mersky

Selfie by Rachel Anderson


teddy by Sunnie Yun

Student/s:
Ewa Lefmann, Rhys Atkinson, Inari Sirola, Adam Bloomfield and Reece O'Toole

The Jelly Experiment

Tutor/s: Sian Cook

Contact details: ewa-c-l@hotmail.com / s.cook@lcc.arts.ac.uk

Design School: London College of Communication, University of the Arts London, http://www.arts.ac.uk

Aim: To provide an accessible way for companies to understand the effects of space-consuming packaging.

Project description: The Jelly Experiment aims to highlight the unnecessary transportation of wasted space due to the poor packaging design of supermarket products. It shows what cannot be seen by visualising the space in and around a selection of products. It demonstrates this through a pop-up exhibition of small 'wasted space sculptures', cast in jelly and displayed to the consumer. Both intriguing and educational, it is intended to spur consumers to encourage supermarkets to reconsider the design of their packaging and thus minimise their ecological impact.

Less wasted space = Less transportation vehicles= Less CO_2 emissions.

Sustainability aspects: The Jelly Experiment was born out of a desire to show others the wasted space that cannot be seen. Various packaged products were cast in eco-friendly material to create moulds of the non-product. After researching several materials, including bio-resin, we concluded that jelly would be the most appropriate material to cast the wasted space in – it is biodegradable, affordable, aesthetically pleasing (as well as intriguing) and is itself, supermarket bought. To pilot the project, four jelly sculptures (each of a different, own-branded product) where exhibited in a gallery setting. The tangible sculptures were not only intriguing, but helped viewers to process the information and message; each labelled with the product name, the volume of wasted space, an illustration of the original packaging and a link to an online petition. Whilst the gallery space gave the installation an engaging comic irony, our ambition is to take the piece to public spaces and shopping malls, to capture and inspire a larger consumer-focussed audience. Furthermore, this pop-up exhibition of wasted space can be replicated with ease and featured in retail capitals around the world. Those inspired, or keen to find out more can join the campaign, petition via the website and be provided with a template letter to send to supermarket head office.

Duration & Date completed: The Jelly Experiment was made as part of UAL Green Week, February 2013

Results & Photos:

Student/s:
Sam Julius

Sustainable Urban Housing

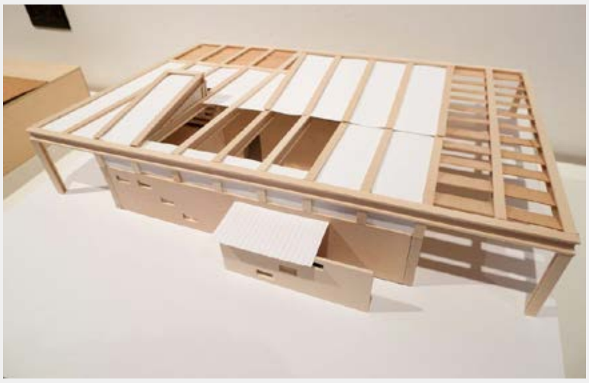
Tutor/s: Heidrun Mumper-Drumm, Dice Yamaguchi

Contact details: samjulius@microatomic.com

Design School: Art Center College of Design, www.artcenter.edu

Theme Abstract: This project analyzes existing materials in a home that can be reused for building a new, more sustainable structure.

Aim: Rebuild the house using as much original material as possible, reduce the amount of transportation needed for building materials & debris, and help the home be more independent of the grid.



Project description: Each year, 124,670,000 tons of demolition & renovation debris is put into landfills. As much as 85% of this material can be recycled or reused. When building on an existing site, the house is traditionally bulldozed and new materials are transported to the location.

As an alternative, this process carefully deconstructs a house, and useful materials can be sold, recycled or stored on site for the construction of a new home. The goal is to eliminate as much material entering landfills as possible, and to reduce the amount of transportation needed to ship heavy building materials and debris. Any saved materials will be reused in such a way that would let the new house require less energy and water by using passive building techniques.

Urbanization is a growing trend. Cities are congested with buildings, which means that anything we want to build will have to replace an existing structure. Our houses will have to start meeting a demand for charging electric vehicles, and the increased sustainability will be undermined if that energy is coming from coal-fired power plants.

Many designs for sustainable housing rely heavily on technology for smarter energy control, but the resources used in electronic components, battery technology and solar panels are both toxic and finite; we need to apply these sparingly to our green home solutions. Rather than use batteries for energy storage, compressed air tanks are a clean way of storing solar energy for use during non-peak hours.

Because this design is a process, not a finished product, the end result would change person-to-person based on their particular property and desires. The scope was limited to Southern California, but the philosophy of saving wanted materials and using local heavier materials could be adapted regionally or globally to best utilize local resources. A design firm comprised of architects, designers, material experts and engineers would need to provide the proper site/usable materials analysis on a case-by-case basis. This business could also offer on-site storage rentals for people to keep the materials in usable condition during construction. Unwanted materials could be recycled or sold.

Based on the amount of materials saved, a new home using re-purposed material and rammed earth construction has about six times less impact than the materials used for constructing a standard house. This reduction does not include the alleviated impact of transportation, or the amount of energy that would be saved over the structure's lifetime by using passive building techniques that leverage sun position, wind currents and geothermal temperature control.

The construction industry is generally resistant to change, which is part of the reason why techniques such as rammed-earth have not caught on as much. This project is about opening up consumers' minds to the possibilities when building new homes, and eventually having a market demand for more sustainable construction practices. Approaching the demolition of a house knowing that materials will be saved can change the way people see the possibilities of something new, and how valuable the sentimental value of the old really is.

Sustainability aspects: Construction, Green Material Usage, Passive Energy Use, Transportation/Shipping, Landfill Waste.

Duration & Date completed: 14 weeks, completed December 2013

Results & Photos: 1/6th the material impact over building a new house of similar size. Dramatically reduced shipping of heavy debris, and reduction of energy & water use during the lifetime of the structure.

Student/s:

Ben Saperstein

Wild Edibles

Tutor/s: Kelly Murdoch-Kitt, “Interactive 1”

Contact details: kmmfaa@rit.edu

Design School: California College of the Arts

Theme Abstract: Wild Edibles was created in response to a project brief entitled “Apps for Social Good.” Students were asked to choose an issue in the local community that they could research firsthand. Using a “mobile first” approach, each student conducted research, brainstormed, planned and ultimately designed a series of screens for a mobile app that addresses the social issue(s) they identified in the initial discovery stages of the project.

Aim: The project aims to begin the process of informing local residents of the types of consumable native foods that already grow wild in the area. There will also be user-driven content that aims to create a local network of residents that share food grown on private land with their neighbors.

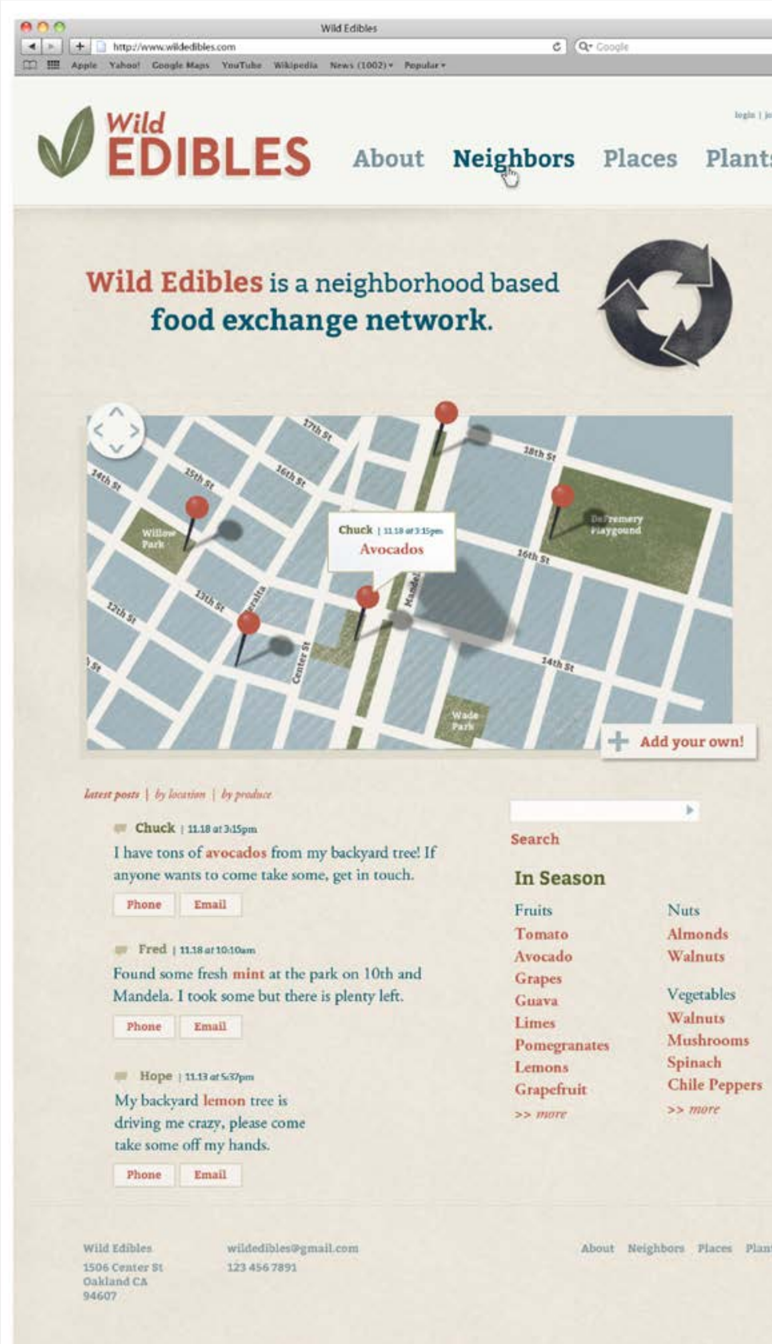
A future goal will be to create a campaign to repurpose the median on Mandela Parkway from 7th Street to West Grand Avenue from just a decorative landscape to a viable community resource.

Project description: In the Lower Bottoms area of west Oakland, there are people who do not have adequate or consistent access to unprocessed foods. However, the area does have plenty of unused or under-used spaces that could support the growth of edible native plants--some of which are already naturally occurring. This includes both public areas and private yards or lots. Wild Edibles enables residents of this area to identify and share abundant “wild” or cultivated edibles growing in the neighborhood, through a mobile app and companion website.

Sustainability aspects: This project addresses local food systems, food scarcity and food “deserts,” and building/ reinforcing local communities.

Duration & Date completed: October - December 2012

Results & Photos:



Student/s:
Cornelia Stahl

Wood in repeating patterns – convertible, reusable

Tutor/s: Tina Moor, Marion Becella, Ursula Hersperger

Contact details: corneliastahl@yahoo.de

Design School: Hochschule Luzern Design & Kunst, Textildesign, www.hslu.ch


2

Theme Abstract: Textile pattern design is used to give waste wood a new lease of life. The systematically designed pattern repeat on parquet planks is created with laser technology. Patterns – created by lines, structures and surfaces – can be realised in herringbone pattern, parallel or English laying system. The reusable planks are retrieved from demolition, reconstruction or renovation sites. They are treated in a way that their appearance varies in each laying system due to pattern multiplication. Inspired by the traditional intarsia technique, different structures, materials as well as colour interplay are combined on the floor or on the wall.

Aim: As a textile designer, I enter the area of wood design and envision that floor coverings and panels can be reused through the systematic combination of pattern, colour, material and technique. Material designated as waste can be recycled with little intervention. My aim is to create designs that help to give waste wood a second life.

Project description: In the project «Wood in repeating patterns», repeatable patterns on the floor are realised. I am thrilled about how laying systems for parquet open the way to innumerable possibilities for patterns. The design of the wood planks ensures floors to show new effects with each laying system. As it is a characteristic of parquet and panel to be removed and reinstalled in a different place, I want to make use of this feature for the recycling of wood products. The material retrieved during demolition, reconstruction or renovation activities is not discarded, but removed and redesigned with laser technology. Surfaces, structures and colour interplay become repeating patterns on the wood. Traces of use are also integrated into the designs. After the treatment, the laser patterned wood can be reused. Pattern and arrangement ensure the adaptation of the parquet or panel to the new location or the style of the user.

Sustainability aspects: Discover waste material – design waste material – make a treasure out of it

The project illustrates how waste material can be recycled through systematic creative interventions. Wood is given a second life due to its refining with repeating patterns and combinations of dissimilar material. Designing with scrap products helps to raise the awareness of material.

For this project, waste material is processed, including a parquet floor, more than 100 years old, which was removed during the reconstruction of a farm in Lucerne canton and which should have been incinerated. A parquet floor of a Culture and Center in Lucerne, is used as well as some 30-year-old panel which was retrieved during the renovation of an alpine chalet in the Bernese Oberland. Leftover pieces from floor installation are also used in this project.

The traditional intarsia technique was a source of inspiration for the drafts. Variations of these ornaments are integrated with a laser into the wood in an innovative way, so the traditional craft is presented to the audience through the patterning in the wood.

Duration & Date completed: November 2013 to June 2014

Results & Photos: 02 Parquet from a farmhouse,Lucerne canton

03 Waste wood panels from an alpine chalet, Bernese Oberland

06 Parquet plank with structure (laser technology), filled up with colour and leather residues

07 Parquet plank with pattern (laser technology)

7

6

3

Student/s:
Shi Weilu

Jump^n

Tutor/s: Li Wenlong

Contact details: gasparduillier@163.com

Design School: China Central Academy of Fine Arts, http://design.cafa.edu.cn, http://www.cafa.edu.cn

Theme Abstract: An entertaining, useful and green toy for kids.

Aim: It can not only be used as an exercise tool but also in the evening on the children's way back home.

Project description: The Jump^n is a product that combines jumping rope and flashlight. There is a capacitance inside that can absorb electricity which is generated by the generator when you are skipping, and then store it. Therefore the children can use it as a flashlight in the dark.

Sustainability aspects: The way Jump^n charges itself is totally green and sustainable. It can generate electricity and then use it to give light.

Duration & Date completed: 2/2013 – 5/2013

Results & Photos:

Student/s:

Students of the Workshop Plant Design of the ESAD de Reims

Urban Agriculture

Tutor/s: Patrick Nadean and Sara Lubtchansky

Design School: ESAD de Reims

Duration & Date completed: 2/2013 – 5/2013

Results & Photos:

Theme Abstract: In 2013 Students of ESAD of Reims concentrated on urban agriculture placing it in the context of the City of Reims and in the Reims 2020 project. Led by Patrick Nadeau, architect, designer and founder of the Plant design workshop, Sara Lubtchansky, town planner, and Nicolas Bonnenfant, landscape architect within the organization COLOCO, they were invited to explore the issue from their point of view as designers, placing themselves at the level of interaction between man and his environment.

Aim: Projects as diverse as nursery gardens, ways to promote local production, the creation of networks between consumers and producers ... have been devised. Often with an educational approach, several projects have sought to develop a methodical and temporal vision of the agricultural productivity cycle. Five projects were brought together having in common the desire to go beyond the purely market garden approach, by using practices from the past or from elsewhere in the world, to show that agriculture is an activity that can contribute to the development of trade and re-organize industrial production cycles. Originally designed to be independent they prove to be complementary and interdependent.

Project description: Projects as diverse as nursery gardens, ways to promote local production, the creation of networks between consumers and producers ... have been devised. Often with an educational approach, several projects have sought to develop a methodical and temporal vision of the agricultural productivity cycle. Five projects were brought together having in common the desire to go beyond the purely market garden approach, by using practices from the past or from elsewhere in the world, to show that agriculture is an activity that can contribute to the development of trade and re-organize industrial production cycles. Originally designed to be independent they prove to be complementary and interdependent.

1) Bio-gas: Methane is also a product of rotting compost. Compost mixed with air makes humus which feeds the soil and produces heat. Mixed with hot water, it ferments and produces methane. This bio energy feeds the stove to cooks the vegetables. In Japan and Cambodia, cabins are heated with compost; in Rwanda and Benin, methane is used for cooking, while in Sweden, bio gas is produced industrially to heat houses and run cars.

2) Stills: If fruit trees grew in the city ... the city would be a village! So as not to throw out rotten fruit from our urban orchards and supermarkets, we could distill them and make fruit brandy or a small amount of alcohol to run an engine. Fire produces ashes to make bricks, creates heat or cooks a snack and creates a social well-being, allowing some time to think. What if the city adopted the rural traditions?

3) Educational garden: This project shows the children that each plant grows in a differently: the potato is earthed up, chicory is grown in the dark, the strawberry plants are layered and tomato plants climb ... . These educational gardens in sacks of non-woven fabric are suspended along the walls of the school in order to follow the growth cycle of the plants.

4) Compost bricks: Putting humus into a brick form: a brick of dry and carbonnés organic waste is composed of sawdust, fungal matter, dry leaves, paper, cardboard, coffee grounds, egg shells and ashes. Mixed, wet, compressed and then dried, the brick is compact and easy to carry; it comes back to life with compost and water in order to fertilize.

5) Mushroom bed: Mixture of industrial and amateur practice in 6 steps.

- Step 1: Develop the mycelium in a jar of sweet water
- Step 2: Fill sterile jars with cereals (maize, rye, oats, wheat ...)
- Step 3: Make substrate with leftover fruit, organic bricks, fermenting dregs. Step 4: Deposit grains coated with mycelium on the substrate
- Step 5: Start the process of mushroom production in a dark humid place Step 6: Consume mushrooms (usually oyster mushrooms)

Student/s:

Sara Zouaoui

bottled light – environmentally conscious social design

Tutor/s: Moritz Schmid & Prof. Nina Gellersen

Contact details: sara.zouaoui.01@gmail.com

Design School: Lucerne University of Applied Sciences and Arts School of Art and Design,
http://www.hslu.ch/objektdesign, http://produktdesign.hslu.ch

Theme Abstract: Bottled Light is a series of lamps that have a distinctive aesthetic as a result of their combination of environmentally conscious design and social design. Produced in a sheltered workshop, each lamp is made from recycled glass bottles that are partially sandblasted, which gives a distinct quality of illumination. Bottled Light acknowledges the potential inherent in everyday objects by breathing new life into used and discarded glass bottles.

Aim: The aim was to create a regional upcycled product that is both sustainable and socially engaged. The challenge was to communicate these ethical values to the end user and raise their awareness of the commonplace objects they come in contact with.

Project description: As a designer, it is important to create objects mindfully. This entails recognizing our ethical responsibilities to society and the environment and acting upon them in our approach to aesthetic considerations. In recent years, terms such as regional origin, sustainability and longevity have become an integral part of our design vocabulary. When we produce, we cannot ignore these issues. Upcycling, as a method of designing objects, respects the environment and uses resources efficiently. It gives a second life to discarded objects and materials by upgrading and recontextualizing them.

Not only can this be a viable solution to the challenges posed by sustainable design, but it is also an opportunity to draw attention to overlooked and undervalued everyday objects. Bottled Light has taken one such overlooked everyday object, namely the discarded glass bottle, and transformed its hidden potential into aesthetic features.

Sustainability aspects: Apart from making a commitment to sustainable design principles, I also wanted this lighting series to be socially engaged. For this reason, I collaborated with the workshop ConSol Glas, which is part of an organization based in Zug, Switzerland that provides sheltered employment for people on disability incomes. The workshop recycles waste glass into new products. It's infrastructure and employee skills provided the framework for my designs to evolve, which meant that I had to find a way of balancing my wish to be innovative with the simple modes of production offered by ConSol Glas. This was accomplished through focusing on the intrinsic characteristics of the glass bottles themselves, such as variety of form and colour range. I designed four hanging light fixtures and one table lamp. Each model consists of a maximum of three different types of bottle. Rather than make straight horizontal cuts across each of these bottles, the cropping is intentionally curved.

The colours and proportions of the bottles have determined the distinct aesthetics of the lamps. This means decisions regarding reflection of light and the positioning of each coloured glass surface have been considered in the design process. In order to achieve an appropriate degree of brightness from the sandblasted glass, I decided to use 10W LED spots, which are strong enough to illuminate a living room. Each individual lamp has been given a name that acknowledges the original content of the bottles used in its fabrication. Collectively, as Bottled Light, they represent a commitment to environmentally and socially aware innovation.

Duration & Date completed: This project was developed for my Bachelor Thesis within a stipulated timeframe of one semester. A supporting dissertation discussed upcycling and upgrading by recontextualizing. Both were completed in June 2013.

Results & Photos:

Part 4

The Sustainability Glossary

Peter Stebbing

25 Parallel Worlds for Re-orienting Design

> *"When we try to pick out anything by itself, we find it hitched to everything else in the Universe"* John Muir (2013).

Sustainability is a complex subject because it embraces our entire existence and the impact of every individual person and their actions on the Earth. Consequently, due to its holistic character there are many important concepts and terms which it is helpful to know about when trying to understand sustainability. Indeed, sustainability is more an attitude to life than it is a subject to be defined within a curriculum or a volume. The entries compiled in this (I emphasize), incomplete glossary, embrace a spectrum of subjects ranging from technical terms to philosophical concepts. Anything approaching a complete Glossary for Sustainability would be an encyclopaedia in itself. This Glossary, unable to be comprehensive is therefore intended to illustrate an attitude towards the character of sustainability across the diversity of terms described here.

It is anticipated that should there be a future edition that other authors would also contribute to this Glossary.

Sustainability is a rapidly evolving field with expanding and unfocussed edges continually growing as we learn more and more about our impact on the Earth. Daily, we learn how our actions have caused further damage to the systems on which our survival depends. Consequently, specific questions to problems may find answers well beyond traditionally defined fields of knowledge as we discover the interconnectedness of our world. The fact is that we must recognise that we all are an integral part of the Earth system; swapping gases, obtaining nutrients, participating in and disturbing the flows of energy, water, and other resources etc.

The aim of this glossary is not merely to help the reader acquire environmental and sustainability literacies. I realise that all the information available in this glossary can be found somewhere on the Internet, however, that is not the point; I want to help you to connect through this glossary by providing small introductions (springboards if you will) which I hope will stimulate curiosity and facilitate your perception of our interconnectedness with our world. Many of the entries are cross referenced in this synthesis to other entries to facilitate a perception of how we are interconnected.

Sustainability (science?) is a subject rapidly acquiring its own language and I hope that this Glossary will help students to achieve a grasp of some of the terms and concepts which sustainability embraces. Finally, I hope that students may find the terms described in this glossary as starting points for arousing their own curiosity for their own projects for achieving a sustainable future.

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25.1 1970, + / - 1 year: the environmental awareness tipping point

(q.v. Greenpeace, Friends of the Earth, Earth Day, Club of Rome, The Ecologist)

The decade of the sixties gave birth to a new counter-cultural consciousness concerning many existing social inequalities and which many felt empowered to change. Consequently, the decade spawned movements for racial equality, women's rights, gay rights, and environmental concern. Concern for the environment was further stimulated by disillusion with materialism, the urban environment and food containing agricultural chemicals etc. (The Sixties, 2005; Carson, 1962). So it was that environmentalism and an environmental philosophy emerged as a social movement. On looking back one can identify many indicators of environmentalism.

One particular stimulant which many believed contributed to the development of environmentalism was the picture taken of the Earth by the crew of the Apollo 8 mission. Sir Fred Hoyle, had proclaimed that: *"Once a photograph of the Earth, taken from outside, is available, we shall, in an emotional sense, acquire an additional dimension ... once let the sheer isolation of the Earth become plain to every man, whatever his nationality or creed, and a new idea as powerful as any in history will be let loose"* (Hoyle, 1950). On the 24 December, 1968, the crew photographed the Earth whilst they were in orbit around the moon creating the now iconic image Earthrise. Subsequently, Hoyle was to observe that: *"Well, we now have such a photograph ... Has any new idea been let loose? It certainly has. You will have noticed how quite suddenly everybody has become seriously concerned to protect the natural environment. Where has this idea come from? You could say from biologists, conservationists, and ecologists. But they have been saying the same things as they're saying now for many years. Previously they never got on base. Something new has happened to create a world-wide awareness of our planet as a unique and precious place. It seems to me more than a coincidence that this awareness should have happened at exactly the moment man took his first step into space"* (Clayton, 1975).

1970, plus give and take a year (1969-1971), somehow marked a cultural turning point when environmentalism could be said to have achieved a critical mass in many developed countries. Environmentalism is a movement concerned with protecting the environment from the harmful activities of mankind. Environmentalism recognizes that living forms, other than human beings, along with natural environments deserve moral and ethical consideration in human thinking about social, political, and economic policies.

In 1968 the Italian industrialist, Aurelio Peccei and a Scottish scientist, Alexander King invited a group of professionals to Rome to discuss short term thinking in international affairs together with the consumption of resources and the world's increasing interdependence. The meeting was the birth of the Club of Rome (accessed at: http://www.clubofrome.org/?p=375). They commissioned a group of systems scientists at the Massachusetts Institute of Technology to investigate questions such as *"Are current policies leading to a sustainable future or to collapse? What can be done to create a human economy that provides sufficiently for all?"* (Meadows, Randers, Meadows, 2004) The resulting book entitled *The limits to growth* was published in 1972 and translated into 25 languages and sold 30 million copies (Meadows, Meadows, Randers & Behrens 1974).

Also in 1968 Stewart Brand and a group of colleagues created and published the first Whole Earth Catalog which provided the reader with a diverse range of tools and subjects so that, like the Internet, one could find information about anything. *"Standing with one foot firmly in the rugged individualism and back-to-the-land movements of the Sixties counterculture and the other in the nascent global community made possible by the Internet, the WHOLE EARTH CATALOG offered an integrated, complex, challenging, thought-provoking, and comprehensive worldview."* (Source 1. below)

Entries were grouped into the following sections

› Understanding Whole Systems
› Shelter and Land Use
› Industry and Craft
› Communications
› Community
› Nomadics
› Learning

In 1969, an offshore oil spill in Santa Barbara, was the initial catalyst for an organization concerned with the environment (Source 2. below). However, internal differences about confronting nuclear issues resulted in David Brower leaving the Sierra Club (concerned with protecting USA's mountainous wild regions) to set up a new organization. Brower wanted it to operate internationally and so it was that in 1971 'environmentalists' from Great Britain, France, the USA and Sweden met in Roslagen, Sweden, and founded *Friends of the Earth International* (Source 3. below).

A less well known, but now prominent organization, is the Union of Concerned Scientists which began as a group of students and faculty members at the renown Massachusetts Institute of Technology in 1969 and is now an alliance of 400,000 scientists and citizens. The Union is an organization independent of political and commercial interests but concerned that *"scientific analysis … should guide our efforts to secure responsible changes in government policy, corporate practices, and consumer choices …"* to secure a sustainable future (http://www.ucsusa.org/)

In July 1970, in the UK, the first edition of the magazine The Ecologist was printed by Edward Goldsmith which published articles of concern about achieving a sustainable future and contributed to a greater awareness of approaching problems including: waste, the exhaustion of natural resources, population, social disorder, and the compartmentalization of knowledge, etc. (Goldsmith, 1970). The edition of the Ecologist (vol 2, no 1) which was published in January, 1972 was devoted to *"much more than just another review of man's environmental problems: it offers radical proposals for immediate action. The storm of debate it provoked among politicians and scientists has generated constructive action and widespread concern."* The issue was reprinted as a Penguin Special entitled: *A Blueprint for Survival.*

Another world renown organization was also born in 1970-71. The USA was planning to carry out a second nuclear weapons test on one of the Aleutian Islands called Amchitka. A group of environmental activists planned to sail into the testing zone so as to hinder the test. In 1970 they organized a pop concert to raise funds for the purchase of a boat but on its voyage to Amchitka it was unfortunately intercepted by the US navy. Although, at the time it seemed that the voyage was a disaster the action, nonetheless caused a public stir. The boat was "The Greenpeace" and the rest of story, as they say, is history. (Source 4. below)

On 22 April, 1970, the first Earth day was proclaimed in the USA by Senator Gaylord Nelson. Since then the event has taken place annually to promote and encourage everyone's participation in supporting a healthy environment for the planet.

In 1971 a book was published entitled *"The Closing Circle"* by Barry Commoner. In it Commoner defined four laws of ecology (see Chapter 3, *Why we have to design for sustainability – the new paradigm, schesiological links and externalities.*) which Greenpeace freely adapted for their own Greenpeace Declaration of Interdependence, 1976. According to the Greenpeace Declaration:

› *First Law of Ecology: All forms of life are interdependent.*
› *Second Law of Ecology: The stability of ecosystems is dependent on diversity (complexity).*
› *Third Law of Ecology: all resources (food, water, air, minerals, energy) are finite and there are limits to the growth of all living systems. (Source 5.)*

During the -60s wetlands experts, government and NGO representatives, concerned with what was happening to the world's wetlands began discussing how to protect wetlands ecosystems and in 1971 they met at Ramsar and on 2 February, created the first international agreement for environmental protection now known as the Ramsar Agreement. The delegates called *"for an international treaty on wetlands and for a list of internationally important wetlands"* (Ramsar, 2014) and for their protection.

The 1971 Ramsar Agreement begins: *"The Contracting Parties, Recognizing the interdependence of man and his environment;*
Considering the fundamental ecological functions of wetlands as regulators of water regimes and as habitats supporting a characteristic flora and fauna, especially waterfowl;
Being convinced that wetlands constitute a resource of great economic, cultural, scientific and recreational value, the loss of which would be irreparable;
Desiring to stem the progressive encroachment on and loss of wetlands now and in the future;
Recognizing that waterfowl in their seasonal migrations may transcend frontiers and so should be regarded as an international resource;
Being confident that the conservation of wetlands and their flora and fauna can be ensured by combining far-sighted national policies with coordinated international action."

The signatories to the original agreement confirmed that *"1. Each Contracting Party shall promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands, whether they are included in the List or not, and provide adequately for their wardening."*

The Ramsar Agreement was the first international agreement concerned with protecting the environment. Today it has 168 contracted parties and there are

2,186 wetlands Ramsar sites with a total surface area of 208,449,277 ha. (http://www.ramsar.org/, 2014)

Obviously, there is much more in the history which brought about this cultural and social critical mass to create the environmental movement. A generation which felt that it could change the world may indeed have done so in the seeds that were planted in the second half of the -60s.

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25.2 The Association for the Advancement of Sustainability in Higher Education or AASHE

The Association for the Advancement of Sustainability in Higher Education is an American Association based in Denver. The following text is from its web site at: http://www.aashe.org. They write that:

- *"Our Mission: AASHE's mission is to inspire and catalyze higher education to lead the global sustainability transformation.*
- *Our Vision: AASHE will lead higher education to be a foundation for a thriving, equitable and ecologically healthy world.*
- *Our Values: Transparency, Collaboration, Hope, Stewardship, Innovation, Courage, Accountability.*
- *Our Goals (Adopted June 4, 2011 as Goals for 2015)*

Extending its role as a thought leader for higher education sustainability.*

AASHE will:

1. *Deliver services that increase its value to a growing and diverse membership and will increase its impact on sustainability in higher education;*
2. *Convene experts and collect, evaluate, and disseminate information and tools to increase the understanding of sustainability and its relevance to higher education stakeholders;*
3. *Support and enable higher education to reduce greenhouse gas emissions and to adapt to the impacts of global climate disruption;*
4. *Lead the transformation of educational practices (including the curriculum) to ensure that all students acquire the knowledge, skills, and dispositions to meet sustainability challenges;*
5. *Lead the assessment and reporting of metrics of sustainability in higher education for the purpose of driving improvements in sustainable practices and education through its Sustainability Tracking, Assessment & Rating System (STARS);*

**AASHE defines sustainability in an inclusive way, encompassing human and ecological health, social justice, secure livelihoods, and a better world for all generations."*

Furthermore, it will help to transform *"higher education institutions to model exemplary sustainability practice and learning is not easy! AASHE is prepared to assist sustainability staff, faculty and leadership in their efforts by providing professional development that introduces sustainability into curriculum, facilities, operations and services."*

The Association offers a number of resources which are accessible on its web page and with which one must register.

Sources

http://www.aashe.org

25.3 Adaptive Design

(q.v. mitigative design, planetary boundaries, resilience, stationarity)

One of the definitions of adaptation is *to become adjusted to new conditions*. It is in this sense that adaptive design is crucial for both sustainability and resilience.

What are the new conditions we face resulting from our unsustainable practices? Unfortunately, there are many, but let us take the example of climate change and the consequence of sea level rise. Clearly, it will be necessary to protect cities located on seaboards from flooding. London has the Thames Barrier to protect it from sea-level rise. In recent years this has been increasingly raised to protect London from flooding. The Thames Barrier is a classic example of adaptive design. There are many mega-cities (with more than 10mn inhabitants) located on sea-boards and which will be affected by the rising sea-level.

Meteorologists now recognize increasingly 'weird weather' resulting from global warming with exceptional events causing disasters such as floods, heatwaves and fires etc. Prior to global warming weather was defined by an "envelope" of "normal" ranges of weather for rainfall, temperature etc. Meteorologists call this "envelope" stationarity (qv), however, the concept has now been abandoned as we move to greater extremes which will now become the new norms.

Adaptive design is concerned with the fields of rescue, emergency, health, the translocation of people, disaster communication and management and we now need to address problems on a scale not previously anticipated (Alexander, 2000; Alexander, 2002; Phillips, 2009) in design education.

Kruse (2006) describes a range of adaptations in which obviously design will play a key role, for example:

"*(D) actions to prevent negative environmental impacts on humans (e.g. construction of dams, use of sun protection against ultraviolet radiation, development of drought resistant crop strains).*

(E) curative measures treating damage already manifest or imminent (e.g. evacuation from areas threatened by flood ...), or

(F) measures to preventively reduce vulnerability of the human/social system to global environmental change (e.g. diversification of agricultural systems)." (Kruse, 2006)

We know that our world is entering a phase of transition due to the fact that we have and continue to change both the environment and climate. The significantly sceptical population of the US is being warned by its Environmental Protection Agency *"that climate change is not only already strengthening storms, accelerating ice melt, and raising global sea levels, but that it's happening faster than anticipated. "These indicators make it clear that climate change is a serious problem and is happening now here in the U.S. and around the world," Janet McCabe, acting assistant administrator for EPA's Office of Air and Radiation, said in a statement"* (Neuhauser, A., 2014).

Adaptive design measures would therefore strategically explore and address a range of responses to emergency situations such as the impact of hurricane Sandy on New York or the Paris heatwave of 2003 causing an estimated 3,000 deaths.

In contrast to adaptive design, mitigative design is concerned with the avoidance or (reduction) of problem creation. In the case of global warming and sea level rise, mitigative design (see Glossary) entails strategies to reduce CO_2 emissions, for example replacing fossil fuel energy with renewable energy sources such as solar, wind and wave etc. and even nuclear power.

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25.4 Afrigadget

(q.v. Honeybee Network)

'*Afrigadget*' is a web site showcasing, promoting and publicizing African sustainable ingenuity. It began in May 2006 since when it has been presenting case studies describing designs developed and created by people from all over Africa.

"The purpose of Afrigadget is to showcase African ingenuity with technology. Many times Africans do not have access to the same quality tools or items that are found in other areas of the world. What is available to be used to solve problems or fix equipment can be wide and varied. You would be surprised at what can be made, fixed or created with bailing wire, inner-tubes and wood."

In many respects '*Afrigadget*' is comparable to the Honeybee Network set up by Prof Anil Gupta in India. The Honeybee Network (qv) promotes, patents and protects the inventions of many Indians who create designs with minimal resources.

Afrigadget (as does the Honeybee Network) provides many valuable examples of what can be achieved with limited materials.

The projects being publicized here are important because it illustrates how *"limited means can provide unlimited possibilities. The Greeks argued that all machines can be constructed by combining six elementary mechanisms: namely the lever, screw, inclined plane, wedge, wheel and pulley"* (Lewin, & Regine, 1998). Obviously, today the complexity of electrical and digital equipment obscures fundamental principles of this kind, but nonetheless, educationally it begs the important question as to what are the limited means of today?

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25.5 Anthropocene

(q.v. planetary boundaries)

The World's geological history is recorded in periods lasting millions of years; geological ages. These periods are characterized by the Earth's geo-chemico-physical characteristics of the time. Most recently, mankind has lived in the Holocene Age for the past 10-12 thousand years.

Now for the first time one species, Homo sapiens sapiens, our species, dominates and determines our planet's environment – our species has now become a force of nature, like volcanoes, asteroid strikes, earthquakes, etc. Mankind has and is changing the chemistry of both the atmosphere and the oceans. He is moving billions of tons of earth, over the last 5 decades he has created 50,000 dams re-directing rivers and cutting the flow of nearly a fifth of them. The polar ice caps and glaciers all around the world are melting. It has even been proposed that during the summer of 2016 and more certainly by 2020 that the Arctic Ocean and North pole may be completely ice free.

Paul Crutzen, writing in Nature (2002) coined and proposed that we have now entered the *Anthropocene age* because of our impact on the world. Our environmental influences now parallels any of nature's existing forces. As a consequence we are changing the environment and changed environments demarcate geological ages from one another. We have changed the proportions of the atmosphere's constituents (CO_2 is now 400ppm) which in turn are both warming and changing the chemistry of the oceans, making them more acidic and in addition we are polluting them with plastic. Species have been redistributed either directly by human intervention or indirectly as the climate changes. Populations of vertebrate animals have declined by 52% (WWF, 2014). We have also removed large areas of forest which in turn affect the climate and so on.

The challenge mankind now faces is that he must learn to sustainably manage the Earth system. We must acknowledge that a finite world has planetary boundaries or limits (Rockström, et al. 2009). If we want to manage it wisely we must also leave a buffer between our requirements and these boundaries. Unfortunately, it appears we have substantially overstepped 3 planetary boundaries (qv):

1. the loss of ecosystems and biodiversity
2. climate change
3. nitrogen pollution

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25.6 Bhutan: Gross national happiness (GNH): a tiny state's big idea that could change the world

(q.v. GDP, Consumerism & Ladakh)

The small eastern Himalayan state of Bhutan, located between India and China, does not accept Gross Domestic Product (GDP) as the sole measure of progress. Instead, since 1971, Bhutan has promoted a new concept for development by measuring prosperity with the formal principles of gross national happiness or GNH, initiated by King Jigme Dorji Wangchuck who, although he died in 1972, but was continued by his son, now King Jigme Singye Wangchuck (Mayhew, Brown & Mahapatra, 2011). In assessing GNH, the spiritual, physical, social and the environmental health of its citizens and natural environment are taken into consideration. Bhutan has provided a strong warning that the rest of the world's nations are on an economic and environmental suicide path. A mark of success of Bhutan's national strategy is that 68 countries have endorsed the UN's call for a holistic approach to development and a UN panel is now examining how Bhutan's GNH model could be adopted globally.

The country has placed environmental conservation and sustainability at the centre of its political agenda and actually enshrined the protection of the environment into its national constitution. Furthermore, the government has pledged to remain carbon neutral and that at least 60% of the country will retain its forest cover for ever. It has also banned timber exports and every month there is a pedestrian day when all private vehicles are banned from the roads. In the last two decades it has overhauled its infrastructure, enrolled nearly 100% of its children in primary schools and doubled life-expectancy.

Bhutan's minister for education, Thakur Singh Powdyel says that: *"It's easy to mine the land and fish the seas and get rich. Yet we believe you cannot have a prosperous nation in the long run that does not conserve its natural environment or take care of the wellbeing of its people, which is being borne out by what is happening to the outside world … GNH is an aspiration, a set of guiding principles through which we are navigating our path towards a sustainable and equitable society. We believe the world needs to do the same before it is too late"* (Kelly, 2012).

Bhutan's strategy is based on achieving what it calls the 4 pillars of GNH (Gross National Happiness)

1. Sustainable and equitable socio-economic development
2. Conservation of the environment
3. Preservation and promotion of culture
4. Good governance

The ways for progressing towards the four pillars of GNH are through the 9 Domains of GNH:

1. Psychological well-being
2. Standard of living
3. Good governance & gross national happiness
4. Health
5. Education
6. Community vitality
7. Cultural diversity & resilience
8. Time use & happiness
9. Ecological diversity & resilience

Four years ago the four GNH pillars were integrated into the educational system and all educational institutions changed into "green schools". Initially the government's policy was not fully understood, however, a head teacher at a primary school in Thimphu, Ms Choki Dukpa, says that: *"The idea of being green does not just mean the environment, it is a philosophy for life"* (Kelly, 2012). Since the principles were introduced into education huge changes have been witnessed to the children's emotional wellbeing.

In addition to maths and science, the children are also taught basic agricultural techniques and environmental protection. Furthermore, every piece of material used at the primary school in Thimphu is recycled.

Bhutan is one of the world's poorest nations and a quarter of its 800,000 people live on less than $1.25 a day and 70% have no electricity. Regrettably, it is struggling with rises in violent crime, population and global food prices. These difficulties may well be the influence of 'westernization' which has also been observed in the Indian Province of Ladakh by Helena Norberg-Hodge (1991).

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Norberg-Hodge, H. (1991) Ancient Futures, learning from the Ladakh, San Francisco, Sierra Club Books.

Source

www.theguardian.com › News › World news › Bhutan
http://www.grossnationalhappiness.com/9-domains/
http://www.project-syndicate.org/commentary/growth-in-a-buddhist-economy

25.7 Biodiversity

(q.v. TEEB, ecosystem services, Sixth extinction)

The Millenium Ecosystem Assessment defines Biodiversity as: *"the variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." The TEEB (2010) team add that: "In other words, biodiversity includes diversity within species' populations (genetic variation); the number of species, and the diversity of ecosystems."*

- › *Biodiversity forms the foundation of the vast array of ecosystem services that critically contribute to human well-being.*
- › *Biodiversity is important in human-managed as well as natural ecosystems.*
- › *Biodiversity includes all ecosystems – managed or unmanaged.*
- › *Decisions humans make that influence biodiversity affect the well-being of themselves and others."*

The conservation of biodiversity is the largely unrecognized key to human survival because biodiversity, the collective inhabitants of ecosystems, provides the ecosystem services on which human existence depends. Unfortunately, the recognition of the role of biodiversity, because it has not until recently been given a monetary value, means that it has been unrecognized in supporting human existence. The Intergovernmental Panel on Climate Change was established in 1988 whilst the parallel organization for biodiversity: Intergovernmental Platform on biodiversity and ecosystem Services was set up only as recently as April 2012! In Sept 2014 the World Wildlife Fund revealed that the populations of mammals, birds, reptiles, amphibians and fishes had dropped by 52% since 1970 (WWF, 2014).

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25.8 Bioneers

(q.v. eco-literacy, schesiology)

Bioneers is a New Mexico corporation founded by Kenny Ausubel and Nina Simons in 1990 who also coined the term.

Bioneers is primarily concerned with promoting and advancing holistic education concerned with "*global social, cultural and environmental issues. Bioneers identifies progressive yet nature-honoring solutions to rising challenges of instability, inequality, and sustainable growth and disseminates this knowledge*" via a variety of actions.

- › Bioneers promotes its concerns through the National Bioneers Conferences which are held annually.
- › Producing a series of radio programmes and filmed lectures for free online access.
- › Bioneers also organizes community action networks to disseminate holistic education.
- › and they publish a book series, for example: Stone, M.K., & Barlow, Z., 2005, *Ecological literacy; educating our children for a sustainable world*, The Bioneers Series, San Francisco, Sierra Club Books

Bioneers provides an invaluable resource and repository of information on sustainability issues through its recorded lectures and programmes of a kind as exemplified by a talk given by Amory Lovins on the future possibilities of energy which may be viewed at:

http://media.bioneers.org/listing/reinventing-fire-amory-lovins3/

References and further reading

Stone, M.K., & Barlow, Z. (2005) Ecological literacy; educating our children for a sustainable world, The Bioneers Series, San Francisco, Sierra Club Books

Sources

www.bioneers.org/
http://media.bioneers.org/listing/reinventing-fire-amory-lovins3/

25.9 Biophilia

(q.v. sixth extinction)

'Biophilia' is a hypothesis proposed by probably the foremost biologist of our times – E. O. Wilson (Kellert, S.R., & Wilson, E.O., 1993). He writes that *"Biophilia, if it exists, and I believe it exists, is the innately emotional affiliation of human beings to other living organisms. Innate means hereditary and hence part of our ultimate human nature."* Wilson explains that it is not so much a single instinct but rather a complex of learning rules from which one can analyse individual behaviours or responses. Furthermore, multiple emotional responses are elicited from symbols which compose a large part of human cultures.

The question of how *'biophilia'* could have evolved is illustrated by the example of the human innate response and aversion to – and fascination with snakes, which although potentially threatening, are deeply embedded in many cultures.

There is much evidence to support our affinity to organisms. Our species has been hunter-gatherers for more than 99% of its existence living in close association and dependence on other organisms. There is mounting evidence of the health benefits of natural environments. In a pioneering experiment (Ulrich, 1984) medication and recovery rates were compared between patients kept in a ward with windows looking out onto trees and patients in another ward with a view of the wall of an adjacent building. It was found that the patients who were able to look out at the trees recovered more quickly and needed less medication.

Furthermore, it can hardly be accidental that we decorate textiles, ceramics, ironwork, jewellery etc. with the organic motifs of plants and animals. A characteristic which pervades most, if not all, cultures.

Japanese research (Li, 2010) reports that walking through woods ('forest bathing' called *Shinrinyoku* in Japanese) benefits the immune system due to chemical compounds emitted by trees. The inclusion of nature into cities brings many sustainable benefits ranging from a reduction of vandalism, improved health (Hardy-Gould, 2008) and an aesthetically pleasing environment. Research into our relationship with pets and other animals (Olmert, 2009) are also found to have psychological, therapeutical and physiological benefits, for example: lowering blood pressure in the aged to strengthening the immune systems of children.

There is clear evidence that integrating nature, in its broadest sense, into the human environment, brings great benefit both physiologically and psychologically to human health. Surely, there is a whole field of design awaiting development which explores the purposeful integration of nature and/or its representation in the human environment for human wellbeing and sustainable development-applied biophilia?

One branch of architecture is called biophilic design and follows the idea, verified by Ulrich, that nature promotes human health (Sternberg, 2009). Biophilic design, recognizes that nature and natural systems have a beneficial effect on human wellbeing. Therefore, instead of creating the 'concrete jungles,' the biophilic design problem is how to integrate nature throughout the urban environment; concreted public spaces, ministerial buildings, hospitals, park houses, office blocks etc. (Kellert, 2008).

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25.10 Bioregionalism

(q.v. DESIS, Community supported agriculture)

Bioregionalism is defined as the theory that regions should not be defined by political and bureaucratic priorities for administrative convenience as they are now. Rather, naturally defined bioregions should determine environmental policies and social organisation. Bioregions are defined by a coherence of geophysical, topological and environmental characteristics such as watershed, terrain, soil characteristics, ecosystems etc. which give the region a natural unity and ecological identity. The concept of bioregionalism also recognizes that its identity is composed of the cultural characteristics and the local identity of the population and their lifestyle.

Bioregionalism is a concept which re-establishes the identity of inhabitants with their locality and as a part of the environment promoting sustainability and greater harmony with a naturally defined region.

Bioregionalism seeks to promote the use and stewardship of a particular region's own resources, land, local foods, plants and materials etc.

Bioregionalism provides a new framework for designers to promote activities to develop the care of the localities in which people live and to create a perception of environmental stewardship.

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http://www.thefreedictionary.com/bioregionalism
http://sustainability-now.org/bioregionalism.htm

25.11 Borrowing – A new ethic (instead of re-cycling)

(q.v. the Re-Strategies: Reduce, Recycle, Repair, Reuse & Remanufacture, Disasssembly design, Decomplexifying design)

We need to adhere to the ethic of, not merely recycling materials, but that design *borrows* the world's resources to create temporary arrangements of resources known as 'designs.' The concept of *borrowing* has the moral obligation (lacking in the term 'recycling) of *returning* materials for further use. This is the real responsibility of design, designers *borrow* the world's resources and are therefore morally obliged to ensure the *return* of the materials required for their design for further re-use by those who follow.

The whole concept of borrowing the resources we need changes our relationship to the Earth and the materials we use during our short existence.

25.12 Brown Economy

(q.v. Green economy, Economics)

The brown economy (Sukhdev, 2012) is based on the exhaustive use of finite resources and fossil fuels, regardless of environmental degradation, ecosystem loss and pollution. *"Brown growth describes economic development that relies heavily on fossil fuels and does not consider the negative side effects that economic production and consumption have on the environment," says Uwe Deichmann, Senior Environmental Specialist at the World Bank and co-author of the recently published book: Growing Green: the economic benefits of climate action"* (Deichmann, & Zhang, 2013).

The antidote to the brown economy is the green economy on which the new design paradigm is based. UNEP has defined the green economy as *"one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one which is low carbon, resource efficient and socially inclusive"* (UNEP, n.d.).

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25.13 Capitalism's basic incompatibility with sustainability

(q.v. Wicked Problems, Syndromes)

Capitalism and sustainability are fundamentally incompatible. In order to understand why, we need to define capitalism and Chang does it for us very simply: *"So what is the capitalist economy, or capitalism? It is an economy in which production is organized in persuit of profit, rather than for own consumption (as in subsistence farming where you grow your own food) or for political obligations (as in feudal societies or in socialist economies, where political authorities, respectively aristocrats and the central planning authority, tell you what to produce)"* (Chang, 2014).

In an earlier book, Chang writes that *"The profit motive is still the most powerful and effective fuel to power our economy and we should exploit it to the full. But we must remember that letting it loose without any restraint is not the best way to make the most of it, as we have learned at great cost over the last three decades"* (Chang, 2010). This is part of the problem due to the extent of deregulation (… of the banks by President Clinton who repealed the Glass-Steagall Act (Tran, 2008)) and weak controls of the banks and the attribution of 'personhood' to corporations so that they have enormous powers. Consequently, investigations by Trucost in 2008 into the activities of the top 3000 largest publicly quoted companies revealed that *"no-one is made to pay for the disastrous impact of pollution and the rapid loss of freshwater, fisheries and fertile soils"* (Jowit, 2010). The report revealed that just for the year 2008 these companies made profits in the region of $6 trillion but had caused an estimated $2.2 trillion of environmental damage and pollution. In other words about a third of their profits. *"What we are talking about is a completely new paradigm … markets are not fully aware of these risks, and don't know how to deal with them." said Richard Mattison, the leader of the report and Trucost's chief operating officer* (Jowit, 2010).

When we also recall what Gregory Bateson (1980) wrote: *"… for the organism … for all objects and experiences, there is a quantity that has an optimum value. Above that quantity, the variable becomes toxic. To fall below that value is to be deprived … This characteristic of biological value does not hold for money … For example, $1001 is to be preferred to $1000. But this is not so for biological values."*

"The most important producers today are large corporations …" (Chang, 2014) and given that their raison d'etre is to create profit then this is where unsustainability begins. Let us take for example a corporation producing synthetic fertilizer, they want to sell as much as possible. However, the use of synthetic fertilizers after several seasons damages the soil. The organic component within the soil declines causing it to become more compact and to degrade (heavy machinery also contributes to the compaction). The compaction means that it is more difficult for water to infiltrate the soil which consequently holds less water and instead runs off the surface. All of these effects slow plant growth. The reduction of the soils natural biota further reduces fertility. Further applications of fertilizer become less effective because it easily runs off the land due to soil compaction (Goering, Norberg-Hodge & Page, 1993; Ahmed, 2013) causing pollution of water systems, eutrophication, damage to ecosystems and dead zones around our coasts and the nitrate pollution of the groundwater. In addition the fertile topsoil can be washed off the land, down rivers and out to sea as happened in the UK during the 2013-14 winter (Monbiot, 2014). This of course reduces soil fertility. Furthermore, the reduction of the soils natural organic matter means that during dry, windy weather the topsoil can be blown away (Ahmed, 2013). Meanwhile the problem of lost fertility is happily resolved by the application of yet more fertilizer.

We can see from this illustration that the aim to increase the soils productivity is actually thwarted by the continued application of fertilizer. However, for the agro-chemical industry profits are up together with GDP. However, the costs to the farmer and the externalities, the costs to others are enormous.

› The topsoil is damaged and lost.
› Instead of rainwater soaking into the ground, soil compaction causes flooding.
› Homes and properties are damaged.
› Eutrophication occurs killing off life in both freshwater and marine ecosystems to the detriment of fisheries.
› Water that is absorbed into the ground takes with it some of the fertilizer causing pollution and health problems.

What is needed is a systemic approach to the use of synthetic fertilizer but this would undoubtedly mean a reduction of sales and profit. A systemic approach would identify the correct amount of fertilizer to be used so as not to damage the soil's ecology.

Capitalism is not concerned with the *"optimum value"* (Bateson, 1980) which would holistically benefit the system but the maximum gain possible. Consequently, we can see with this illustration how capitalism, driven by the need to create profit, falls outside the way in which Nature functions. Legislation is needed which protects and supports, in this case agricultural sustainability, but which addresses the management of whole systems. Something which developed cultures are not good at due to their cultural phenomena of specialization and the fragmentation of knowledge and a political system manipulated by lobbying. Consequently, usually too few, if any, have a holistic view of the ("wicked") problem. Furthermore, any legislation that might cap the use of fertilizer would be instantly lobbied against by the powerful chemical industry.

Jules Pretty OBE (2007) the expert on agricultural sustainability writes that: *"Systems high in sustainability can be taken to be those that aim to make the best use of environmental goods and services while not damaging these assets. The key principles for sustainability are:*

- *to integrate biological and ecological processes such as nutrient cycling, nitrogen fixation, soil regeneration, allelopathy, competition, predation and parasitism into food production processes;*
- *to minimise the use of those non-renewable inputs that cause harm to the environment or to the health of farmers and consumers;*
- *to make productive use of the knowledge and skills of farmers, so improving their self-reliance and substituting human capital for some costly external inputs, and*
- *to make productive use of people's collective capacities to work together to solve common agricultural and natural resource problems, such as for biodiversity, pest, watershed, irrigation, forest and credit management."*

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25.14 Center for Ecoliteracy

(q.v. bio-regionalism, eco-literacy, Bioneers)

The Center for Ecoliteracy, founded in 1995 by Fritjof Capra, Peter Buckley and Zenobia Barlow, is a public foundation dedicated to the education of school children from Kindergarten to twelfth grade (17-19 yrs old) or K-12 for sustainable living. The Center proposes a number of strategies for integrating ecoliterate education into the school curriculum and in addition has a bio-regional approach so that for example food should come from the locality, schools should have their own gardens to provide the experience of growing food and ecology. School campuses should be green in their organization, procurement and adopt long term sustainable cost saving administration. The curriculum should support an understanding of nature, systems, networks, social change and resilience.

References and further reading

The Center provides a number of pdf downloads as well as expert publications, including:

Goleman, D., Bennett, L., Barlow, Z. (2012) Ecoliterate; how educators are cultivating emotional, social and ecological intelligence, Hoboken, Jossey-Bass, Wiley.

Stone, M.K., Barlow, Z. (2005) Ecological literacy; educating our children for a sustainable world, San Francisco, Sierra Club Books.

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Sources

www.ecoliteracy.org/

25.15 Change; the creation of systemic change for a sustainable future

(q.v. Paradigm shift)

Anne Birney (2014) writes that there is currently an enormous buzz about system change and we all know that there has been much activity and social pressure to bring about system change. Few will have missed the impact of the "Occupy" protests around the world as well as the more recent protests for action for climate change (21-22 September, 2014) which took place around the world.

We are now all beginning to recognize the complexity and the interconnectivity both within and between globalization, climate change and environmental issues. So for example, global trade is causing the destruction of ecosystems and the extinction of species (Hertwich, 2012; Lenzen, et al, 2012) which is of little concern to politicians as they continue to forge trade agreements to create jobs. It has been estimated that imports into the USA threaten over 900 species with extinction and exports from Indonesia threaten nearly 200 species. About 30% *"of red-listed species world-wide are caused by internationally traded commodities."*

It continues to be confirmed that politicians are unable to steer our world towards a sustainable future as they pay most heed to the wishes of trans-national corporations which are run only for their own profits.

The question is how can we, at the grass roots, catalyze change? Anne Birney has been working for over a decade on how to bring about system change and provides below six strategies. The extensive quote below (1 - 6) is from Anne Birney's article on the Guardian.com web page (see source below)

"1. Convene people

System change begins and ends with people ready to lead themselves and their organizations. If we take the Sustainable Shipping Initiative [see Sources below] as an example, it took three years to find the right people in the right organizations and form this coalition through envisioning and developing innovation work-streams. This has set a strong foundation for its impact in future.

2. Find opportunities

By their nature, systems are complex and we are not always sure where or when they might transform. Scanning what is going on in the world helps find windows of opportunity and points of leverage. Taking a systemic approach means we need to analyze the landscape through mapping, and observe and experience where these opportunities lie. The Sustainable Food Lab, [see Sources below] for example, takes participants on learning journeys to places like Santo Domingo, Dominican Republic. There they engage in activities across the food system such as cocoa farms, cooperatives, producers, manufactures and eco-tourism initiatives.

3. Align visions to our living systems

Many of our actions do not feel as if they are helping us get close to solving the huge sustainability challenges we face – issues like climate change. We often feel locked into the current way of doing things. Sustainability requires us to take approaches that recognize that our social systems are part of the wider ecological system. We need to create visions and purposes that help us shift to this perspective.

So, in the Finance Innovation Lab [see Sources below] they are trying to radically reimagine how the finance system can be transformed. This involves letting go of the prevailing perspectives that have built our current institutions and economy.

4. Experiment system

Change will not happen unless we create something new. In nature, our living systems change through multiple experiments that evolve and shift the world around us. Shell Foundation [see Sources below] has been pioneering new social enterprises such as Envirofit [see Sources below] which produces affordable cookstoves that create beneficial environmental, health and social impacts. Through constant learning, the Foundation has realized that creating products and services is not all that is needed – instead, we need to experiment with the way one builds markets. This is why it supports the Global Alliance for Clean Cook Stoves [see Sources below] to create a thriving global market for these stoves.

5. Innovation and learning platforms

We spend a lot of time creating new innovations or piloting projects but this in itself will not create a system shift. We need to create platforms that support innovation and learning so we start to accelerate the scale and reach of change. Nike, with USAid and Nasa, have created such a platform called Launch2020 [see Sources below], which seeks to accelerate a revolution in sustainable materials *through utilizing networks, strategies and resources for change.*

We need to start connecting different actors and organizations so that radical ideas and innovations can be joined up with each other and help shift systems. Cultivating system change is also about creating the space for the emergence of innovations and active networks of practitioners.

6. Communicate a coherent story

Environmental and social NGO campaigns have tended to focus on what is going wrong by looking to change the polices and parameters of a particular system. To actively open up permission to create change, we need to support the consolidation of change into new narratives for society.

Creative initiatives like the Story of Stuff [see Sources below] have started to do this by helping to shift the conversation from the buying of more stuff to having less – and better – stuff. However, we need to get more sophisticated in how we come together to influence the wider cultural conversation. This will influence how we operate in systems such as food, energy and finance." (Birney, 2014, theguardian.com)

"Anna Birney is head of the system innovation lab at Forum for the Future [see Sources below] and author of Cultivating System Change: A practitioner's Companion"

Another author, Bruce Watson (2014), is also published on the Guardian's Web Page [see Sources below]. His article is entitled: "How to create system change that solves sustainability challenges. Shifting a whole system, such as food, is a big ask. A map that shows the big picture can help companies make each right turn." It provides approaches for collective thinking and the visual mapping of problems, and again follows six steps.

"The six steps, which seem to draw heavily from the dialectic, outline the generally theoretical process of a systemic transition. Joe Hsueh, partner in Second Muse and founding partner of the Academy for Systemic Change, offers a more tangible process for system change.

He begins by gathering all stakeholders, then asking them, together, to bring all problems to the table. In this way, Hsueh notes, stakeholders are able to create a "Participatory Causal Systems Map." Or to put it simply, they're able to diagram every aspect of a problem, so that each actor is aware of the challenges facing every other actor."

Clearly, there are many strategies for creating change but I hope that these few examples provide at least a starting point, inspiration and information.

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Birney, A. (2014) Six strategies for creating system change for a sustainable future (accessed at:
http://www.theguardian.com/sustainable-business/blog/six-strategies-systems-change-sustainable-future)

Forum for the Future: We are an independent non-profit working globally with business, government and other organizations to solve complex sustainability challenges (accessed at: http://www.forumforthefuture.org/)

Please note, The descriptions by each web page are quoted from the pages:

Sustainable Shipping Initiative: *"The Sustainable Shipping Initiative (SSI) brings together some of the biggest names in the maritime sector to plan how it can contribute to – and thrive in – a sustainable future."* (accessed at: http://ssi2040.org/)

The Sustainable Food Lab: *"The mission of the Sustainable Food Lab is to accelerate market-driven progress toward a sustainable mainstream food system by supporting diverse and influential leaders."* (accessed at: http://www.sustainablefoodlab.org/)

The Finance Innovation Lab: *"The Finance Innovation Lab was born in the Great Hall of the Institute of Chartered Accountants in 2008, in the heart of the city of London to the sound of pouring rain. It was launched in the wake of the largest financial crisis since the great depression, two weeks before Christmas. Our two very different organizations came together to host a joint event asking the question 'how can we create a financial system that sustains people and planet?'"* (accessed at: http://www.thefinancelab.org/)

The Global Alliance: *"The Global Alliance for Clean Cookstoves calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020. With your help we can make this happen. Nearly 3 billion people in the developing world cook food and heat their homes with traditional cookstoves or open fires. 4 million premature deaths occur every year due to smoke exposure from these methods. Women and children are the most affected."* (accessed at: http://www.cleancookstoves.org/)

The Shell Foundation: *"Shell Foundation's goal is to catalyze the innovation and scale-up of disruptive new models and technologies that can ultimately transform the lives and livelihoods of many millions of people. In line with our "enterprise-based" approach, we focus on measuring our own performance and our partners' progress towards sustainability and large-scale impact. We consistently find that pioneering social enterprises require significant financial and non-financial support to achieve these goals. For this reason, we prefer to track and measure changes in performance against pre-defined milestones and impact targets – both developmental and financial. We find this allows for a meaningful analysis of the drivers of impact (which a narrow focus on absolute data at any one point in time does not support)."* (accessed at: http://www.shellfoundation.org/)

Launch2020: *"LAUNCH is an open innovation platform that was founded by NASA, NIKE, The U.S. Agency for International Development (USAID) and The U.S. Department of State to identify and foster breakthrough ideas for a more sustainable world. LAUNCH aims to move beyond incremental change and make an impact at a system-wide level. LAUNCH is currently focused on positively transforming the system of materials and manufacturing, which can have dramatic social, environmental and economic impacts on the world. In order to harness the innovation needed to advance this system, LAUNCH has issued a series of global challenges to address key barriers. Our current challenge focuses on green chemistry, a crucial component in a sustainable materials and manufacturing system. A portfolio of approximately 10 innovators will be selected for support, networking, and mentoring from influential business and government leaders."* (accessed at: http://www.launch.org/)

The Story of Stuff: *"We're a Community of 750,000 changemakers worldwide, working to build a more healthy and just planet. Together, we believe it's possible to create a society based on better not more, sharing not selfishness, community not division. We invite you to be inspired by and share our movies, participate in our study programs, and take part in our campaigns on the issues you care about. In December 2007, Annie Leonard and her friends at Free Range Studios put a 20-minute movie about the way we make, use, and throw away Stuff on the internet, unleashing a torrent of pent-up demand for honest conversation about the impacts of our consumer-crazed culture on people and the planet. In the six years since The Story of Stuff was released, Annie's 'cartoon about trash' has been viewed more than 40 million times worldwide. Annie responded to viewers' thirst for more information and ways to get involved by founding The Story of Stuff Project in 2008."* (accessed at: http://storyofstuff.org/)

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25.16 Circular economy or Cradle to Cradle

(q.v. paradigm shift, WEEE, Re-Strategies)

Walter R. Stahel presented an award winning paper in 1982 at the Woodlands Conference on *'The Future and the private sector'* concerned with the issue of production and the sustainable society. Stahel presented a prizewinning paper entitled *"The product life factor"* in which he described how extending the use-life of products could be a strategy for a transition towards a sustainable economy. Furthermore, the strategy would provide a role for the private sector.

The existing economy is based on the short life of products and a rapid turnover of materials with the precipient danger of material exhaustion (see Chapter 2). Stahel proposed extending product life and reducing resource consumption which would actually increase wealth. The large scale industries currently associated with resource extraction, and waste promoting production (old design paradigm) could be partially replaced by many smaller scale private sector companies associated with product life extension by *Reuse, Repair, Reconditioning and Recycling* (new design paradigm). Such a transition would require increasing skilled labour and reduce our economic dependence on consuming the world's resources and throwing them away. Stahel proposes that the appropriate economic and financial incentives could mobilize the 'consumer' culture to make this transition.

Throughout his work during the 1980s Stahel has promoted the *"loop economy"* now frequently referred to as the *"circular economy"* and to which Stahel during the 1980s first employed and coined the term *"cradle to cradle."*

In an early report to the European Commission presented by Stahel and Genevieve Reday in 1976 they visualized a diagram of a circular economy. The concept could have a positive impact on *"job creation, economic* *competitiveness, resource savings and waste prevention. The report was published in 1982 as a book "Jobs for Tomorrow, the Potential for Substituting Manpower for Energy".*"

"… in 1987, some experts put forward the idea of a product responsibility "from cradle to grave" as an alternative to a circular economy, with the advantage that cradle to grave was compatible with the existing linear economic model. Walter R. Stahel, by training an architect, countered this idea by pointing out that "cradle to grave" is simply a marketing upgrade for gravediggers, because it still relies on end-of-pipe solutions. Stahel insisted that the really sustainable solution was to use durable goods in a loop from "cradle back to cradle."

The concept of cradle to cradle has been popularized by McDonough & Braungart's (2002) in their book entitled *Cradle to Cradle*.

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The writings of Walter Stahel can be found on the home page of:

The Product Life Institute (http://product-life.org) along with the papers below:

Mitchell Prize Paper: http://product-life.org/en/major-publications/the-product-life-factor.

http://www.product-life.org/en/cradle-to-cradle)

http://www.product-life.org/en/the-30th-anniversary-of-walter-r-stahel-prize-winning-paper-the-product-life-factor.

The emergence of the modern circular economy: http://product-life.org/en/circular-economy.

25.17 Climate Change, Global Warming, Greenhouse effect

(q.v. Planetary boundaries, Anthropocene, Climate Change Doubt and Deceit)

Our species is causing climate change (see Glossary: Anthropocene) which is warming the world. Unfortunately, despite the scientific warnings in recent years about global warming, there have been record carbon dioxide (CO_2) emissions during 2008, 2010, and 2011. Furthermore, CO_2 emissions continue to rise and now stand at about 400 parts per million (ppm) having risen from about 280 ppm prior to the industrial revolution.

What is the greenhouse effect? What causes it?

Several greenhouse gases such as CO_2, and methane (CH_4) and the aerosol, water vapour (H_2O), enable our planet to support life because they trap the sun's warmth as it is reflected back into space from the Earth's surface as infra-red radiation. If there were no greenhouse gases then the Earth would be a frozen planet with an average temperature of minus 15°C! (Kolbert, 2006; Walker & King, 2008). However, in their naturally occurring quantities the greenhouse gases (pre-industrial revolution) create a benignly warm climate because they are warmed by the infra-red radiation from the Earth's surface (The average amount of energy reflected back from the Earth's surface is about 235 watts per square meter which is equivalent to 4 household light bulbs).

Naturally occurring CO_2 composes less than 0.04% of the atmosphere and the proportion of methane is even less. The greenhouse gas which makes the biggest contribution to the Earth's atmosphere is gaseous water. As a consequence the Earth has an average temperature 57°F or 13.8°C due to the 'natural greenhouse effect.'

The Victorian John Tyndall who discovered this phenomenon had an eclectic range of scientific interests one of which was heat and in 1859 he built the first spectrophotometer to compare how different gases transmit and absorb radiation. A spectrophotometer is basically a tube which can be filled with gas through which radiation can be projected and measured after its passage through the gas in the tube. He found that infra-red and visible radiation could travel through both oxygen and nitrogen as if they were transparent but that CO_2, methane and water vapour were partially opaque to infra-red radiation. Tyndall fully understood the significance of his discovery and used the metaphor of a dam holding back terrestrial rays instead of water creating the "natural greenhouse effect."

Ice core measurements reveal that around the time of Tyndall's discovery (1859) the atmosphere contained about 290 ppm (parts per million) CO_2 prior to the industrial revolution.

Unfortunately, since Tyndall's discovery mankind's industrial and many other activities have caused the release of enormous quantities of greenhouse gases into the atmosphere. In 1957 Charles Keeling began monitoring the quantity of CO_2 in the atmosphere at the South Pole and also in Hawaii (1958) and found that the air had 316 ppm of CO_2. By March 2007 the proportion of CO_2 had risen to 384 ppm. Unfortunately, the rate at which CO_2 is accumulating in the atmosphere is accelerating so that from 1970 to 2000 the annual concentration rose by 1.5 ppm per year but after 2000 the average annual concentration rose by 2.1 ppm! Scientists reported that both 2007 and 2008 were record years for emissions with emissions for CO_2 levels rising to 387 ppm in 2008. The economic crisis in 2008-9 saw a drop in emissions but then again 2010 was another record year with 30.6 gigatonnes of CO_2 being emitted which was 5% more than the 2008 record. In 2014 400ppm of CO_2 have been recorded and the hockeystick curve continues to climb!

In addition to CO_2, methane (CH_4) and the aerosol, water vapour (H_2O) and another green house gas, nitrous oxide (N_2O) are emitted from fossil fuel by combustion. These greenhouse gases are differently effective in trapping the Earth's infra-red radiation. As already mentioned CO_2 is measured in parts per million and its global warming potential (GWP) is rated as 1. CH_4 is measured in parts per billion (ppb) but its GWP is 79 (without the presence of aerosols) i.e. 79 times more powerful as a greenhouse gas than CO_2. However, in the presence of aerosols, such as water vapour increases the GWP of CH_4 to 105 times that of CO_2! (Shindell at al, 2009).

The main anthropogenic sources of these gases are fossil fuel combustion, land use changes, natural gas extraction, and agriculture. The rush for natural gas extraction by fracking is based on the lie that "gas is clean energy," it is not, it is a dirty energy. *"Gas burning for power can be much dirtier greenhouse gas-wise than coal burning."* (https://sites.google.com/site/gasisnotcleanenergy/). Furthermore, Robert Howarth, the Cornell University biogeochemist & environmental scientist states that: *"The large GHG footprint of shale gas undercuts the logic of its use as a bridging fuel over coming decades, if the goal is to reduce global warming"* (https://sites.google.com/site/gasisnotcleanenergy/howarth).

All these gases have varying effective lifetimes as green-house gases; so that for example CO_2 lasts about 100 years and N_2O about 114 years and CH_4 12 years.

A consequence of anthropogenic global warming is the melting of the permafrost causing it to emit CH_4 because the previously frozen organic matter is now able to rot down and release methane. However, of even greater concern is that the warming Arctic Ocean is now releasing methane from the methane hydrates or clathrates (ice-like substance maintained at low temperatures and high pressures containing methane within the pore spaces of seabed sediments) within the upper sea bed. In 2009 over 250 methane gas plumes were discovered in the sea west of the Svalbard archipeligo in Norway (New Scientist, 2009). In addition recent research reports that warming to the Gulf Stream have resulted in the destabilization of 10,000 square kilometers of seabed with methane hydrates along the North American continental margin. The consequences of methane releases from an estimated 2.5 gigatonnes of methane hydrates from the oceans could be very serious for both acidifying seawater and atmospheric emissions. (Mienert, 2012; Phrampus & Hornbach, 2012)

Yet, despite all the publicity about the dangers of increasing the proportion of greenhouse gases in the atmosphere 2011 was another record year for emissions with 31.6 gigatonnes (billion) being emitted globally.

In their paper on planetary boundaries Prof Rockström (2009) and his team calculate that we have exceeded the safe boundary for CO_2 emissions and that we are now in 'overshoot' (see Glossary). Prof Rockström and his team have calculated a safe limit of 350ppm of CO_2. Unfortunately, in 2009 the atmosphere's CO_2 content already stood at 387ppm. The setting of the 350ppm boundary had the aim of ensuring the stability of the polar ice sheets. It has been established that there is a close correlation between the atmosphere's CO_2 content and the temperature and evidence from the past shows that the world was largely ice free when the CO_2 content rose above 450ppm. This has serious implications for sea-level rise which has accelerated over the past 10-15 years.

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25.18 Climate Change: Debate, Doubt, Deception and Denial

(q.v. Climate Change, Politics)

In a public address given in 1955 to the National Academy of Sciences Richard Feynman, a Nobel Prize-winning physicist, said that *"Scientific knowledge is a body of statements of varying degrees of certainty – some most unsure, some nearly sure, but none absolutely certain."* Feynman describes how science was born out of a historical struggle to doubt the dogma of authority which used its dogma to rule. Doubt and uncertainty therefore provided the drive to establish knowledge – scientific knowledge. Feynman concludes that *"It is our responsibility as scientists, knowing the great progress which comes from a satisfactory philosophy of ignorance, the great progress which is the fruit of the freedom of thought, to proclaim the value of this freedom; to teach how doubt is not to be feared but welcomed and discussed; and to demand this freedom as our duty to all coming generations."*

Now while all but a few scientists know how to work with uncertainty for the greater good of mankind there are some who deliberately set out to cheat on the truth. In the past decade there have been several well publicized cases of scientists who have plagiarized or fabricated their research. They have been discovered because other scientists replicated their experiments and were unable to achieve the same results. This is the way science works. Scientists publish a complete account of their work. The peer-review process of scientific publication aims to ensure the transparency of scientific activity. Where results are not verifiable facts cannot be established nor can further investigation be built on those results. Science could not function without peer-review and verification. Consequently, it was ridiculous when US Senator James Inhofe, in July 2003, claimed that global warming was "the greatest hoax ever perpetrated on the American people." Such a hoax would be impossible to perpetrate because scientists verify each others work in their search for patterns of consistent knowledge.

The following account has been prepared from the following sources and fully cited below and include: Brulle (2013); Goldenberg (2013); Monbiot (a & b 2006); Oreskes & Conway (2010); and Wijkman, A., Rockström, J. (2012).

Unlike science, most big businesses, work without any generally accepted code of conduct and always, if not primarily, for financial gain. Some of the largest businesses have corruptly created public uncertainty about global warming to deliberately delay effective legislative action by years if not at least a decade (Monbiot, 2006). Furthermore, some of those responsible for creating doubt about climate change had also created doubt that smoking is carcinogenic long after it had been scientifically established. This handful of scientists and business people have been written about by Monbiot (2006) and more recently by Oreskes and Conway (2010) and Wijkman & Rockström (2012).

Finally, in 2013 a paper was published by Prof Robert Brulle of Drexel University, USA, entitled "*Institutionalizing delay: foundation funding and the creation of U.S. climate change counter-movement organizations*" which describes the biggest deception carried out against mankind. Nearly a billion dollars was paid annually to 'think tanks' and other associations from 2003 to 2010 by 140 large corporations, mostly involved with the fossil fuel industries. The task for the 'think tanks' et al was to create spurious literature and publicity aimed at undermining and denying the science on global warming and create a climate change counter-movement. The aim of these industries was to delay the implementation of legislation concerned with curbing greenhouse gas emissions that might reduce these industries' profits. In the United States they successfully achieved a delay of any political action until 2014 when President

Obama announced his legislation for reducing emissions by 30% (Drexel, 2013; Goldenberg, 2013).

The story is complex but begins with the tobacco industry's largest giant, Philip Morris, which campaigned to discredit a report produced by the US Environmental Protection Agency (EPA) in 1992. The report entitled *Respiratory Health Effects of Passive Smoking* described that exposure to environmental tobacco smoke (ETS), a lung carcinogen, was annually responsible for approximately 3,000 lung cancer deaths amongst US non-smokers. Furthermore, it reported that every year ETS caused an estimated 150,000 to 300,000 cases of respiratory infections amongst infants upto 18 months old. Within a couple of months a vice president of Philip Morris's, Ellen Merlo, was planning a strategy to discredit the EPA's report to ensure that there would be no passive-smoking ban throughout the USA. Merlo hired the public relations firm Apco which employed the strategy of not using those within the tobacco industry to contradict the EPA findings but outsiders who would appear to be acting of their own volition. The issue of passive smoking would then become viewed as another 'unfounded fear' like those associated with pesticides and cell-phones. Furthermore, Apco organized a fake citizens' group with a diverse membership called The Advancement of Sound Science Coalition (TASSC) with the aim of getting the passive smoking issue to ride along with other *"questions about government research and regulations,"* including nuclear waste disposal, global warming and biotechnology and to create the impression that there was a grassroots concern about these issues.

TASSC participants included respectable figures from industry, science and business who were concerned about promoting proper science. A terminology was also employed in which "junk science" referred to the peer-reviewed studies which showed that smoking was associated with cancer and other illnesses. Meanwhile, the term "Sound science" referred to studies sponsored by the tobacco industry indicating that a link was inconclusive.

The industry's whole strategy was ably summed up by the Brown & Williamson tobacco company *"Doubt is our product since it is the best means of competing with the 'body of fact' that exists in the mind of the general public. It is also the means of establishing the controversy."*

Philip Morris, however, did not just apparently philanthropically sponsor TASSC (which would have directly drawn attention to their own creation) but many groups and think tanks all of whom are interested in promoting private enterprise and free markets and supporting self interest. Secondly, opposing and lobbying against any legislation, taxes etc. that would inhibit their private enterprise and profits; climate warming, IPCC and climate science included.

The advisory board of TASSC listed a scientist, Frederick Seitz, a physicist, and one time president of the US National Academy of Sciences (NAS) who was also being paid by Exxon. ExxonMobil is the world's most profitable corporation with daily sales of $1bn a day! (Monbiot, 2006). Naturally, Prof Frederic Seitz, is not the only actor in this history of fabricated doubt but by focusing on him one can begin to understand some of the motivations of those denying climate change.

Seitz was an ardent believer in the American way of life and following the Cold War an ardent anti-communist who supported the Vietnam War. He later became a supporter of Reagan's Star Wars defence plan. Anything that appeared to him in the least socialist or might inhibit private enterprise and profit was to be opposed with his full support. Seitz worked for the tobacco firm R.J.Reynolds from 1979 to 1987 where he was in charge of deciding which medical research projects should be funded and allocating millions of dollars a year to US universities with the aim of refuting *"the criticisms against cigarettes."*

The strategy developed by Philip Morris of donating money to a variety of organizations with the subterfuge of discrediting the science confirming that cigarettes caused cancer was similarly employed by ExxonMobil. This time to discredit the science on global warming by sponsoring 124 groups including some of the best known "think tanks" in the world. These groups and organizations have basically the same stance on global warming, namely: the scientists are in disagreement; environmentalists are charlatans or mad; and were governments to implement legislation to counter climate change they would be putting the world's economy at great risk.

Free enterprise in the USA is sacrosanct and nothing should inhibit a companies' profitability, not even government regulations. The commercial instances of where the health of babies, children, workers and consumers are deliberately ignored and politicians and the public deceived so as not to inhibit profits are consistently well illustrated. Everyone is familiar with Rachel

Carson's book Silent Spring. Maybe less well known are the lead in paint and vinyl chloride monomer in plastics scandals (Markowitz & Rosner 2002). The problem in the US has been that the Toxic Substances Control Act (TSCA) which was passed in 1976 placed the onus to demonstrate a compound's toxicity on the US Environmental Protection Agency (EPA) and not on the manufacturer to confirm that the substance was safe. Of the 84,000 chemicals currently on the market only 200 have been tested for safety and only 5 banned. In other words the TSCA was ineffective in protecting the public and the environment from toxic substances because the EPA could only request safety testing by a company once evidence existed that demonstrated that a chemical is dangerous.

In July 2012, a Senate Committee approved Senator Frank Lautenberg's Safe Chemicals Act which would have reversed the existing situation by placing the onus to prove that a chemical is safe before it could be marketed on the manufacturer. Unfortunately, the bill never got to be discussed in the Senate itself. Enormous payments of over $500 million by the chemical industry to candidates for federal office, political lobbying and advertising ensured the failure of Lautenberg's Act. Sadly, Lautenberg died in June 2013 and so the US chemical industry continues to produce new chemicals and market them without having to prove that they are safe. This is a reason to stop the TTIP trade agreement between Europe and the United States.

ExxonMobil has successfully created the impression that scepticism about climate change is widespread. One group sponsored by ExxonMobil is the Science and Environmental Policy Project chaired by Frederick Seitz who in 1998 penned the Oregon Petition which, as Monbiot (2006) writes, *"has been cited by almost every journalist who claims that climate change is a myth."* The Petition reads *"We urge the United States government to reject the global warming agreement that was written in Kyoto, Japan, in December 1997, and any other similar proposals. The proposed limits on greenhouse gases would harm the environment, hinder the advance of science and technology, and damage the health and welfare of mankind. There is no convincing scientific evidence that human release of carbon dioxide, methane, or other greenhouse gases is causing or will, in the foreseeable future, causes catastrophic heating to the Earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the Earth."*

This Petition together with a letter entitled Research Review of Global Warming Evidence was published by the Oregon Institute of Science and Medicine and the George C. Marshall Institute. The lead author of the review is a Christian fundamentalist, Arthur B. Robinson, who is not a professional climate scientist and his 22 year old son together with two employees of the George C. Marshall Institute. The George C. Marshall Institute has received $630,000 from ExxonMobil since 1998 and its chairman is … Frederick Seitz.

The Petition has achieved a substantial presence on the Web and consequently it has been cited by global-warming sceptics as having been authored by climate scientists. However, although some 17,000 graduates have signed it most have no background in climate science. Furthermore, would they have signed it had they known they were participating in the world's largest scam?

So the situation is clear. The Internet WWW is permeated by false information. Identifying reliable sources is now essential.

It is worth repeating Noreena Hertz's warning described in Chapter 3. Hertz (2014) draws attention to the problem of false information on the internet. For example, one estimate is that one third of online consumer reviews are fake and furthermore "astroturfing," (fake grass) as it is called, is now big business with, for example, specialist companies paid by hotels to write fake reviews. Hertz advises researching and verifying who is the source the information? how are they funded? how do they get their information? where are they located? what is the source saying – opinion or fact? is there another source which could verify the information? etc. Hertz writes that verification is often not difficult and much can be found out by investigating and scrutinizing the information on the web site itself.

In view of the gravity of the revelations by Brulle (2013) knowledge authentification now needs to become a component of the educational curriculum.

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25.19 The Club of Rome

This text is slightly adapted from the Club of Rome's own web page (at: http://www.clubofrome.org/?p=375) where the complete text can be read. It is important that students and designers should become aware of the Club of Rome's philanthropic encouragement for achieving a sustainable future.

The Club of Rome has been responsible for organising enormously important and publications and reports prepared by experts which are perceptively years ahead of their time. Consequently, a list of these publications is included below (accessed from the web page: http://www.laetusinpraesens.org/links/clubrome.php).

"In April 1968, a small international group of professionals from the fields of diplomacy, industry, academia and civil society met at a quiet villa in Rome. Invited by Italian industrialist Aurelio Peccei and Scottish scientist Alexander King, they came together to discuss the dilemma of prevailing short-term thinking in international affairs and, in particular, the concerns regarding unlimited resource consumption in an increasingly interdependent world.

Each participant in the meeting agreed to spend the next year raising the awareness of world leaders and major decision-makers on the crucial global issues of the future. They would offer a new and original approach in doing this, focusing on the long-term consequences of growing global interdependence and applying systems-thinking in order to understand why and how it was happening. The Club of Rome was born."

The originality of their approach soon became clear. "In 1972 the campaigning of this growing group of like-minded individuals gained a new worldwide reputation with the first report to the Club of Rome: "The Limits to Growth", commissioned by the Club from a group of systems scientists at the Massachusetts Institute of Technology. The Report explored a number of scenarios and stressed the choices open to society to reconcile sustainable progress within environmental constraints.

The international effects of this publication in the fields of politics, economics and science are best described as a 'Big Bang': over night, the Club of Rome had demonstrated the contradiction of unlimited and unrestrained growth in material consumption in a world of clearly finite resources and had brought the issue to the top of the global agenda.

With its focus on long-term vision and provocative scenarios, the report sold more than 12 million copies in some 30 languages worldwide.

Building on this success, the Club of Rome membership grew as it continued to produce reports on the global issues it identified. Particularly, the goal of raising long-term awareness among world leaders and decision-makers regarding the delicate interaction between human economic development and the fragility of the planet was achieved, contributing to the establishment of Ministries of the Environment in numerous countries."

The Eighties and Nineties were characterized by *"Grappling with Growing Complexity, Globalisation and Increasing Interdependence ... the Club of Rome continued its high-level work on a global scale. It contributed significantly to the development of the concept of sustainability, which has played an important role in highlighting the interdependence of environment and economics."*

Simultaneously, the Club of Rome increased the breadth of its work and reports appeared on *"Microelectronics and Society, The Future of the Oceans or No Limits to Certainty reflected common preoccupations and the growing complexity and interrelation of major global issues."*

The Club of Rome continued its work *"in the nineties by focusing on major issues such as the Digital Divide between North and South, global governance and cultural diversity. Reports such as The Capacity to Govern and Factor Four: Doubling Wealth – Halving Resource Use and No Limits to Learning were particularly influential during this period in pointing the way towards solutions."*

The "influence that the Club of Rome had come to enjoy in its early years had started to diminish as perceptions moved towards the view that global issues would be resolved through the "Magic of the Marketplace".

However, "*At the beginning of the 21st Century, international problems such as rising global inequality, the consequences of climate change and the overuse of natural resources have proved that the Club of Rome's fundamental views are broadly correct and have revived interest in its activities: unlimited consumption and growth on a planet with limited resources cannot go on forever and is indeed dangerous.*

In recent years, the Club of Rome has embarked on a whole new range of activities and has modernised its organisation and its mission. Its commitment to finding new and practical ways of understanding global problems and turning its thinking into action are as strong as ever.

The size and number of the National Associations have continued to grow: there are now over 30 worldwide with a membership of over 1,500 committed people in five continents. They have become pillars of the Club's global work, expanding and strengthening the activities and awareness of the International Club with assistance from the Club's European Support Centre in Vienna."

"… Since May 2008, it has also launched a new three year programme, A New Path for World Development, which will be an important focus of the Club's activities until 2012."

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25.20 Collaborative Consumerism: sharing, swapping and bartering

(q.v. resilience, ecometrics, social networks)

The 2008 financial crisis has stimulated new strategies for 'having' and supporting material welfare without consuming. Cooperative or collaborative consumerism embraces a variety of social strategies which enable people to live economically and sustainably while being able to fulfill their needs. All these strategies use resources already within the community and which an individual does not have to purchase or own. This means that less products and services are purchased thereby saving resources while those that are within the community are used much more. Basically, any skill or possession becomes an asset to share and make available to others in some way.

Time swapping or time banks

The resource that is swapped is an individual's time so that one person might look after someone's large garden in exchange for receiving language lessons from the garden's owner. Time exchange could open up an almost endless range of creative possibilities.

Car sharing

Cuts the cost of travelling when two people both owning cars, living relatively close together share one car to commute to work. One week one of them will use their car and the following week the other. This is becoming increasingly popular in many countries.

Product swapping

Tools and garden equipment, used perhaps infrequently, can be rented or borrowed or swapped with owners or perhaps swapped at local centers. In Berlin the organization Leila (the all-sharing-shop) has become successfully established and there are many others (http://www.leila-berlin.de/).

Home swapping

Internet groups now exist for short stays in other peoples' homes. For example, Airbnb list thousands of homes in different countries enabling people to stay abroad free either by offering the same opportunity to share one's own home to others or renting out ones home.

Meal sharing

In addition to being able to find accommodation people are also sharing meals using web sites to offer the opportunity to get together with local residents and enjoy a home-cooked meal in their homes.

Examples of some organizations

Yerdle at: https://yerdle.com/

Yerdle describes its aim as follows: *"Yerdle is a place where you can give and get great things for free. Right now, thousands of items are being shared on yerdle, from camping gear to kid's toys. We are a community powered by generosity. All you have to do is give to get. Members post items they're willing to give away, and yerdle connects them to a grateful receiver. It makes sense when you consider that 80% of the items in our homes are used less than once a month, and self-storage is up 1,000% over the past 30 years. Yerdle's mission is to reduce the durable consumer goods we all need to buy by 25%. Why shop when you can share?"*

The Centre on Sustainable Consumption and Production (CSCP) is at http://www.scp-centre.org

CSCP was founded in 2005 and its mission is to address questions such as: *"What would be your vision for an improved livelihood and lifestyle in the future? … How can we better visualize sustainable living to inspire action? … Finding answers to these questions, co-creating and enabling sustainable futures is at the centre of our work on sustainable lifestyles. Our aim is to inspire decision-makers, stakeholders and the public to think differently about how to enable more sustainable ways of living. Co-creating new stories, as well as envisioning and designing the future we want are central to the scope of our work."*

The Centre works for a wide range of small and middle sized enterprises and others. It has an invaluable range of publications freely available on its web site at: http://www.scp-centre.org

Centre on Sustainable Consumption and Production (CSCP)

Peers: Collaborative consumption
http://www.peers.org/
http://www.collaborativeconsumption.com/

"Peers is a member-driven organization that supports the sharing economy movement. We believe that by sharing what we already have – like cars, homes, skills and time – everyone benefits in the process.

The sharing economy is helping us pay the bills, work flexible hours, meet new people or spend more time with our families. We think it's how the 21st century economy should work, so we're coming together to grow, mainstream and protect the sharing economy" (http://www.peers.org/).

Furthermore, the digital technology opens up a range of new possibilities and is reinventing sharing. The web page reports that:

- Home sharing, for example, residents in San Francisco earned on average \$5,000 per year by sharing their homes.
- Peers claim that they build stronger communities because over 75% of people who share online claim that they have greater trust in their communities.
- Sharing creates less waste and Peers calculates that up to 27% of US CO_2 emissions could be saved by car sharing
- The local community is economically strengthened when people buy their produce from local sources.

Airbnb

https://www.airbnb.com/

Airbnb was founded in 2008 by Nathan Blecharczyk, Brian Chesky and Joe Gebbla after graduating from the Rhode Island School of Design. They were motivated by the idea: *What if you could share your home and what you have with somebody else.*

Airbnb has been enormously successful with about 350,000 hosts in 34,000 cities registered with the scheme enabling people to find accommodation throughout 192 countries from around the world. Airbnb recorded that in one night 175,000 people were staying in somebody else's home.

It was calculated that Airbnb guests have spent $630 millions in New York but not merely strengthening the local economy but also creating cross cultural bridges.

Meal sharing

http://www.mealsharing.com

Mealsharing write that *"We want to make it possible for people, who otherwise would probably never meet, to get together and have a good time over food. We want to make that experience safe and enriching for everyone involved."*

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25.21 Consumerism

[q.v. Consumerism & Ladakh, Global Calculator, Dashboard for sustainability]

Consumer behaviour is concerned with nourishing deep psychological needs such as:

- the need for individual identity,
- the need for gender identity,
- the need for group identity and belonging,
- the need for status and prestige, all of which we possess as a species and which can be found in nearly every culture.

Our need for individual identity goes back into the mists of time, even to our predecessor species, Home erectus, beyond 100,000 years ago. Shell necklaces and traces of red ochre have been found at the Blombos cave in South Africa. *"Jewellery and cosmetics were probably prestigious, suggesting the existence of people of higher and lower status and challenging the egalitarian sensibilities that had existed since the early days of H. erectus"* (Nuwer, 2014).

One of the first authors to expose the problem of consumption was Thorstein Veblen (1992) whose book The theory of the Leisure class first appeared in 1899 and today remains a classic. He is renown for creating the terms *'conspicuous consumption,' 'conspicuous leisure'* and *'conspicuous waste'* which Veblen described as canons or laws. Veblen wrote *"As wealth accumulates, the leisure class develops further in function and structure, and there arises a differentiation within the class. There is a more or less elaborate system of rank and grades."* Today, in 2014, Veblen's perceptions are well illustrated by the city of Dubai in the United Arab Emirates with its obvious conspicuous consumption and waste of resources by creating the world's *"tallest building, highest fountain, an airport terminal that is one of the world's largest buildings. What it can't lay claim to is global supremacy as the most popular luxury fashion magnet, because that belongs to London. Dubai is second … Surely it is inconceivable that a megalopolis in the Arabian desert is the second most popular place in the world to go shopping for fashion? What about Paris, New York, São Paulo? Yet there it is. One of the reasons is Dubai Mall, one of the world's largest, naturally, and as of last year said to be a global tourist destination with 80 million customer visits a year – a place where shoppers are reported to spend £3 billion a year, while wandering aimlessly around trying to find a way out. (Tourists are reported to have spent $10.4 billion in Dubai last year)"* (Rickey, 2014). Meanwhile, in Europe status is flaunted by 4 x 4, Jeeps and Rangerovers and whose owners have nothing to do with either building sites or farms. In the fashionable district of Chelsea, London, such vehicles are ironically referred to as "Chelsea tractors."

The social commentator and critic Vance Packard (1957; 1960; 1961), in his revelatory writings, describes how in the late -50s the US was saturated with material goods. Sales began to drop. One leading industrial designer, Brooks Stevens, *"explained obsolescence planning in these terms: 'Our whole economy is based on planned obsolescence, and everybody who can read without moving his lips should know it by now. We make good products, we induce people to buy them, and then next year we deliberately introduce something that will make these products old fashioned, out of date, obsolete … It isn't or-*

ganized waste. It's a sound contribution to the American economy.'" Packard (1961) adds that other designers disagreed with Steven's opinion! Packard describes three kinds of obsolescence: function (new features), quality (well or badly made) and desirability (styling and fashion). So the question at the time was: what is to be done about declining sales? The bankers and advertisers got together and came up with a new way of spending: the credit card or buying on 'the never-never.' Obsolescence and the creation of dissatisfaction plus the credit card equals increased consumption and status! A strategy had been found to keep production rolling and the economy growing.

The light bulb manufacturers had a cartel to ensure that none of the manufacturers would produce bulbs that would work longer than 1,000 hrs and products were designed with 'death dates.' Some products were even falling apart before the consumer had paid for it with credit card instalments! (Packard, 1961). More than 50 years later the computer+printer owning public is on another consumer treadmill created by the computer industries whose products feature the same obsolescence mechanisms.

We can identify that there are two sides to consumption. On the one side are the needs of the consumer and on the other the needs of manufacturers to create profit. The question is who is there for whom? Is the market there for the benefit of the consumer or is the consumer there for the benefit of the market and manufacturers? Neo-liberal capitalism is currently driving us towards the latter. The perceptive Victor Papanek wrote in the Preface to Design for the Real World "*Advertising design, in persuading people to buy things they don't need, with money they don't have, in order to impress others who don't care, is probably the phoniest field in existence today*" (Papanek, 1971). Nor should we forget environmental welfare and sustainability; a point which Vance Packard, writing in 1960, had not missed. "*It should not be long before even the most blissfully optimistic American will recognize the truth of Fairfield Osborn's [1954] comment in The Limits of the Earth, 'It is evident that year by year, the entire problem of adequacy of natural resources for the maintenance and development of our civilization is becoming more acute.'*"

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25.22 Consumerism & Ladakh: How we can learn about ecological solutions from an ancient Culture?

(q.v. Consumerism, Bhutan, Kogi people)

> *"We are still reaching for the sky. In the developed countries people are coming back down, saying 'It's empty up there.'"Gyelong Paldan, at a meeting in Sakti Village* (Norberg-Hodge, 1991).

Helena Norberg-Hodge believes that we can gain an important insight into the destructive nature of western consumerism by the observations she has made since living in Ladakh. When she first went to live there it was a happy and contented society. However, the development of progress and consumerism means that young people are unhappy, as they see it, to live in a backward society. They now aspire to the comsumerism and role models exemplified by American consumer culture. Advertising has created aspirational needs for a life style of moving to a job in a city and acquiring the purchasing power to consume. This is clearly presented in both Norberg-Hodge's book and the associated film: *Ancient Futures, learning from the Ladakh* (1991).

The following text is quoted from Green Planet Stream website: *"Ladakh, or Little Tibet, is a wildly beautiful desert land high in the western Himalayas. It is a place of few resources and an extreme climate. Yet, for more than a thousand years, it has been home to a thriving culture.*

Traditions of frugality and cooperation, coupled with an intimate and location-specific knowledge of the environment, enabled the Ladakhis not only to survive, but to prosper. Then came development. Now in Leh, the capital, one finds pollution and divisiveness, inflation and unemployment, intolerance and greed. Centuries of ecological balance and social harmony are under threat from modernization.

The breakdown of Ladakh's culture and environment forces us to re-examine what we really mean by progress – not only in the developing parts of the world, but in the industrialized world as well. The story of Ladakh teaches us about the root causes of environmental, social and psychological problems, and provides valuable guidelines for our own future" (Green Planet Stream).

Helena Norberg-Hodge set up the *Local Futures, International Society for Ecology and Culture* and also the *International Alliance for Localization* whose web pages are below.

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25.23 Community Supported Agriculture Movement (CSA)

(q.v. Resilience, DESIS)

Is the agro-industry sustainable?

It is increasingly being recognised that the oversubsidised agro-industry with its intensive and exhaustive use of oil for fuel, chemical fertilisers, herbicides and pestcicides is unsustainable. In order for the agro-industry to continually produce monoculture-crops on the same ground requires increasing use of chemicals which is actually destroying the soil by killing the organisms responsible for the soil's natural fertility (1.)

In addition the heavy machinery used by the agro-industry compacts and destroys the soil's physical structure on which the soil biota depend for aeration and drainage.

Soil is an essential and limited resource but is being wasted for the short term gain. Furthermore, the heavy dependence on oil makes the agro-industry vulnerable to prices subject to oil's supply. Even where supplies of oil might be available they are susceptible to politics. The consequences can be food price rises and famine as witnessed by the biofuels fiasco of 2008. Sustainable agricultural strategies, such as *'no-till'* are proving just as successful at food production as the agro-industry's chemical practices (Pretty, 2003; Pretty, 2007).

One sustainable and resilient answer is to produce food by Community Supported Agriculture (CSA). These CSAs are often small farms or smallholdings farming sustainably, organically and ecologically, and supporting biodiversity. Chagfood, Devon, UK (2.) is a good example of a CSA managing three acres of rented land. They concentrate on producing high quality organic vegetables and fruits and are supported by members of the community through annual subscription who receive weekly foodboxes of the produce in season. In addition the community participates in helping on the farm. CSA farms usually depend on a social network with members not only helping to grow the food but also participating in various associated social events. CSAs take a variety of forms but essentially they are a cooperative between the community fed by the farm and the farmer. Essentially, a CSA is "*… a framework to inspire communities to work together with their local farmers, provide mutual benefits and reconnect people to the land where their food is grown.*

The emergence of Teikei in Japan (4.), Community Supported Agriculture in USA and UK, Association pour le Maintien de l'Agriculture Paysanne in France, Agriculture Soutenue par la Communauté in Canada/Québec, Voedselteams in Belgium and of many, many other initiatives shows how consumers and farmers in various places are responding to the same global pressures. This supports the development of organic family-run farms and local fair food systems." (3.)

URGENCI is the international Network of Community supported agriculture and the acronym stands for *"An Urban - Rural Network: Generating new forms of Exchange between CItizens."* URGENCI is concerned with ... *"fostering peer-based solidarity among Community-Supported Agriculture initiatives worldwide to actively contribute to the food sovereignty movement."*

CSAs have also become popular in cities.

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25.24 Dashboard for Sustainability (... the Planet)

(q.v. Global Calculator, Planetary Boundaries)

Medard Gabel quotes Stephen Few (2013), the author of 'Information Dashboard Design: displaying data for At-a-glance monitoring'. *"A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance."*

Gabel continues that: *"An Earth dashboard is needed so that everyone from UN Representatives and world leaders to students and the general public can get an easy-to-understand fix on the condition of their ship, its resources, problems, crew and passengers. Because we are now, more than ever, one world, we need a one-screen dashboard type of display that shows us the key indicators of our ship. Because of the size and complexity of our ship, an Earth Dashboard also needs to be able to zoom in from the whole Earth to the local and to do so in a way that shows links between levels.*

If the world had such a dashboard, and this dashboard was available in a highly visible and credible public (and web) location where all could get access and see it, the dashboard would function as a critical source of global visualization. Those viewing the dashboard will come away with an increased and more tangible sense of the whole world, its interrelationships, problems, and options" (Gabel, et al, 2014).

Remarkably, this dashboard now exists!

It can be seem at the Stockholm Resilience Centre web page (at: http://www.stockholmresilience.org/21/research/research-news/1-15-2015-new-planetary-dashboard-shows-increasing-human-impact.html). It shows a graphic of the demands that one species, Homo sapiens sapiens, mankind, makes on the finite planet, the Earth. The dashboard is divided into two, the left half shows 12 Socio-economic Trends and the right half shows 12 Earth system Trends.

The 12 Socio-economic trends are:

1. Population
2. Real GDP
3. Foreign direct investment
4. Urban population
5. Primary energy use
6. Fertilizer consumption
7. Large dams
8. Water use
9. Paper consumption
10. Transportation
11. Telecommunications
12. International tourism

The 12 Earth system Trends are:

1. Carbon dioxide emissions
2. Nitrous oxide emissions
3. Methane emissions
4. Stratospheric ozone
5. Surface temperature
6. Ocean acidification
7. Marine fish capture
8. Shrimp aquaculture
9. Nitrogen to coastal zone
10. Tropical forest loss

11. Domesticated land
12. Terrestrial biosphere degradation

Remarkably, all trends show an exponential curve of all our demands on the planet's resources and of our emissions.

This new "planetary dashboard" highlights how the trajectories of human development is tightly bound to the Earth as if it and its resources were infinite.

The paper by Will Steffen, Wendy Broadgate, Lisa Deutsch, Owen Gaffney and Cornelia Ludwig (2015) is of remarkable significance. The 'dashboard' was published in a paper entitled: *'The trajectory of the Anthropocene: The Great Acceleration.'*

The paper is remarkable because it is a visualized warning of our dilemma. We are in a free fall of accelerating consumption and we shall hit the bottom when the resources are exhausted. However, even if the resources do not run out immediately it is clear that we are substantially changing the Earth.

It is sobering at this point to recall the story told by Meadows et al (1974) in The limits to growth. A fecund water lily doubles the area it covers in a pond every day (exponential growth like human consumption etc.). It completely covers the pond in 30 days. On what day will the pond be half covered? From this small tale we can understand a little more of our own dilemma on the finite Earth and the possibly sudden occurrence of resource exhaustion. (The answer is day twenty nine.)

Meanwhile, 2014 has been the hottest year on record (Goldenberg, 2015) and levels of CO_2 have reached 400ppm (Simms, 2013). The World Wildlife Fund (WWF (2014) in conjunction with other conservation organizations reported an estimated loss of 52% of the populations of the world's vertebrate fauna. Another paper reports on the "defaunation" of the oceans. *"Humans have profoundly decreased the abundance of both large (e.g. whales) and small (e.g., anchovies) marine fauna. Such declines can generate waves of ecological change that travel both up and down marine food webs and can alter ocean ecosystem functioning."* The only consolation the authors make is that defaunation of the global oceans is not as serious as that now occurring on land! (McCauley, et al. 2015).

Education and society must recognize the necessity for us all to become Earth stewards and participate in the restoration of the Earth and its Natural Capital and ecosystems. Could this be a design challenge?

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25.25 Decomplexifying Design

(q.v. First things first)

There is an evolutionary trend by which organisms can become increasingly complex and/or specialized. The survival advantage in this strategy maybe to reduce competition with competitors. However, biologically this can be dangerous in times of rapid change because specialized species may become extinct as their niches change and they are unable to adapt fast enough. A well known palaeontological example of evolving complexity is to be found in the ammonites whose suture patterns became increasingly complex over millions of years during the period from the Palaeozoic to the Mesozoic.

Today the design of many consumables now follows a similar course at vast cost to the environment and wasted resources. One sustainable strategy is therefore one of de-complexifying or simplfying designs and products. Here are some examples to illustrate the principle. It is not suggested here to revert to the simpler examples but rather illustrate a strategy when designing:

Design simplicity	Design complexity
Safety razor made of four metal components, plus soap and brush for wet shaving.	Electric, rechargeable 3 rotating headed razor with x components or 'Safety' razors with multiple blades
Slide rule	Calculator
Clockwork clock	Battery digital Clock
Simple Ticket Machine	Deutsche Bahn Ticket Automat
Melitta Coffee Filter	Nespresso Coffee Machine
Simple lever door handle	Complex cylinder door handle (Milan Design Fair)
Shampoo	Conditioner, Preconditioner, Shampoo, Post-conditioner
Hand knife sharpener	Electric knife sharpener
Cake Knife etc.	Electric cake knife etc.

25.26 Deep Ecology and attitudes

(q.v. Ecology, Ecosystems, ecological literacy, ecometrics, resilience)

Arne Naess developed a philosophy called 'deep ecology' for living sustainably and ecologically. Naess, who died in 2009 was a widely celebrated Norwegian philosopher.

Naess's approach was to find and clarify the major principles, what even might be called universals. He saw *"biodiversity and cultural diversity as inextricably interconnected"* (Dregson & Devall, 2008). In identifying the deep ecology movement he summarized its raison d'etre into eight platform principles.

1. *"All living beings have intrinsic value.*
2. *The richness and diversity of life has intrinsic value.*
3. *Except to satisfy vital needs, humans do not have the right to reduce this diversity and richness.*
4. *It would be better for humans if there were fewer of them, and much better for other living creatures.*
5. *Today the extent and nature of human interference in the various ecosystems is not sustainable, and the lack of sustainability is rising.*
6. *Decisive improvement requires considerable changes: social, economic, technological, and ideological.*
7. *An ideological change would essentially entail seeking a better quality of life rather than a raised standard of living. ['being more rather than having more']*
8. *Those who accept the aforementioned points are responsible for trying to contribute directly or indirectly to the necessary changes"*

Naess was a fascinating character whose thoughts, insights and writings provide a rich lode of thought for investigation as we try to redefine and reorganize ourselves towards achieving a sustainable existence.

His ideas and philosophy lead us towards acting in ways which can be described as ecologically literate (q.v.) and challenge the attitudes which underlie our consumer life style.

A commonly met attitude is that to live sustainably will require reversion to a somehow more primitive life style without the consumer comforts to which we have become accustomed. However, to be unable to imagine a richer alternative to the consumer lifestyle reveals our dependence on it. The alternatives could make us a lot happier with ourselves so that we become far more fulfilled and substantially contribute to a sustainable future. In *The ecology of wisdom*, a compilation of Naess's writings (Drengson & Devall 2008), we find a listing of lifestyle trends which, while it might not be possible to follow all of them, nonetheless, show a way forward and we quote them here:

"Lifestyle trends within the deep ecology movement. The following list offers ways that supporters of the deep ecology movement can joyfully adapt their lifestyle to the movement.

1. *Use simple means, avoid unnecessary, complicated instruments and other sorts of means.*
2. *Choose activities most directly serving values in themselves and having intrinsic value. Avoid activities that are merely auxiliary, have no intrinsic value, or are many states away from fundamental goals.*
3. *Practice anti-consumerism. This negative attitude follows from trends 1 and 2.*
4. *Try to maintain and increase the sensitivity and appreciation of goods in sufficient supply for all to enjoy.*

5. *Eliminate or lessen neophilia – the love of what is new merely because it is new.*
6. *Try to dwell in situations of intrinsic value and to act rather than being busy.*
7. *Appreciate ethnic and cultural differences among people; do not view the differences as threats.*
8. *Maintain concern about the situation in developing nations, and attempt to avoid a standard of living too much higher than that of the needy (maintain a global solidarity of lifestyle).*
9. *Appreciate lifestyles that can be maintained universally – lifestyles that are not blatantly impossible to sustain without injustice toward fellow humans or other species.*
10. *Seek depth and richness of experience rather than intensity.*
11. *Appreciate and choose, when possible, meaningful work rather than just making a living.*
12. *Lead a complex, not complicated life, trying to realize as many aspects of positive experiences as possible within each time interval.*
13. *Cultivate life in community (Gemeinschaft) rather than in society (Gesellschaft).*
14. *Appreciate, or participate in, primary production – small-scale agriculture, forestry, fishing.*
15. *Try to satisfy vital needs rather than desires.*
16. *Attempt to live in nature rather than just visiting beautiful places; avoid tourism (but occasionally make use of tourist facilities).*
17. *When in vulnerable nature, live "light and traceless."*
18. *Appreciate all life-forms rather than merely those considered beautiful, remarkable, or narrowly useful.*
19. *Never use life-forms merely as means. Remain conscious of their intrinsic value and dignity, even when using them as a resources.*
20. *When there is conflict between the interests of dogs and cats (and other pet animals) and wild species, try to protect the wild creatures.*
21. *Try to protect local ecosystems, not only individual life-forms, and think of one's own community as part of the ecosystems.*
22. *Besides deploring the excessive interference in nature as unnecessary, unreasonable, and disrespectful, condemn it as insolent, atrocious, outrageous, and criminal – without condemning the people responsible for the interference.*
23. *Try to act resolute and without cowardice in conflicts, but remain nonviolent in words and deeds.*
24. *Take part in or support nonviolent direct action when other ways of action fail.*
25. *Practice vegetarianism."*

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25.27 De-materialization

(q.v. natural capital, decomplexifying design, ecological rucksack, MIPS, systems, Factor five)

Dematerialization is a strategy first identified in 1992 by Schmidt-Bleek and his colleagues at the Wuppertal Institute. The question which they considered was *"Can we technically organize the level of prosperity we are accustomed to with a much lower input of resources?"* (Schmidt-Bleek, 2008). Schmidt-Bleek and his team calculated that, it could be possible to radically reduce material consumption by a factor of 10. This means reducing global consumption by half and for the established industrialized nations reducing their consumption by 90% !

Dematerialization is defined as "*… the reduction of material natural resources to satisfy human needs by technical means*" (Schmidt-Bleek, 2008) and again: *"Dematerialization refers to the production of goods and services in the future with a much lower input of material than is usual today"* (Jäger, 2008).

The thesis of the book Natural Capitalism (Hawken, Lovins & Lovins, 1999) is "*… that 90-95 per cent reductions in material and energy are possible in developed nations without diminishing the quantity or quality of the services that people want.*" In other words improving the productivity of materials.

Weizsäcker, et al. (2009) claim that this process begins with posing the right questions before beginning to design. For example: *"what is the required service or product, and how else can this service or product be provided with less environmental impact?"* Furthermore, thinking about services and products in terms of systems presents more options for solutions than might initially be apparent.

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25.28 DESIS: Design for Social Innovation and Sustainability; Network and Association

(q.v. Collaborative consumerism, Community Supported Agriculture Movement, Incredible Edible, Bio-regionalism, Transition initiatives)

Design for Social Innovation and Sustainability or DESIS began as a network of labs in design schools supporting and promoting sustainable social change initiated by Prof Ezio Manzini, Politecnico di Milano. The network now has labs in design schools on every continent. In 2013 the network became an Association and is affiliated with the Cumulus Association.

The principle ideas behind DESIS are:

- design driven global network based in design schools for sharing knowledge about sustainable change for urban innovation.
- social innovation could be a driver towards sustainability.
- design schools could both support and accelerate the process.
- *"Social innovation is a new idea that works in meeting social goals" (Mulgan, 2006). In other words, social innovation can be seen as a process of change emerging from the creative re-combination of existing assets (social capital, historical heritage traditional craftsmanship, accessible advanced technology) and aiming at achieving socially recognized goals in new ways. A kind of innovation driven by social demands rather than by the market and/or autonomous techno-scientific research, and generated more by the actors involved than by specialists."* (DESIS, 2012).
- *"Over the past decade social innovation has spread: a variety of social actors throughout the world (institutions, enterprises, non-profit organizations and, most of all, networks of collaborative people) have moved outside mainstream models of thinking and doing, generating a variety of promising initiatives such as community-supported agriculture, co-housing, carpooling, community gardens, neigh-bourhood care, talent exchange and time banks. These initiatives propose viable solutions to complex problems of the present (e.g., social cohesion, urban regeneration, healthy food accessibility, water and sustainable energy management) and, at the same time, they represent working prototypes of sustainable ways of living"* (DESIS, 2012).
- *"Today, social innovation is generating a constellation of small initiatives. Nevertheless, if favourable conditions are created, these small, local social inventions and their working prototypes can spread. They can be scaled-up, consolidated, replicated and integrated with larger programs to generate large-scale sustainable changes. To do that, new design competencies are needed. Indeed, social innovation processes require visions, strategies and co-design tools to move from ideas to mature solutions and viable programs. That is, they ask for new design capabilities that, as a whole, can be defined as design for social innovation"* (DESIS, 2012).

The DESIS network encourages design schools to set up social innovation projects which are sustainable and which once approved receives the network's support. Projects are encouraged which involve cooperation with other design schools (a regional cluster) on joint projects.

Projects range from:

- The banana textile project aimed at designing a new textile culture based strongly on traditional practices and local raw materials.
- A student platform for buying and selling goods that some students no longer require but which other students need.
- Designing social contact which aims to establish and sustain relations between mentally retarded citizens and (medically non-professional) members of the community to make

the lives of the mentally retarded similar to other citizens.
- Innovative reclamation of materials through community based collaboration in which the materials from demolished buildings are made available for re-use.

The DESIS Association is supported by an excellent web site.

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25.29 Design for Disassembly and recycling (DFD/R)

(q.v. circular economy, traditional Japanese wood joinery, Re-Strategies)

Design for disassembly is essential for supporting the efficient recycling of products and resources and the transition towards the circular economy and the new design paradigm. In the old design paradigm a product was thrown away once it was broken, no longer wanted or had reached its end-of-life phase. Unfortunately, the design education curriculum, rooted in the old design paradigm, still places too much attention to a product's Life Phase and rarely enough on its before- and end-of-life-phases.

Ecologically the important phases of a design's life-cycle are not necessarily those during the product's-life time (unless it has heavy running costs) which has been the focus of the design curriculum but rather its before- and end-of-life phases. In the past these two phases have scarcely impinged on design education and its curriculum. The new design paradigm for achieving sustainability now means that all three phases are of equal importance and require equal consideration in the curriculum and by the design team.

The before-life phase is characterized by the extraction and transport of all the raw materials, the processing of the raw materials for the manufacture and assembly of the product. Great thought has to be given to this phase in order to reduce as much as possible all the environmental costs.

Similarly, in the end-of-life phase equal design consideration has to be given to the design "corpse" (a compilation of resources) so that it can be disassembled and the components can easily be reused and their materials recycled.

Some of the strategies for design for disassembly include:

- design for easy repair and upgrade where this applies.
- use fewer materials.
- use as few numbers and types of components as possible for easy sorting during disassembly.
- where possible use fasteners.
- use as few fasteners and kinds of fasteners as possible.
- make fastenings easily visible and accessible.
- if glues must be used then select those that can be easily dissolved (soluble in water) rather than chemical solvents or use heat reversible adhesives.
- include disassembly cues, such as lift or turn so that a product can be easily and quickly dismantled.
- avoid synthetic materials, such as paints, adhesives etc. as much as possible because they frequently off gas chemical compounds into the atmosphere where they can combine with each other an form unexpected compounds which may be toxic.
- avoid plastics since they can contain secret and sometimes toxic chemicals used by manufacturers to give their plastic formulation unique properties in a competitive market. Despite regulations, they can contain compounds which offgas and can be toxic. (http://www.plastic-planet.de/) (accessed at: www.autodesk.com/sustainabilityworkshop)

We need to adhere to the ethic of not merely recycling materials but rather that designers borrow the world's resources to create temporary arrangements of resources known as 'designs.' The concept of borrowing has the moral obligation (lacking in the term 'recycling) of returning materials for further use. This is the real responsibility of design, designers borrow the world's resources and are morally obliged to ensure their return for re-use.

Traditional Japanese wood joinery developed over a 1000 years for building wooden houses to withstand earthquakes employ a rich vocabulary of fastening structures many of which can be easily disassembled. The principles can be readily applied and adapted to other design areas such as plastic housings.

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25.30 Do good design

(q.v. First things First)

David Berman appeals for moral responsibility in graphic design conveying a similar message that Ken Garland had appealed for with his 1964 Manifesto First things first (q.v). Berman's publishers, Peachpit, write in their promotion that: *"Author David B. Berman offers a powerful and hopeful message that will inspire readers to do good design in 2009 and beyond.*

Do Good Design is a call to action: It alerts designers to the role they play in persuading global audiences to fulfill invented needs.

Berman outlines a more sustainable approach to both the practice and the consumption of design. All professionals will be inspired by the message of how one industry can feel better about itself by holding onto its principles. In this time of unprecedented environmental, social, and economic crises, designers can choose what their profession will be about: inventing deceptions that encourage more consumption, or helping repair the world.

An AIGA Design Press book, Do Good Design is published under Peachpit's New Riders imprint in partnership with AIGA."(1.) (the entire book can now be downloaded as a pdf from this web page: http://www.davidberman.com/wp-content/uploads/DoGoodBermanForCh-1Ch12Index.pdf

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25.31 Earth Day First Earth Day was held 22 April 1970

(q.v. 1970 - the turning point)

On 22 April 1970, the first Earth Day was proclaimed in the USA by Senator Gaylord Nelson after he saw what damage an enormous oil spill had done to the coast of Santa Barbara, California. Nelson, recognizing the power of the student anti-Vietnam war movement, thought that it might be possible to infuse the public with a similar concern about the environment. He recruited a staff of 85 to promote simultaneous events across the US. On 22 April, about 20 million Americans demonstrated in massive rallies for a healthy and sustainable environment. Furthermore, many individual groups protesting against individual or local pollution and ecosystem destruction recognized that they were all joined together in a common cause (1.)

Since then the event has taken place annually to promote and encourage everyone's participation in contributing to and supporting a healthy environment for the planet.

Its current campaign is concerned with its 2012 goal of A Billion Acts of Green® encouraging everyone to a green act for the Earth and its environment. According to its web page (accessed 17.12.2013) 1,019,890,582 acts of green have been reached. These include actions such as:

› buying local produce,
› stop using disposable plastic,
› supporting renewable energy,
› planting 10 million trees in impoverished areas,
› ... etc.

Today the Earth Day movement has about 900,000 members.

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25.32 Eco-conflicts & Climate

(q.v. UNEP, globalization, Dashboard for sustainability)

The possible connections between climate change and conflict are unclear due to a lack of information and the complexity of the interconnecting pathways. *"Freak weather in some of the world's vital food producing regions is ravaging crops and threatening another global food crisis like the price shocks that unleashed social and political unrest in 2008 and 2010. As the US suffers its worst drought in more than 50 years, South America has been similarly effected, whilst flash flooding in Russia has put the wheat harvest under threat"* (Guardian Reporters, 2012).

However, conflicts over food resources are illustrated by the competition for fish resources during the 1970s and the production of bio-ethanol in this century:

Fish

The UK and Iceland fought over cod fishing in the "Cod Wars" because some nations wanted to increase their national waters to a 200 mile range from their coasts in order to protect their fish stocks. Other nations did not accept this ruling. The cod inhabit inshore areas and move into deeper waters to breed. A favoured cod fishing ground was around the Icelandic coasts and during the 1970s conflict flared between British trawlers and the Icelandic coast guard because the British did not accept the new 200 mile zone around Iceland. *"In five months, there were thirty five ramming incidents as the Icelandic Coast Guard cut forty-six British and nine German trawls. Both sides were becoming practiced at the arcane skill of friendly naval battles"* (Kurlansky, 1999).

More recently, the industrialized fishing of the developed nations has contributed to the poverty of developing nations, notably in West Africa but also off the coasts of east Africa and Somalia where fisherman have turned to piracy in order to survive (Vidal, 2012).

Bio-ethanol

Food insecurity has resulted in riots in recent years with the increase of food prices brought on by the agricultural land being diverted from growing food to growing bio-mass for bio-ethanol. In 2008 an internal World Bank study revealed that *"Biofuels have forced global food prices up by 75% - far more than previously estimated - according to a confidential World Bank report obtained by the Guardian. The damning unpublished assessment is based on the most detailed analysis of the crisis so far, carried out by an internationally respected economist at the global financial body. The figure emphatically contradicts the US government's claims that plant derived fuels contribute less than 3% to food-price rises. It will add to pressure on Washington and governments across Europe, which have turned to plant derived fuels to reduce emissions of green house gases and reduce their dependence on imported oil. Senior development sources believe the report, completed in April, has nor been published to avoid embarrassing President George Bush ...*

Rising food prices have pushed 100 million people worldwide below the poverty line, the World Bank estimates, and have sparked riots from Bangladesh to Egypt. Government ministers here have described higher food and fuel prices as "the first real economic crisis of globalization"" (Chakrabortty, July, 2008).

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25.33 Eco-design

(q.v. positive impact design)

"Every business places a burden on the environment, because there is no such thing as "environmentally friendly goods," but only more or less environmentally impactful goods (products, infrastructures and services) ... More than 80% of all product related costs and environmental impacts of a product during its manufacture, use and disposal are determined during the product planning phase. If environmental aspects are taken into account during the earliest phases of product development, then it is more likely that reduced environmental impacts can be integrated into the final product." (Tischner et al, 2000).

In 2008, the London Agency Trucost investigated the environmental impact of the 3,000 biggest public companies in the world and calculated the cost of the damage to the environment caused by them and which totaled an estimated $2.25 trillion for the year 2008. The damage to the environment includes pollution and the rapid loss of freshwater, fisheries and fertile soils. This is a sum bigger than the national economies of all but seven nations for 2008!

Consequently, Ecodesign is an essential step towards achieving sustainability because *"It must be our goal to restrict the consumption of natural resources and environmental pollution to the lowest possible levels while simultaneously making best use of these resources from both a customer and company viewpoint"* (Tischner et al, 2000) as well as the environment. *"The term Ecodesign directly expresses the fact that Ecology and Economy must be joined inseparably by means of good design in Ecodesign procedures." Briefly put "Ecodesign leads to "products, systems, infrastructures, services, which require a minimum of resources, energy and land area to provide the desired benefit in the best possible way while at the same time minimizing pollutant emissions and waste arising over the entire life cycle of the product.""*

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25.34 Eco-Refugees or Environmental Refugees

(q.v. indigenous peoples)

"Environmental refugees are "those people who have been forced to leave their traditional habitat, temporarily or permanently, because of a marked environmental disruption (natural and/or triggered by people) that jeopardized their existence and/or seriously affected the quality of their life." (1, Vine, 2005)

The Red Cross has estimated that there were about 25 million environmental refugees (1, Vine, 2005) and the projection cited by Vine was that there could be 50 million environmental refugees by 2008 and 150 million by 2050! Wars and persecutions cause peoples to flee their homelands and seek shelter in other countries where according to international law and the Geneva Convention they are normally recognized as refugees. Currently, however, international law does not recognize eco-refugees who are forced to leave their homes due to other disasters some of which include:

- industrial activity (e.g. displacement due to dam building such as the Aswan dam which displaced 100,000 people and the Three Gorges Dam which will displace 1.2 million people).
- industrial disasters (e.g. Bhopal, Chernobyl and Fukushima).
- indigenous peoples forced off their traditional lands by ruthless developers, mining businesses, foresters and farmers.
- geological disasters (e.g. tsunamis, volcanoes, earthquakes and desertification).
- meteorological disasters (hurricanes which severely damaged Haiti and the typhoon Haiyan which recently devastated the Philippines).
- climate change which is causing sea level rise and droughts.

The problem of eco-refugees is an increasing problem of the present times because on the one hand the human population continues to grow while on the other the scrabble for resources and greenhouse gas emissions are exacerbating the previously benign climate. It has been estimated that in 1998 *"natural and manmade disasters caused an estimated 25 million eco-refugees."* (2)

Arctic temperatures are rising at twice the average global rate of global warming. Consequently, ever larger areas of the Arctic surface, both on sea and land, are no longer covered by frozen snow and ice so that the sun's energy is no longer reflected. Scientists think that Arctic has now passed a tipping point into a positive feedback regime which will continue to increase the melting of the ice and the permafrost. This means substantial changes for all those living around the Arctic circle, how will they adapt or will they move south and become eco-refugees?

Meanwhile, sea-level rise is not in question but rather how high and how fast. In 2007 Rahmstorf's estimation correlated sea-level rise with global warming so that for the 20th century every degree C of global warming resulted in a sea-level rise of 3.4 millimeters per year above the 1990 level. *"When applied to future warming scenarios of the Intergovernmental Panel on Climate Change, this relationship results in a projected sea-level rise in 2100 of 0.5 to 1.4 meters above the 1990 level"* (Rahmstorf, 2007). The factors contributing to this rise include not just the melting of glaciers and ice caps but also the thermal expansion of water as well as water extracted from aquifers. If the ice sheets completely melted they would cause a sea level rise of about 70m. Countries like Bangladesh with a heavily populated estuarine region is already in great danger from sea level rise and its inhabitants becoming eco-refugees. Schools are built on boats so as to avoid the floods which already occur (3. National Geographic.com, 2014).

Sea level rise is increasingly causing flooding on the islands of Tuvalu and New Zealand is preparing to accept the 11,000 inhabitants. This is a serious warning of future problems because more than half of the world's mega-cities (with inhabitants of more than 10 million) are located on seaboards (Tokyo, Mumbai, New York, Shanghai, Dhaka, Karachi, Los Angeles, Rio de Janeiro, Osaka-Kobe, Lagos, London and Istanbul). Therefore, we can anticipate that future sea level rises will cause millions of eco-refugees from flooded mega-cities if we are unable to limit green house gas emissions.

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25.35 Ecological Economics

(q.v. Planetary Boundaries, Economics, Brown Economy)

Herman Daly is a professor of ecological economics at the University of Maryland, a field of which he was one of the founders and which posits that the scale of the economy should not exceed sustainable limits (qv planetary boundaries). Prof Daly was a senior economist at the World Bank in the environment department from 1988 to 1994.

In 1992 Prof Daly was participating in a series of meetings concerned with the preparation of the 1992 World Development Report. An early draft of the report included a diagram labelled *"the relation of the economy to the environment."* However, the diagram merely showed a rectangle labelled "economy" with two arrows, one entering the rectangle labelled "inputs" and a second leaving the rectangle labelled "outputs" and, as he writes. *"That was it"*. He suggested adding a big circle around the rectangle and labelling it "ecosystem" thereby indicating resources taken from the environment with the input arrow and waste and pollution returned to the environment by the output arrow. Despite several meetings and modifications the diagram was finally dropped because, as Daly writes *"The idea that economic growth should be constrained by the environment was too much for the World Bank in 1992, and still is today. The Bank recognised that something must be wrong with that diagram – but better to omit it than deal with the inconvenient questions it raised.*

That was when I realised that economists have not grasped a simple fact that to scientists is obvious: the size of the Earth as a whole is fixed … The overall size of the system – the amount of water, land, air, minerals and other resources present on the planet we live on – is fixed."

Daly suggests that we are approaching the limits of what the Earth can cope with as we fish out the seas, log the forests and pollute the atmosphere etc. *"When the cost of an activity outweighs the benefit, we should stop"* and *"How big can the economy possibly be before it overwhelms and destroys the ecosystem in the short run?"* In other words how long before the tree will provide more benefit to us as a tree than as a chair? Daly observes that: *"… we are already encountering the economic limit at which benefits of extra growth are increasingly outweighed by the costs."*

Therefore, the question is how do we transform our economy from an exponentially growing one to a steady-state economy? As has been written elsewhere, life should be less about having and more about being. The situation is urgent since we are now overconsuming the Earth's replenishable resources by about 50% (Ehrlich, & Ehrlich, 2013) faster than she can provide them or, in other words, our annual consumption depends on 1.5 worlds. This means we are consuming our natural capital in addition to nature's annual provision!

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25.36 Ecological Footprint

(q.v. Ecological rucksack, MIPS, SIPS)

The ecological footprint was a term which William Rees 'coined' as a result of a third 'Eureka' moment when a colleague asked him how he liked his new computer. In 1990 it was a new tower model. He replied that *'It was great, it has a smaller "footprint" on my desk.'* He was at the time preparing a paper (Rees,1992) about the area of land humans needed to source themselves and the term he was using was something like the *human impact indicator*. Then he realised that *'footprint'* was the term he really needed! In his introduction he went on to wrote that *"This paper uses the concepts of human carrying capacity and natural capital to argue that prevailing economic assumptions regarding urbanization and the sustainability of cities must be revised in light of global ecological change. While we are used to thinking of cities as geographically discrete places, most of the land "occupied" by their residents lies far beyond their borders. The total area of land required to sustain an urban region (its "ecological footprint") is typically at least an order of magnitude greater than that contained within municipal boundaries or the associated built-up area. In effect, through trade and natural flows of ecological goods and services, all urban regions appropriate the carryimng capacity of distant "elsewheres," creating dependencies that may not be ecologically or geopolitically stable or secure. Wealthy nations appropriate more than their fair share of the planet's carrying capacity ... This paper is based on the premise that human bio-ecology may soon become more important to understanding the political and socio-economic implications of urban development than economics"* (Rees, 1992).

In the Glossary to their book *"Our ecological footprint"* Wackernagel & Rees (1996) define the ecological footprint as *"the land (and water) area that would be required to support a defined human population and material standard indefinitely."*

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25.37 Ecological Literacy / Environmental Literacy

(q.v. ecosystem, ecosystem services, circular economy, Life Cycle analysis, MIPS, SIPS, Net Primary Production, Anthropocene)

The word ecology is derived from the Greek word meaning 'house'. Ecology is the science concerned with the study of the inter-relationships between plants, animals and micro-organisms in their natural environment and their distributions and numbers. Consequently, an ecologist studies the patterns of interactions and the flows of energy and compounds which cycle through an ecosystem. Ecosystems provide the model for our own existence but unfortunately, we are the first and only species to produce waste and pollution. In nature different organisms utilize the waste products of other species thereby endlessly cycling materials and energy through the ecosystem. In contrast to mankind, natural systems are non-polluting and therefore provide the model for a sustainable future.

Ecology is an essential key to understanding how we can sustainably manage our lives and the Earth's natural resources on which our survival depends. All organisms alter their environment to a lesser or greater extent: fungi break down organic material and contribute to the fertility of soil which benefits other organisms. Plants photosynthesize, sequestering carbon from the atmosphere, creating biomass (q.v. NPP) and thereby changing the composition of the atmosphere, etc. However, there is no species that has changed the Earth's biosphere (where organisms are found and extending down to 11 km in the deepest oceans to the highest plant communities at about 6.2 km above sea-level) to the extent that mankind has modified it. Consequently, scientists have named the current geological epoch the Anthropocene.

There can be no doubt that to be a designer today one must be ecologically or environmentally literate. What does this mean?

To be literate in this context means *"having or showing education or knowledge, typically in a specified area"* and in this case about the environment and ecology. This leads to the question as to why this should be necessary for designers? Of course a complete answer requires a book of its own, however, the principle can be readily explained.

Any design, be it a product, a service or process, requires inputs from the environment and creates outputs which are returned to the environment. In other words design participates in a flow of resources temporarily 'borrowed' (q.v.) from the environment. Although today designers cannot be ecologists, they must nevertheless think beyond the client's brief as characterized by the "old paradigm". An early step for environmental/ecological literacy is the knowledge about the 'upstream' inputs (the required resources, materials and energy etc.), where they come from and what are the environmental costs. Another step is to recognize that a design's 'downstream' outputs also affect the environment, not only during its lifetime but its end-of-life phase; can the design be dismantled and the materials recycled? The resources that were borrowed; can they be returned for further use so that they can continue in a circular economy?

Today we now understand the natural world as an holistic system which is based on three fundamental principles:

1. *"life's basic pattern of organization is the network;*
2. *matter cycles continually through the web of life,*
3. *all ecological cycles are sustained by the continual flow of energy from the sun."* (Stone, M.K., Barlow, Z., 2005).

Barry Commoner identifies four ecological laws:

1. *"Everything is connected to everything else.*
2. *Everything must go somewhere.*
3. *Nature knows best (to which we could also add that … and everything depends on Nature)*
4. *There is no such thing as a free lunch."* (Commoner, 1972)

These four points are elucidated in Chapter 3.

Consequently, design's demands impact on the Earth's system in diverse ways so that we must ask:

› do I choose this material or another …?
› do I choose this process or another …?
› does it require this much energy or could it be less …?
› etc., etc.

"What then?"
The ability to pose this question, according to Garrett Hardin, is *"ecological literacy,"* (Orr, 1992) because it leads naturally to considering how to reduce the ecological and environmental impact, recycling and/or reusing the resources etc.

Ecological literacy is therefore an attitude of concern for the natural world and the details can be researched. It is at this point we can talk about deep ecology (q.v.) because an attitude leads to a philosophical approach for how we do design, an approach which is sustainable and compatible with the Earth and its natural systems. An awareness and knowledge of ecological literacy will steer us towards sustainable design without necessarily having to possess an exhaustive knowledge of ecology.

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25.38 Ecological Rucksack

(q.v. ecological footprint, virtual water)

The concept of the ecological rucksack, like the ecological footprint, provides a measure of the ecological cost of a product. The two methods measure the environmental costs of a product in different ways. The ecological footprint provides a measure of the land surface area required to manufacture a product. The ecological rucksack visualizes the total amount of material flow and natural resources required along the whole production line (Jäger, 2008). It also includes the waste produced or spoil, for example, from refining a metal used in the manufacture of a product. In an example of the production food, a kilogram of beef requires 9,680 liters of water or virtual water (Vidal, 2004). However, the Water Footprint Network quotes Mekonnen and Hoekstra (2010) who calculate that 15,415 liters of water are required to create a kilogram of beef. *"In the case of a PC, the ecological (abiotic) rucksack weighs at least 200 kg per kg of product"* (Schmidt-Bleek, 2000).

The concept of the ecological rucksack was developed by Friedrich Schmidt-Bleek working at the Wuppertal Institute of which he was a co-founder and he defines the ecological rucksack of a product *"as its material input from the cradle to the point of sale, MI (including energy) minus its own weight (own mass) ... (MI factors or rucksack factors (MIF) are the material intensity values for individual materials (raw, basic, and building materials))"* (Schmidt-Bleek, 2008).

The ecological rucksack for a service Schmidt-Bleek (2008) defines as *"the sum of the shares of the rucksacks of the technical means employed (for example, equipment, vehicles, and buildings), plus the sum of its share of materials and energy used while the technical means are employed,"*

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25.39 The Ecologist

(q.v. 1970, + / - 1 year)

No 1 of Vol 1 of The Ecologist magazine was published in July 1970 and founded by its editor Edward Goldsmith. It established a reputation as a *"Leading environment magazine known for its campaigns and hard-hitting investigations will merge with Resurgence"* (van der Zee, 2012).

In 1972, the January Issue published "A Blueprint for Survival" which was subsequently re-published as a Penguin special book. The cover 'blurb' claimed that it *"is much more than just another review of man's environmental problems; it offers radical proposals for immediate action. The storm of debate it provoked among politicians and scientists has generated constructive action and widespread concern.*

The Blueprint is supported by 34 distinguished biologists, ecologists, doctors and economists, including Sir Julian Huxley, Peter Scott and Sir Frank Fraser Darling. 'Governments', they warn, 'are either refusing to face the relevant facts, or are briefing their scientists in such a way that their seriousness is played down.' Unless we minimize the disruption of eccological processes and stabilize the population, in the knowledge that our industrial way of life, with its ethos of expansion, is not sustainable, we shall inevitably face the exhaustion of food supplies and most resources, and the collapse of society as we know it" (Goldsmith, et al eds., 1973).

"The Ecologist has always retained its serious reputation, and has been involved in some notable campaigns. In 1998 the magazine's printers pulped the entire run of an edition critical of Monsanto; it was eventually printed elsewhere and became one of their best-selling editions. In recent years it has run hard-hitting exposés of US mega-dairies and animal rights issues. A recent investigation into links between Coca-Cola and cheap migrant labour in Italy became an international issue. More recently the website ran a special series of articles on breastfeeding around

the world. The website was getting about 200,000 unique page views a month" (Zee, van der, 2012).

In 2012 *The Ecologist* merged with another environmental publication: *Resurgence. "Zac Goldsmith MP and former editor of the Ecologist says: "the Ecologist has been at the heart of the environmental movement for over 40 years and Resurgence has been in publication for the past 45 years and, as sister publications, they have always shared the same values. The Ecologist has spearheaded social, scientific and political ecology while Resurgence has spearheaded cultural and artistic ecology. Now the time has come to bring these two aspects of the environmental movement together by merging Resurgence and the Ecologist"* (Kumar, 2012).

The Ecologist continues to exist but as a web site which is an enormously useful source of information covering a range of issues such as: climate change, food & farming, energy, health, politics & economics, natural world, waste & recycling etc.

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25.40 Ecology

(q.v. Ecosystem, Ecosystem services, The Ecologist, Anthropocene, Gaia)

The word ecology is derived from the Greek word 'oîkos' meaning 'house'. Ecology is the science concerned with the study of plants, animals and micro-organisms and their interactions and relationships with each other and with their physical and chemical environments. As a consequence it is also concerned with the study of their distributions and abundance. Therefore, an ecologist studies patterns of interactions and the flows of energy and compounds through an ecosystem, which is a community of organisms adapted to living in a specific locality such as a rocky shore, a peat bog, or a deep ocean hydro-thermal vent. In natural ecosystems organisms live interdependently, continually cycling energy through foodchains, utilizing waste products and the materials and resources essential for their existence. Natural systems are non-polluting. We are the first and only species to produce polluting waste which biologically is perhaps a defining character of our species.

We all need to understand how ecology functions so that we can care for and protect the natural capital of species, ecosystems and the larger environment which together provide the ecosystem services on which we depend. Ecosystems provide the model for our own existence and from which we can learn how to sustainably care for the Earth's natural resources. All organisms alter their environment to a lesser or greater extent (qv Gaia): fungi break down organic materials and contribute to the fertility of soil which benefits other organisms. Plants photosynthesize and thereby change the composition of the atmosphere, etc. However, there is no species that has changed the Earth's biosphere as much as we have. The biosphere is the life bearing envelope around the Earth which extends down 11 km to the deepest oceans and up to the highest plant communities at about 6.2 km above sea-level. Consequently, scientists now recognize that we have now left the geological epoch of the Holocene and entered a new epoch – the Anthropocene. An epoch which is being defined by the impact of mankind.

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25.41 Ecometrics

(q.v. DESIS, Resilience)

"Ecometrics" (not to be confused with econometrics) are relatively new tools which are being developed to assess and measure a city's social-ecological infrastructure. This is really important for preparing and planning for possible disasters. Ecometrics can be used

to identify and prepare possibly vulnerable neighbourhoods and protect those with a weak resilient social infrastructure from a catastrophe (Sampson, 2013).

The term 'ecometric' was coined by Raudenbush & Sampson (1999). Sampson has scientifically investigated how neighbourhoods and cities function by researching the urban infrastructures, social networks of community leaders and urban events. The research entailed, for example, a "lost letter" experiment in which already stamped letters were dropped in the streets. In five of the communities where stamped letters were dropped none were returned whilst in others they were nearly all returned. The results from the "lost letter" experiment were correlated with other social indicators such as *"crime, violence, health, community organization and population characteristics over 40 years."*

The key factor Sampson and his researchers identified was the extent of social cohesiveness between the residents which clearly differentiated one neighbourhood from another. In other words how prepared were residents to intervene on issues for the sake of the common good. Sampson and his colleagues called this "collective efficacy." The measurement strategy involved asking residents their preparedness to intervene in different social situations ranging from a fight starting to helping a neighbour etc.

Collective efficacy

The greater the measure of "collective efficacy" correlated with less violence and social disorder within a community. Sampson and his team are working on developing ways of measuring *"the social-ecological infrastructure of cities, known as 'ecometrics'. This can be directly applied to disaster planning. Cities can use ecometrics to identify and support not only those neighbourhoods that are physically vulnerable, but also those that lack a resilient social infrastructure ... The more community groups in an area, the greater the collective efficacy, social altruism and collective civil engagement"* (Sampson, 2013). Coordinated activities, be they neighbourhood groups, baby-sitting networks, tenants associations etc. enhance collective and spontaneous initiatives in an emergency. Regardless whether the network is a stamp club or ladies coffee group the key is the existence of organizational infrastructures overlapping with other networks. The key to the successful confrontation between a community with a crisis depends not merely on civic services such as the hospitals and fire sevice but also the "collective efficacy," strength and number of overlapping infrastructure networks, its "ecometrics."

We can now recognize that design activities associated with communities (e.g. DESIS) have multiple functions. The project may not merely be concerned with only its theme, be it a neighbourhood vegetable garden or care for the elderly: it is also building a network infrastructure which will provide resilience against unexpected disasters. In other words design can create benefits at multiple levels so that creating a community garden is as much about growing food as it is about growing a community, developing its resilience to stressors, etc.

The reason that so many old people died in the Paris heatwave of 2003 was due to *"the decline of social solidarity, exacerbated by government mismanagement ..."* and *"that victims tended to live in simple rooms located on the highest stories of popular residential buildings throughout Paris, meaning the victims were the literal neighbors of many well-off urbanites ... these top-story apartments have historically been low-rent rooms ... The heat wave produced death by urban design that was decades, not days, in the making"* (Stark, 2015).

Ecometrics will play a key role in the development of new curricula for areas of non-commercial design such as social welfare etc.

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25.42 Economics

(q.v. Politics, Ecological economics)

Economics is defined by the New Oxford Dictionary of English (Pearsall, 1998) as *"the branch of knowledge concerned with the production, consumption, and transfer of wealth."* Design and art students might think that economics is a subject which they need not bother too much about. However, art and design make a substantial contribution to the wealth and GDP of many countries, especially the developed nations. *"Sir Kenneth Corfield, reviewing Design and Innovation edited by Richard Langdon and Roy Rothwell, in a review entitled* Design as a prime factor in economic advantage (Corfield, 1986) writes that *"It is largely due to Richard Langdon, head of the department of design research at London's Royal College of Art … and his like minded peers, that design has been elevated from a subordinate to a commanding role in the successful industrial environment … Design and Innovation … draws out, loud and clear, the case for the total design concept as an inseparable element of innovation and wealth creation."*

Unfortunately, with today's level of political (q.v.) and economic incompetence (not to mention deceit) we must all possess a far more holistic perception of the world and one which certainly embraces some knowledge of economics. This is important because of design's contribution to economies and the impact of economics on our own lives. Money, is afterall, the currency of humankind's 'energy' to which we contribute and so we all need to have some understanding of it (Chang, 2010), especially as politicians decide how our taxes are spent or not spent for the benefit of society and business.

Unfortunately, although mainstream economists were happy with their neat economic models (some, however are so complicated that they themselves do not agree about them (Chang,2010)), these models did not reflect the reality of how money, banks and debt function. Oblivious of their ignorance or concern for accurate economic models, and like the passengers on the Titanic, mainstream economists were profoundly surprised by the 2008 crash (Chakrabortty, 2015). Hardly an economist, even *"The Queen herself asked why hardly any of them saw the crash coming, while the Bank of England's Andy Haldane has noted how it rendered his colleagues' enchantingly neat models as good as useless"* (Chakrabortty, 2014; Chakrabortty, 2015; Giles, 2008). Andy Haldane was appointed the chief economist at the Bank of England in June 2014. He *"is seen as one of the Threadneedle Street's intellectual heavyweights. But as well as gaining admiration for his sharp analysis and the elegance of his papers he has also shown a radical streak, insisting in 2012 that the Occupy protesters were right to attack the workings of globalized capitalism. He has been chief economist at the Bank for just a few months: he moved into the role under a shakeup by governor Mark Carney"* (Allen, 2014).

Since the 2008 crash, the economics' curriculum and its teaching has been profoundly criticized by *"over 65 associations of economics students from over 30 different countries, believe it is time to reconsider the way economics is taught"* and who demand a complete overhaul of the subject (Chakrabortty, 2014; Chakrabortty, 2015). In an Open Letter (ISIPE, 2014) the students write that they *"are dissatisfied with the dramatic narrowing of the curriculum that has taken place over the last couple of decades. This lack of intellectual diversity does not only restrain education and research. It limits our ability to contend with the multidimensional challenges of the 21st century - from financial stability, to food security and climate change. The real world should be brought back into the classroom, as well as debate and a pluralism of theories and methods. Such change will help renew the discipline and ultimately create a space in which solutions to society's problems can be generated. United across borders, we call for a change of course." They continue in their carefully argued Open Letter that "Three forms of pluralism must be at the core of curricula: theoretical, methodological and interdisciplinary"* (ISIPE, 2014).

Neo-liberal capitalism

It may be a surprise to learn that the European Union is not a true democracy but a corporate oligarchy (see Chapter 1.15 Conclusion). Naturally, there are democratic elections for the members of the European Parliament, however, once elected they are very heavily lobbied by company lobbyists of which there are about 30,000 in Brussels. Meanwhile there are about 31,000 people working in the European Parliament itself, including the MEPS. It is estimated that corporate lobbying influences 75% of European legislation. "Lobbying is a billion-euro industry in Brussels" (Traynor, 2014). Consequently, it is the biggest and most powerful corporations who have consistently manipulated the EU for their benefit.

In the early -80s when the EU was somewhat in the doldrums a group of seventeen industrialist leaders got together to tell the politicians what they wanted. They are the European Round Table or ERT and in 1983 they bribed the European politicians into fulfilling their economic wishes (Balanya, et al, 2003; Moser, Dhoet, Lietaert, & Hoedeman, 2013) with the threat that otherwise they would take their business outside Europe.

The wishes of the ERT were those which today characterize what is called neo-liberal capitalism (see Chapter 1.15, Conclusion). In the early -80s Thatcher and Regan wanted the same conditions supported by the economists with their growing faith in the free market economy. The European Union therefore adopted:

- a liberal single or free market.
- monetary union.
- deregulation of the financial markets.
- rolling back of member states' powers to minimize government control of commercial activity.
- national austerity measures.
- the reduction in public spending, (i.e. government spending) supporting social welfare, healthcare, pension provision, education, etc.
- privatization.
- flexible labour markets.

(Balanya, et al, 2003; Moser, Dhoet, Lietaert, & Hoedeman, 2013).

It was thought that encouraging "full blown capitalism" would bring:

- low unemployment.
- inflation control.
- high economic growth.

It hasn't.

- It was thought too that privatization was a more efficient, and profitable way of managing publicly owned utilities and reduce their costs etc. such as water, transport, electricity etc. This has not been the case. They have become more expensive in order to provide profits for shareholders.
- It was also thought that by encouraging private enterprise and for people to become richer, that profits and finance would 'trickle down' to enrichen the lower echelons of society. This has also not been the case. The lower echelons of society have become poorer. The metaphor used was that as the economic water level would rise then it would take everyone with it. It didn't (Chang, 2010). As is well known, the rich have become very rich and the poor have become poorer.

Growth is measured by Gross Domestic Product, or GDP, which as we have written elsewhere (q.v. Glossary: GDP and Chapters 12, Poverty and Chapter 1.15 *Conclusion*) is a flawed measure of economic productivity. The World Bank (2014) defines *"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources."* Consequently, by adhering to this blatant distortion of profit and GDP, the World Bank is a driver of ecosystem and environmental destruction on the planet. A fact confirmed by Herman Daly who was employed by the World Bank as a senior economist when the 1992 World Development Report was being prepared. Daly "*… suggested we draw a big circle around the economy and label it "ecosystem". Then it would be clear that the inputs represented resources taken from the ecosystem, and the outputs represented waste returned to it as pollution. This would allow us to raise fundamental questions, such as how big the economy can get before it overwhelms the total system … In the third draft, the diagram was gone. The idea that economic growth should be constrained by the environment was too much for the World Bank in 1992, and still is today*" (Daly, 2008). Most dangerously, politicians and mainstream economist's continue to regard resources and growth as infinite despite the fact we all live on a finite planet. However, there are other economists who are warning that *"Economic indicators that omit the depletion and degradation of natural resources and ecosystems are misleading"* (Barbier, 2014). Barbier's logic is unarguable for anyone living on a finite planet: *"If we use up more natural capital to produce economic output today, then we have less for production tomorrow.*

At the same time, we are also squandering valuable ecological capital – ecosystems provide important goods and services to the economy, such as recreation, flood protection, nutrient uptake, erosion control, water purification and carbon sequestration. By converting and degrading ecosystems, we are depreciating this important ecological capital endowment. Economic indicators change dramatically when the depletion and degradation of natural resources and ecosystems are accounted for" (Barbier, 2014). Rare words indeed from an economist! Prof. Barbier is professor of economics at the University of Wyoming.

Today we can recognize that neo-liberal capitalism has profoundly failed (despite that many politicians, such as David Cameron, the British prime minister, and their firm adherence to it) because it has:

- slowed economic growth,

- greatly increased inequality,
- increased unemployment,
- created more instability,
- made society more unpleasant to live in, (Dr Ha-Joon Chang in program by Chakrabortty, 2015; Chang, 2010)
- and is destroying the natural capital and the ecosystems on which our survival depends (see Glossary: Natural Capital).

The ISIPE initiative to substantially revise the economic curriculum and to integrate real world factors such as waste, sustainability, resources, and how money, banks and debt function is to be praised. We can all hope that this action by the world's economics' students will make a substantial contribution to securing both a safer, and sustainable future.

Meanwhile, *"Ahead of this week's annual meeting of the World Economic Forum in the ski resort of Davos, the anti-poverty charity Oxfam said it would use its high-profile role at the gathering to demand urgent action to narrow the gap between rich and poor. The charity's research, published today [19 Jan, 2015], shows that the share of the world's wealth owned by the best-off 1% has increased from 44% in 2009 to 48% in 2014, while the least well-off 80% currently own just 5.5%. Oxfam added that on current trends the richest 1% would own more than 50% of the world's wealth by 2016. Winnie Byanyima, executive director of Oxfam International and one of the six co-chairs at this year's WEF, said the increased concentration of wealth seen since the deep recession of 2008-09 was dangerous and needed to be reversed ... .*

Oxfam said it was calling on governments to adopt a seven point plan:

- *Clamp down on tax dodging by corporations and rich individuals.*
- *Invest in universal, free public services such as health and education.*
- *Share the tax burden fairly, shifting taxation from labour and consumption towards capital and wealth.*
- *Introduce minimum wages and move towards a living wage for all workers.*
- *Introduce equal pay legislation and promote economic policies to give women a fair deal.*
- *Ensure adequate safety-nets for the poorest, including a minimum-income guarantee.*
- *Agree a global goal to tackle inequality.*

Speaking to the Guardian, Byanyima added: "Extreme inequality is not just an accident or a natural rule of economics. It is the result of policies and with different policies it can be reduced. I am optimistic that there will be change" (Elliott & Pilkington, 2015).

The unsustainability of the concentration of so much wealth owned by so few is that the wealthiest lobby politicians for unsustainable legislation. This has happened in the US where billions of dollars was spent by industrialists and the fossil fuel industry to create the counter climate change movement (Brulle, 2013) and hinder legislation that would have regulated the fossil fuel industry. Meanwhile, in Europe, lobbying has been conducted against implementing legislation to reduce pollution and increase recycling! (Neslen, 2014).

"Oxfam said the wealth of the richest 80 doubled in cash terms between 2009 and 2014, and that there was an increasing tendency for wealth to be inherited and to be used as a lobbying tool by the rich to further their own interests. It noted that more than a third of the 1,645 billionaires listed by Forbes inherited some or all of their riches, while 20% have interests in the financial and insurance sectors, a group which saw their cash wealth increase by 11% in the 12 months to March 2014. These sectors spent \$550m lobbying policymakers in Washington and Brussels during 2013. During the 2012 US election cycle alone, the financial sector provided \$571m in campaign contributions" (Elliott & Pilkington, 2015).

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NOTES

Dr Ha-Joon Chang, teaches economics at Cambridge. “He won the Wassily Leontief Prize for advancing the frontiers of economic thought and is a vocal critic of the failures of our current economic system” and has written two excellent introductions to economics:

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... and another important book provides further elucidation:

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25.43 Ecosystems Services

(q.v. Ecosystems, TEEB, Sixth Extinction)

Ecosystem services are the services which nature's ecosystems provide us with and on which humankind's continued survival depends. Ecosystem services are an anthropocentric way of considering Nature, but nonetheless, helpful in creating a greater awareness of the need to care for Nature rather than merely exploiting it. Furthermore, it leads to placing a financial value on what Nature provides (q.v. The Economics of Ecosystems and Biodiversity – TEEB).

"This phrase was introduced by the biologist Paul Ehrlich and his colleagues in 1974 to acknowledge that an ecosystem was more than a place where biologists could study biodiversity. Ehrlich, like Eugene Odum, viewed ecosystems as local regulators of climate, water, and chemical resources. "Ecosystem services" is a valued term when used in this local sense about an ecosystem such as a tropical forest, but is less useful when applied globally because on a planetary scale geophysical and biological forces are strongly coupled" (Lovelock, 2009).

Ecosystem services are organized into four major categories following an intensive study by over a thousand scientists and published as *'Ecosystems and Human well-being'* (Millenium Ecosystem Assessment 2005). The first finding of the Assessment was that *"Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth"* (Millenium Ecosystem Assessment, 2005).

The statistics for the human impact on the World's ecosystems makes for dismal reading. European farming practices have caused devastating declines in bird populations of 50% between 1980 to 2009 in Europe. The total population fall is estimated to be from 600 million to 300 million caused by removing hedgerows, draining wetlands and ploughing up meadows (McKie, 2012). One in five invertebrates are at risk of extinction and invertebrates are believed to represent 99% of the Earth's biodiversity (Anon, 2012). Furthermore, about half the species of amphibians are in decline with a third threatened with extinction (Ruz, 2011). These three examples illustrate our dilemma and it is no surprise that biologists refer to the current era as the sixth extinction (q.v.), the last being the demise of the dinosaurs, 65 million years ago. In 2014, the World Wildlife Fund reported that: *"Biodiversity is declining sharply, while our demands on nature are unsustainable and increasing. Species' populations [of vertebrates] worldwide have declined 52 per cent since 1970."*

It is the diversity of species and their interactions with each other and their environment which form ecosystems. However, as already indicated by Lovelock, on a global scale, ecosystems play essential roles in the fluxes and cycles of elements and nutrients such as water, carbon, nitrogen, etc. interacting with the geophysical forces, the oceans and the weather.

Humankind now finds itself on the cusp of a dilemma because agriculture depends on ecosystem services and yet must produce 70% more food for the extra 2 billion expected by 2050 (Ehrlich & Ehrlich, 2013) but without reducing the ecosystem services on which agriculture and ourselves are dependent. One dilemma illustrates the problem: pollination. Bees perform about 80% of insect pollination – an ecosystem service (Gill, et al 2012). Meanwhile in the USA alone 59 million hectares (Stokstad, 2012) are protected by systemic insecticides; neurotoxins such as neonicotinoids which have been demonstrated to substantially inhibit bumblebee queen production leading to falling numbers. One question for achieving a sustainable future is how can powerful multinational companies be induced to produce products which do not poison and harm the ecosystems on which we all depend. Ecosystem services are categorized into four groups:

1. Provisioning Services

Includes products obtained from ecosystems which are essential for nourishment, health, warmth and shelter:

- freshwater
- food
- fuel
- wood
- fiber
- medicines

2. Regulating Services

Regulating services maintain and stabilize the environment:

- climate regulation (sequestering CO_2)
- cleaning the air
- purifying water
- disease regulation
- mitigating floods
- controlling erosion
- detoxifying soils

3. Cultural Services

Nature provides every culture with benefits and substantial influences ranging from inspiration for belief systems, decoration, myths, bionics, etc.:

- aesthetics
- intellectual stimulation
- spiritual values
- a sense of place
- recreation
- education

4. Supporting Services

Supporting services are those on which the other services and everything else depends:

- soil formation
- photosynthesis providing primary productivity also known as net primary productivity (NPP)
- nutrient cycling
- pollination

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25.44 Ecosystems

(q.v. Ecology, Gaia, Circular economy, Ecosystem Services)

Definitions:

We quote several definitions for the term 'ecosystem' of varying complexity in order to present its essential character. We favour the definition by James Lovelock.

- *"A community of organisms and its physical environment."* (Chapman & Reiss, 1994)
- *"A community in which energy and matter are transferred in complex interactions between the environment and organisms."* (Byrne, 1997)
- *"A holistic concept of the plants, the animals habitually associated with them and all the physical and chemical components of the immediate*

environment or habitat which together form a recognizable self contained entity. The concept is due to Tansley (1935)" (Begon, Harper & Townsend, 2000).

› *"Conventional science defines an ecosystem as a stable, self-perpetuating system, composed of a community of living organisms and their non-living environment. According to this view, organisms do not alter their environment, they merely adapt to it. The Gaian view of an ecosystem, however, sees the two components of the system, the living and the non-living, as two tightly coupled interactive forces each shaping and affecting the other"* (Lovelock, 1991).

We can identify from these definitions the independent character of an ecosystem which provides a clear model for achieving sustainability. Namely, a self-sustaining system. Currently, the world's cultures are far from an ecosystem organization. This is because too many of our thought processes and activities are linear and not cyclical as are nature's ecosystems. Nature produces no waste, no pollution – all is reused somehow, somewhere, sometime.

Many people have made a start towards recycling with their paper, glass and tins-however this is not enough. The design strategy of the circular economy (popularly known as 'cradle-to-cradle' (qv)) is becoming more familiar and is an approach which requires new infrastructures some of which are being implemented, albeit too slowly.

However, we need to move beyond mere design strategies to a philosophy that everything we use and need during our lives is merely borrowed. Borrowing implicitly obligates us to return everything.

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25.45 En-Riching Sustainability Stars

(accessed at: http://enrichlist.org/the-list/)

The (En)Rich List celebrates a wealth of inspirational individuals whose contributions have enriched paths to sustainable futures through their lives and writings. The (En)rich list includes a 100 individuals but here we include only 10 of them. The list provides an invaluable opening to understanding who is doing what towards achieving a sustainable future as well as identifying key authors. This text is cited from the web page of the En/Rich list.

E. F. Schumacher
An internationally influential economic thinker, statistician and economist best known for his critique of Western economies and his proposals for human-scale, decentralized and appropriate technologies.
Fields of contribution: Economics, Environment/Sustainability, Technology

Herman Daly
The 'intellectual father' of Ecological Economics and the steady state economy, and founder of the journal Ecological Economics.
Fields of contribution: Economics, Environment/Sustainability,

Donella Meadows
Team member of MIT's Club of Rome, co-author of Limits to Growth, founder of the Sustainability Institute and co-founder of the Balaton Group.
Fields of contribution: Environment/Sustainability, Systems Thinking

Rob Hopkins
Author, speaker, activist, educator, and co-founder of Transition Town Totnes and of the Transition Network.
Fields of contribution: Community Development, Environment/Sustainability

Serge Latouche
Professor Emeritus at the University of Paris-Sud, the main intellectual force behind the popularization of the Décroissance (Degrowth) Movement, and author of 'Farewell to Growth'.
Fields of contribution: Economics, Environment/Sustainability, Social Justice

Tim Jackson
Professor of Sustainable Development, Economics Commissioner of UK Sustainable Development Commission, TED Speaker, and author of "Prosperity without Growth".
Fields of contribution: Environment/Sustainability, Wllbeing

Vandana Shiva
Environmental activist, philosopher, a major figure in the eco-feminist movement, author of over 20 books and other works critiquing the corporatization of the global food system.
Fields of contribution: Environment/Sustainability, Feminism, Food/Agriculture, Social Justice

Bill McKibben
Author, activist and environmentalist. Founder of the 350.org movement for addressing climate change.
Fields of contribution: Activism, Environment/Sustainability

Mahatma Gandhi
Political and ideological leader, foregrounded non-violence activist tools and led campaigns for easing poverty, expanding women's rights, ending untouchability and increasing economic self-reliance.
Fields of contribution: Ethics, Food/Agriculture, Politics, Social Justice, Ethics

Bill Mollison
Researcher, author, scientist, teacher and naturalist who, along with David Holmgren, is considered to be the 'father of permaculture'; founded The Permaculture Institute in Tasmania.
Fields of contribution: Education, Environment/Sustainability, Food/Agriculture

Source

http://enrichlist.org/the-list/
http://enrichlist.org/the-complete-list/#.VY5vhijEPzI

25.46 End-of-pipe-treatment (EOP)

(q.v. fracking, externalities)

Manufacturing and industrial processes create streams of polluting wastes. The removal and cleaning of the pollutants from these streams (which can be of air, water and waste) is known as *"end-of-pipe treatment"*. For example, during 'fracking,' (the extraction of natural gas by pumping a high pressure cocktail of millions of liters of water and toxic chemicals deep into geological strata) some of the toxic cocktail of water and chemicals returns to the surface. This waste fluid now has to be treated and managed so as not to cause pollution. This is *"End-of the-pipe-treatment"* (or end of process) and if unmanaged and untreated causes environmental destruction.

In manufacturing *"end-of the-pipe"* solutions can be resolved by redesigning the production process by introducing "upstream" non-polluting procedures. This can add extra costs to the production process and the product. Unfortunately, in the past many industries have acquired the habit of not considering their wastes finding somewhere to dump them at little or no cost to themselves but at a cost to nature. The move now is towards cleaner production benefiting both the environment, nature and society.

In 2008 Trucost, the environmental data agency, calculated that the top 3000 publicly quoted companies damaged or destroyed the environment (externalities) through pollution and other activities to a value of $2.2 trillion (Jowit, 2010). Today (Trucost, 2013) industrial activity destroys and pollutes the environment at an estimated value of $4.7 trillion.

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25.47 Environmental Ethics

(q.v. Cyclical Economy, Walter Stahel, Deep Ecology, Borrowing)

We all (except many politicians and economists) recognize the logic that our Earth and its resources are finite. This was never so more confirmed than by the photo taken by the Apollo 8 astronaut team which has become known as Earthrise, *"Apollo 8, the first manned mission to the moon, entered lunar orbit on Christmas Eve, Dec. 24, 1968. That evening, the astronauts-Commander Frank Borman, Command Module Pilot Jim Lovell, and Lunar Module Pilot William Anders-held a live broadcast from lunar orbit, in which they showed pictures of the Earth and moon as seen from their spacecraft. Said Lovell, "The vast loneliness is awe-inspiring and it makes you realize just what you have back there on Earth""* (Dunbar, 2013).

In 1948, the British astronomer, Fred Hoyle, is attributed with saying that: *"Once a photograph of the earth, taken from outside, is available – once the sheer isolation of the earth becomes plain, a new idea as powerful as any in history will be let loose"* (Clayton, 2009).

What can environmental ethics mean? Prof Andrew Brennan (2008) of La Trobe University, writing on The Stanford Encyclopaedia of Philosophy website provides a definition that: *"Environmental ethics is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its nonhuman contents."*

In the new paradigm (Chapter 2) we can now recognize that as designers our choice and use of *("the environment and its nonhuman contents")* materials and resources is imbued with an ethical, moral responsibility. We are like children in a kindergarten playing with toys, we learn not to damage or destroy them because we also learn that they are not only there for us to share with others, but they are also there for those who come after us in a year of two. The Earth and its resources are the same because they are finite and we must share them with others and when we leave the planet we must ensure that there is no less for others to use as when we arrived. Therefore, the cyclical economy is a moral imperative and Nature provides the model that we must also adopt since it produces neither pollution nor waste. Design that wastes resources so that products, etc. end in landfill and waste dumps is immoral. Perhaps the problem with re-cycling is that it does not communicate an ethical value. However, if we consider that we borrow the Earth's resources for the short duration of our visit (life) then we are morally obliged to return what we use so that it is available for others. In fact designers borrow the Earth's resources to create their designs and so they are ethically obligated to ensure that the materials they specify can be re-cycled.

In a Youtube presentation, *The neglected environment*, Prof Brennan (2011) reports on recent research investigating human behaviour and environmental destruction. Social survey work reveals a clear correlation between environmental destruction and the monotheistic religions: Christianity, Islam and Judaism. The stronger the commitment to a monotheistic religion then the less concern there is for environmental care.

The global environmental crisis is largely a problem created by the developed nations of the so-called west, exacerbated by their belief in their own development and growth. Technologically they may indeed be the developed nations of the world, however, the economics and politics of the developed nations is motivated by greed. There are many other peoples (often perceived of as being less developed) on the Earth who possess environmental philosophies from which the developed nations could learn much. Baird Callicott (1997) in his book *"Earth's Insights widens the scope of environmental ethics to include the ecological teachings embedded in non-Western worldviews. J. Baird Callicott ranges broadly, exploring the sacred texts of Islam, Hinduism, Jainism, Taoism, Confucianism, and Zen Buddhism, as well as the oral traditions of Polynesia, North and South America, and Australia. He also documents the attempts of various peoples to put their environmental ethics into practice. Finally, he wrestles with a question of vital importance to all people sharing the fate of this small planet: How can the world's many and diverse environmental philosophies be brought together in a complementary and consistent whole?"* Google Books (2012).

The answer to this question of diverse environmental philosophies is to ever more closely observe nature, something which many indigenous cultures have done for centuries, if not millenia. The biologist, David Barash wrote that in Zen we find *"the interdependence and thus unity of all things, and the consequent artificiality of 'dualistic' thought patterns"* (Barash,1972; Callicott, 1997).

"To be Zuni is to know that we are children of Mother Earth and Father Sky and that we are the guardians of the heart of Mother Earth." Calbert Seciwa, Director, American Indian Institute, Arizona State University, 1999, (exhibit caption, Heard Museum. Phoenix).

Homeland: *"What I see is my home. I don't own it but it's home – the river, the trees, the birds that fly, they're all mine."* Estefanita Martinez, San Juan, (exhibit caption, Heard Museum. Phoenix).

"We see ourselves as caretakers of that piece of the earth that we use. We have respect for the heavens, the stars, the moon, the sun and nature itself, the clouds, rain,

snow. What makes us whole is to recognize and respect all these things and their seasons. We live on a definite calendar, planting season, Katsina season, Home Dance, are all dictated to us by Mother Nature." Albert Sinquah, Sr., Hopi-Tewy, (exhibit caption, Heard Museum. Phoenix).

For the Hopi people *"Corn is a staple food, deeply entwined with the way of life and a value system that prizes virtues of humility, respect, caring for others and for the earth."* (exhibit caption, Heard Museum. Phoenix).

"We are the Cocopah! I am here and own this land with my heart." Hope Miller, Cocopah, 1993 (exhibit caption, Heard Museum. Phoenix).

In conclusion, *"As Lewis (1989) comments "It is difficult for people from 'advanced' cultures to accept the idea that people from 'primitive' cultures might know something scientifically significant, or even more about a subject …""* (Berkes,1999).

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25.48 Exponential growth or curve

(q.v. Dashboard for Sustainability, Planetary Boundaries, Ecological Economics)

Mathematically an exponential curve occurs where a quantity grows by being multiplied by the same value at regular intervals. More simply it appears like the now familiar "hockey stick" (Mann, 2013) curve of increasing CO_2 content in the atmosphere from anthropogenic emissions.

In October 2008 New Scientist devoted an issue to economics and published a graph over a double page spread. The horizontal (x) axis showed a time span from 1750 to the year 2000, the vertical (y) axis displayed the quantity and graphed the growth, increase or progress of:

- Population
- CO_2 concentration in the atmosphere
- average surface temperature in the Northern Hemisphere
- Gross Domestic Product
- Loss of tropical rainforest and woodland
- Species extinctions
- Water use
- Motor vehicle production
- Paper consumption
- Fisheries exploitation
- Foreign investment
- Ozone depletion

All of the parameters listed displayed an exponential curve over time. Although the situation is dazzlingly untenable, politicians and economists remain unable to recognize the world's finiteness and blindly keep on persuing economic growth. *"Economists see no limits to growth – ever."* (New Scientist, 2008)

This correspondence between the different demands human beings make on the planet has been called the 'Great Acceleration' (Steffen, 2015)and it is very dangerous because these exponential curves confirm that we are increasingly rapidly approaching the exhaustion of the Earth's resources.

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25.49 Externalities

(q.v. Climate Change, Schesiology, Planetary Boundaries)

An externality is defined as *"A consequence of an economic activity that is experienced by unrelated parties. An externality can be either positive or negative.*

… An example of a positive externality is the effect of a well-educated labor force on the productivity of a company."

Externalities are often difficult to anticipate due to the lack of knowledge about how the Earth as a system functions and the consequences of disturbed interdependencies are unforeseeable. Meanwhile, many problems have been anticipated but the motivation is absent to take action particularly in the case of the externalities caused by greenhouse gases. Many of these externalities are the problems which threaten a sustainable future. For example:

Greenhouse gas emissions (ghg) cause global warming and the externalities …

› of melting the glaciers and disturbing the water supply to farmers in the Andes.
› of rising sea-levels threatening the Tuvalu Islands in the Pacific with submersion forcing the inhabitants to become eco-refugees.
› of acidification of the oceans contributing to the demise of coral reefs and the loss of fisheries supported by those reefs.
› of melting the permafrost around the Arctic circle causing buildings to tilt and sink into the ground making them uninhabitable.
› of increasing desertification causing farmers to leave their land.
› of melting the methane hydrates in the ocean floors which will further exacerbate global warming since methane is a ghg 105 times more effective than CO_2 in causing warming.
› etc.

Source

(www.investopedia.com/terms/e/externality.asp)

25.50 Factor Four and Five

(q.v. Club of Rome)

The report *Factor Four, doubling wealth, halving resource use* was published in 1998 for the Club of Rome and written by Ernst von Weizsäcker, Amory Lovins and Hunter Lovins. The book showcases 50 examples of best practice in making major savings of raw materials and energy. They claim that it is possible with their one fourth strategy to double the global living standard and halve our use of resources. The authors also observe that due to our overuse of the Earth's resources, we are creating an enormous amount of waste and at a financial cost of $10 trillion every year. The reasons for being so wasteful include:

› the inertia reinforced by the current education system.
› vested interests in maintaining the status quo.
› inaccurate pricing that omit costs to society, the environment and future generations.
› political preference for centralized projects and organization.
› etc.

The authors describe seven advantages for improving efficiency:

› Improvement in the quality of life.
› Less depletion of resources and less pollution.
› Resource efficiency would increase profits.
› Market forces and innovative policy structures could help to drive resource efficiency.
› Multiply the use of scarce capital by reinvesting the money saved by resource efficiency.
› Resource scarcity can be driven by international conflict.
› Resource efficiency could generate more employment. (Visser, 2009)

In conclusion resource productivity should grow fourfold resulting in less waste were the problem approached holistically any systemically rather than disjointedly, *'the book is about doing more with less.'*

Factor Five: transforming the global economy through 80% improvements in resource productivity: Ernst von Weizsäcker, together with a team of colleagues, produced a follow up report to the Club of Rome entitled Factor Five published about a decade later. They write that while some progress has been made since the publication of *Factor Four "overall not enough has been done to capture such opportunities [i.e. as described in*

Factor Four] on a meaningful scale. Now that scientists are clearly warning that rapid action on climate change and environmental sustainability is needed, it is imperative that the coming decades see a significant improvement in resource productivity as part of a broader sustainable development agenda. This is the focus of this new report to the Club of Rome, Factor Five; transforming the global economy through 80% improvements in resource productivity, led by one of the world's leading sustainable development experts, and supported by a team of young engineers and scientists dedicated to a sustainable future. The work draws from a growing number of dedicated efforts from across various sectors around the world. It shows that by taking an integrated whole systems approach, 80 per cent improvements in resource productivity can and are being used.

Spanning dozens of countries and examining many cases of innovation in design, technology and policy, the book tackles sustainable development and climate change by providing in-depth studies covering residential and commercial buildings, the cement and steel industries, agriculture and the transportation sector. The book is further supported by additional online Sector Studies" (see Sources below).

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25.51 "First things first"

(q.v. Environmental Ethics, Consumerism)

'First things first' was a design manifesto published in the January issue of the journal Design in 1964. It was organized by the renown British designer Ken Garland, and must be about one of the first appeals for sensible, if not sustainable design, quote:

"A Manifesto

We, the undersigned, are graphic designers, photographers and students who have been brought up in a world in which the techniques and apparatus of advertising have persistently been presented to us as the most lucrative, effective and desirable means of using our talents. We have been bombarded with publications devoted to this belief, applauding the work of those who have flogged their skill and imagination to sell such things as:

cat food, stomach powders, detergent, hair restorer, striped toothpaste, aftershave lotion, beforeshave lotion, slimming diets, fattening diets, deodorants, fizzy water, cigarettes, roll-ons, pull-ons and slip ons.

By far the greatest time and effort of those working in the advertising industry are wasted on these trivial purposes, which contribute little or nothing to our national prosperity.

In common with an increasing number of the general public, we have reached a saturation point at which the high pitched scream of consumer selling is no more than sheer noise. We think that there are other things more worth using our skill and experience on. There are signs for streets and buildings, books and periodicals, catalogues, instructional manuals, industrial photography, educational aids, films, television features, scientific and industrial publications and all other media through which we promote our trade, our education, our culture and our greater awareness of the world.

We do not advocate the abolition of high pressure consumer advertising: this is not feasible. Nor do we want to take any of the fun out of life. But we are proposing a reversal of priorities in favour of the more useful and more lasting forms of communication. We hope that our society will tire of gimick merchants, status salesmen and hidden persuaders, and that the prior call on our skills will be for worthwhile purposes. With this in mind, we propose to share our experience and opinions, and to make them available to colleagues, students and others who may be interested.

Edward Wright, Brian Grimbly, Gerry Cinamon, Geoffrey White, John Garner, Robert Chapman, William Slack, Ken Garland, Ray Carpenter, Caroline Rawlence, Anthony Froshaug, Ken Briggs, Ian McLaren, Robin Fior, Sam Lambert, Germano Facetti, Ivor Kamlish, Ivan Dodd, Gerald Jones, Harriet Crowder, Bernard Higton, Anthony Clift

Published by Ken Garland, 13 Oakley Square, London N4

The phrase "hidden persuaders" is a noteworthy reference to Vance Packard's book entitled, The Hidden Persuaders revealing the work of "American super-advertising-scientists." Vance Packard went on to write The Status Seekers describing how, during the 1950s Americans were improving their status and living "up to the Joneses" through symbolic consumerism. Packard went on to write "The waste makers" describing planned obsolescence and revealing how "cars or furniture or washing machines are made either not to last or put out of fashion by the styling of next years model." Although Vance Packard may not be so well known today he revealed the vacuous waste of consumerism as Rachel Carson revealed the toxicity of agriculture. Both Carson and Packard deserve to remain on curriculum reading lists and to be read for their foresight concerning the dangers that western culture has now brought to its people.

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25.52 Friends of the Earth

(q.v. 1970, + / - 1 year, Externalities, Greenpeace)

In 1969, an offshore oil spill in Santa Barbara, was the initial catalyst for an organization concerned with the environment (1.). However, internal differences about confronting nuclear issues resulted in David Brower leaving the Sierra Club (concerned with protecting USA's mountainous wild regions) to set up a new organization. Brower wanted it to operate internationally and so it was that in 1971 'environmentalists' from Great Britain, France, the USA and Sweden met in Roslagen, Sweden, and founded *Friends of the Earth International* (2.).

The Friends of the Earth international today describe what they do on their web page (at: http://www.foei.org/). *"We campaign on today's most urgent environmental and social issues. We challenge the current model of economic and corporate globalization, and promote solutions that will help to create environmentally sustainable and socially just societies."* Their concerns include climate and energy, economic justice, food sovereignty, forests and biodiversity and the defence of human rights. Their motto is to *mobilize, resist and transform.*

FoEi claims that they *"are the world's largest grassroots environmental network, uniting 73 national member groups and some 5,000 local activist groups on every continent. With over 2 million members and supporters around the world, …"* (http://www.foei.org/about-foei/) and they are active on every continent.

In June 2014, through their successful campaign work the *"Friends of the Earth International and other social movements celebrate a great and long awaited victory that challenges corporate power and starts responding to environmental defenders demands. The time had finally come to move forward from voluntary guidelines for business on human rights to a legal framework to bring transnational corporations to justice for their human right violations …*

Friends of the Earth International was part of this historic achievement. It has worked with the Treaty Alliance on advocacy work in Geneva and in the most important capitals in the EU, South Africa, Costa Rica, Mexico, Brazil and others. On the Week of Mobilization organized by Swiss NGOs and the Campaign to Dismantle Corporate Power, Friends of the Earth groups from Europe, Nigeria, Uruguay, Palestine, Guatemala, Brazil and the Real World Radio presented cases at the special session of the Peoples Permanent Tribunal, side events and street protests, denouncing human right abuses by TNCs such as Shell, Mekorot, Hidralia, Philip Morris and FIFA."

The deregulation that is a feature of neo-liberal capitalism has enabled transnational corporations (TNCs) to create profits with impunity regardless of both human and environmental welfare. The externalities of TNCs contribute to ecosystem pollution and destruction, species extinctions, and even cultural genocide (Lenzen, et al. 2012; Trucost, 2013).

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(1.) accessed at: http://www.foe.org/about-us/achievements)

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25.53 Erich Fromm: to be or to have

(q.v. The Kogi, Bhutan, Consumerism & the Ladakh)

In 1976, Erich Fromm (1900 - 1980) was interviewed by Robert Robertson, the presenter of the BBC's The Book Program, about Fromm's book "To have or to be."

In his book Fromm identifies the dichotomy of having and being. Fromm proposes that people use two styles of identity to demonstrate who they are, these are:

I am what I have, what I possess

The mode of a person's identity is concerned with what they possess and consequently, they always have a purpose which is to have more. However, the question arises *'What am I if I loose what I have?'* and consequently, people may suffer enormously if they loose their possessions because in their own eyes they become nothing and loose their sense of self and worth.

I am what I do and what I am

A person whose identity is concerned with being, on the contrary, has no such purpose because they are happy in being. Furthermore, if their identity is concerned with being then their identity cannot be destroyed because it is based on what they have done, their actions, experiences and memories. *"Happy in being, I sit, I see the light: no purpose."* (This concept reminds one of a philosophy highly relevant to sustainability – Zen Buddhism.)

In the interview for the BBC program (1976) about his book *To have or to be?* Fromm said to the interviewer, Robert Robinson, that a similar question was posed by Marx: what is superior; things or life? Later in the interview Fromm says that he doubted the validity of Freud's concept of repression of human irrational strivings, notably sexual striving, because of the development of sexual behaviour since Freud. Rather, Fromm proposed that we are excellent at repressing the truth, a far more fundamental problem. Fromm said that: *"What we do repress is the knowledge of the truth; we know much more than we admit because if we admit to this knowledge we are in a very uncomfortable situation because then we see that most of what we hear is mere swindel, distortion, illusion and that a word of truth is rare and so we prefer to repress what we know what the truth is, what the reality is and I think that is today a much more damaging repression than the one Freud was talking about, the repression of sexual strivings."*

One can observe that Fromm's viewpoint has certainly been confirmed by many politicians, bankers and those in corporations who have attempted, for example to mislead the public by denying climate change for their own greed. If we should wonder how neo-liberal capitalism is able to cause so much destruction to the natural world then it could well be that Fromm has provided us with an explanation ... because we repress the knowledge of the truth.

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25.54 Fun theory

(q.v. nudge theory)

'Fun theory' may not sound an entirely serious idea but experiments convincingly show that it works. 'Fun theory' provides a valuable creative strategy for thinking of ways which can help people to change their behaviour which is especially valuable for both safety and sustainability. The Volkswagen company has proposed and been testing their hypothesis that "*... fun is the easiest way to change people's behaviour for the better. Be it for yourself, for the environment, or for something entirely different, the only thing that matters is that it's change for the better."*

Volkswagen (at 'thefuntheory.com) website illustrates the success of their social experiments with videos which nicely illustrate the successful application of this creative strategy, for example:

1. In order to get all car passengers to wear their safety belts the in-car entertainment system was made to only work when all the passengers are wearing their seat belts.
2. Moving escalators require a lot of energy, furthermore, it is good exercise for people to use the stairs. In order to encourage pedestrians to use stairs the VW team covered the stairs to look like a piano's keyboard under

which were sensors. When the stairs were trodden on they played notes. The result was that 66% more people used the stairs than the escalator.

3. Not enough people recycle glass and so to encourage recycling the VW team designed a bottle bank to resemble an arcade game with the result that 100 people returned bottles in the arcade-game-simulation-bottle-bank against 2 people visiting the normal bottle bank.
4. Normally drivers are fined when they are caught speeding. However, the reverse strategy of rewarding cars that travelled at the correct speed or below with a lottery win had the effect of reducing the average speed from 32 to 25 miles per hour.

The results from these and other experiments confirm that fun does change behaviour (see Chapter 2.6) and provides a strategy which could be very valuable for creating sustainable solutions.

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25.55 Gaia: the Gaia theory, the Gaia hypothesis

(q.v. Ozone Hole, Climate Change)

Gaia theory draws attention to a vital feedbacks between the organic world and the world's inanimate physico-chemical environment. Organisms alter their material environment but simultaneously their environment constrains and naturally selects organisms. Gaia theory posits that organisms have kept the Earth's surface favourably habitable for life by contributing to feedback mechanisms which help to self-regulate the Earth's environment favourable for life. Gaia theory attempts to identify and explain the origin and devlopment of these mechanisms (Lenton, 1998).

The Gaia hypothesis was first propounded by James Lovelock, an independent scientist who worked for NASA on the Mars Viking missions with the task of designing instruments for the detection of life on Mars. He also invented the electron capture detector which led to the discovery of the buildup of the chloroflourocarbons (CFCs) responsible for creating the ozone holes over both the Arctic and Antarctic.

It was during Lovelock's work at NASA that the idea for the Gaia hypothesis first developed and which he published in 1979 in his book *"Gaia: a new look at life on Earth."* Thirty years later in 2009 he published *"The vanishing face of Gaia, a final warning"* in which he also provides a revised definition of Gaia and wrote: *"James Lovelock and Lynn Margulis postulated in the early 1970s that life on Earth actively keeps the surface conditions always favorable for whatever is the contemporary ensemble of organisms. When introduced, this hypothesis was contrary to the conventional wisdom that life adapted to planetary conditions as it and they evolved in their separate ways. We now know that the hypothesis as originally stated was wrong because it is not life alone but the whole Earth system that does the regulating. The hypothesis evolved into what is now Gaia theory."*

James Lovelock continues and defines Gaia Theory as: *"A view of the Earth introduced in the 1980s that sees it as a self-regulating system made up from the totality of organisms, the surface rocks, the ocean and the atmosphere tightly coupled as an evolving system. The theory sees this system as having a goal – the regulation of surface conditions so as always to be favourable for contemporary life as possible. It is based on observations and theoretical models; it is fruitful and has made ten successful predictions."*

The Gaia hypothesis provided the stimulus which led Lovelock to discover that ocean algae, emit dimethyl sulphide, a sulphur bearing molecule. (Indeed, it has been calculated that oceanic algae emit more sulphur than all the world's power stations: 1991) Once in the atmosphere, after leaving the surface waters, sunlight acting on dimethyl sulphide transforms it into acids which form cloud condensation nuclei (CCN). These microscopic particles provide the nuclei necessary for water droplets to form which create clouds. If there are not so many CCN then fewer but larger water droplets form. However, if there is an abundance of CCN then there will be many but smaller cloud droplets which create whiter clouds. Whiter clouds reflect more of the Sun's rays back into space thereby cooling the Earth.

Therefore, if temperatures should rise algal dimethyl sulphide production and the whiteness of clouds should increase to bring about cooling. However, an ice core record from the Antarctic has provided a contrary observation although this may have been due to fast warming occurring as the Ice Age ended.

At this point it might be asked what has this to do with design and sustainability? The answer is that it illustrates the interconnectedness of our Earth and furthermore how a minute organism (but in astronomical numbers) can affect the planet. This should encourage all of us, however ineffective we may think we are to make a concerted and collective effort to live sustainably.

The Gaia hypothesis has stimulated investigations into the regulation of the Earth's environment. It is believed that the quantity of CO_2 in the Earth's atmosphere throughout its history has controlled the planet's temperature. If the Gaia theory is true then one would expect that the life should try to remove more CO_2 from the atmosphere so as to stabilize the temperature rise. Plants, bacteria and other micro-organisms remove CO_2 from the atmosphere by either taking it down into their root systems or by initiating decay. As a consequence, there is normally about forty times more CO_2 in the soil than in the air. The CO_2 in the soil contributes to the weathering of silicate minerals which occur in granite.

Initially, the Gaia theory was only a hypothesis, however, it has become a theory because the hypothesis made a number predictions about the 'behaviour' of the Earth system which have subsequently been proved to be true.

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25.56 The Global Calculator

(q.v. Dashboard for sustainability, Hockey Stick Curve)

The Global Calculator is at: http://www.globalcalculator.org/

It is an interactive dashboard and the texts below are taken from the Global Calculator's webpage:

"The Global Calculator is a free and interactive tool that helps you to understand the link between our lifestyles, the energy we use, and the consequences for our climate. It is aimed at anyone interested in exploring what a low-carbon world could look like in 2050. The Calculator shows that it is possible to prevent dangerous climate change and ensure people's living standards continue to improve if we act now."

"The Global Calculator shows that as lifestyles continue to improve while still tackling climate change, we must transform the technologies and fuels we use, and make smarter use of our limited land resources. The report: Prosperous living for the world in 2050 (PDF 1.43MB) uses evidence from the tool to show what we need to achieve."

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25.57 Global Footprint Network (GFN)

(q.v. Ecological Footprint)

The Global Footprint Network (GFN) was set up in 2003 as a non-profit organisation and NGO and works to "*accelerate the use of the Ecological Footprint – a resource accounting tool that measures how much nature we have, how much we use, and who uses what.*" Furthermore, *"The Ecological Footprint is a data-driven metric that tells us how close we are to the goal of sustainable living."* The GFN homepage enables one to not only evaluate the footprint of one's own lifestyle but also informs us that we are today using the equivalent resources of 1.5 Earths. The GFN is a valuable information source and provides useful pdfs. The following text is from the GFN's webpage:

"What we do: The Global Footprint Network provides tools and programs that can help countries thrive in a resource-constrained world. More than ever, decision-makers are employing Ecological Footprint accounting to manage their ecological capital, both now and for the future.

These programs help decision-makers recognize the impact of ecological overshoot on their own policies, investments and projects, and demonstrate that it is both in their interest and within their power to turn the tide. By proving to national governments, finance institutions, and international development agencies that they can be more successful if they operate within nature's budget, Global Footprint Network aims to foster a more stable and prosperous future.

- *Our Ten-in-Ten campaign is engaging national governments to establish the Ecological Footprint as a prominent, globally accepted metric as ubiquitous as the GDP.*
- *Our stewardship of the National Footprint Accounts is bringing new levels of scientific quality and precision to the Ecological Footprint.*
- *Our Sustainable Human Development initiative is defining what it really means to meet human needs while maintaining natural capital.*
- *Our programs for cities, businesses and financial institutions are extending the Footprint into new domains, developing new methodologies and tools and building the market for Ecological Footprinting.*
- *Our work developing international Footprint Standards is the integrity and comparability of Footprint applications worldwide.*
- *Our network of 90-plus Partners, located on six continents, is comprised of the world's leading Footprint practitioners and users and plays a vital role in guiding our research agenda and making Footprinting relevant and practical."*

(http://footprintnetwork.org/en/index.php/GFN/page/what_we_do/)

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25.58 Global Marshall Plan / Planetary Contract

(q.v. Club of Rome, Millenium Development Goals)

The Global Marshall Plan derives its name from the four year plan initiated by the USA to help restore Europe to its economic feet following the devastation of the Second World War. The Marshall Plan made a significant contribution in bringing about the economic 'miracle' in Europe following the War.

Once again, great economic disparities threaten human welfare today. Sadly, the state of the environment, poverty and distribution issues are becoming increasingly unsustainable, as also is the imbalance between cultures. Indeed, nearly half of the World's population suffers from poverty. Consequently, in 2003 a group of 16 NGOs initiated *The Global Marshall Plan* despite rapid globalization, high growth rates, and innovations being produced as never before.

Born out of the Club of Rome's ideology and principally shaped by Prof Dr Radermacher *The Global Marshall Plan / a Planetary Contract* initiative seeks to develop an international order based on partnership and cooperation (see Chapter 12 by Prof Dr Radermacher) and lead to a fair and optimal use of human and natural resources. The longer term objective is to realize a worldwide Eco-Social Market Economy but the Initiative's mid-term goals are to achieve the UN Millenium Development Goals [q.v.] by 2015.

Funding for the implementation of the *The Global Marshall Plan* was calculated at 0.7% of the gross national product of donor countries equivalent to an estimated US$ 56 billion in 2004 and US$ 190 billion by 2015. Funding was planned to take place from 2008 to 2015.

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25.59 Globalization

(q.v. Millenium Development Goals, Biodiversity, 6th extinction, wicked problems, externalities)

Globalization has been defined "*... as the world becoming more interdependent and integrated. Globalization describes the processes involved. It affects every aspect of life - economic, political, social, cultural and environmental.*" (Moynagh, M., & Worsley, R., 2008) Furthermore, it includes three key factors:

- The multiplication of networks. Due to increasingly better communications every milieu of human activity are more closely connected.
- The stretching of relationships. As a consequence of improved communications networks, everyone can easily reach all around the world be they terrorists or charities. Furthermore, consumers can buy products or components originating from anywhere on the planet.
- The intensification of human contact. Everywhere on the planet is getting nearer either virtually through digital media or in real time through worldwide transport. Everywhere people are spending more time communicating.

Globalization means that we can no longer be unaware of what is happening to people wherever they are. Consequently, design education has a responsibility to ensure that students understand the powerful possibilities that the digital technologies and globalization create in helping to solve problems beyond the design studio, not least, understanding the nature of 'wicked problems' and the problems associated with the Millenium Development goals.

The opening up of international trade and the free trade agreements '*has made it almost illegal for any country to put up any kind of environmental protections*' said Zac Goldsmith, a British MP, in an interview with the environmental journalist, John Vidal (2012). International trade is a great threat to biodiversity. This is because "*in today's increasingly globalized economy, international trade chains accelerate habitat degradation far removed from the place of consumption*" and unfortunately "*the importance of international trade as a driver of threats to species is poorly understood*" (Lenzen, et al. 2012). However, in their research Lenzen and his colleagues reveal that US imports threaten nearly 1,000 species worldwide while exports from Indonesia threatens about 180 of its endemic species. Foreign consumption threatens 70 Malaysian species and German imports threaten 18 species around the world (Lenzen, 2012). Altogether, Lenzen and his team were able to identify that 15,000 commodities produced in 187 countries threaten 25,000 animal species worldwide. Furthermore, "*30% of global species threats are due to international trade. In many developed countries, the consumption of imported coffee, tea, sugar, textiles, fish, and other manufactured items causes a biodiversity footprint that is larger abroad than at home*" (Lenzen, et al. 2012).

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25.60 Greenhouse effect, greenhouse gases

(q.v. Planetary boundaries, Anthropocene)

Two parameters create the 'greenhouse effect' which cause global warming. The first is the amount of carbon dioxide (CO_2) and other greenhouse gases (GHGs) such as methane and water vapour in the atmosphere. The second is the solar radiation reaching the Earth's surface, warming it and then reflected back into the atmosphere as infra-red radiation from the Earth's surface. The greenhouse gases are not transparent to infra-red radiation, as nitrogen and oxygen are (Kolbert, 2006) but trap the infra-red radiation rather like the glass of a greenhouse and retain some of the warmth; some of the warmth goes out into space and some back to the Earth thereby adding to the warmth within the Earth's atmosphere (Kolbert, 2006).

Low concentrations of greenhouse gases normally occur in the atmosphere and maintain a benign temperature enabling life to exist on our planet. Indeed, without greenhouse gases the Earth's temperature would be a chilly minus 15°C (Walker & King, 2008). Today, however, mankind's activities are dangerously increasing the emissions of greenhouse gases into the atmosphere which are retaining the Sun's warmth in the Earth's atmosphere.

Scientists measure the CO_2 content of the atmosphere in parts per million (ppm) and pre-industrial levels of CO_2 up to about 1900 were in the benign range of 260-290 ppm. The scientist Charles Keeling (1928-2005) (Heimann, 2005) began long term measurements of the atmosphere's CO_2 content in 1957 at the South Pole and also in the Pacific; the first results of his work in 1958 recorded CO_2 levels of 316 ppm (Nisbet, 2007). In order to ensure the credibility of his work Keeling continued to make measurements at the Mauna Loa Observatory on Hawaii far away from all center's of industry. The results from both the South Pole and Hawaii corresponded perfectly. However, the more detailed Hawaiian measurements also showed an annual rise and fall creating a saw edged contour which closely corresponded to the polar record (Keeling,2008). The saw edged fall and rise was due to the spring uptake of CO_2 by plants causing a small drop and the autumn/winter break down of photosynthesized biomass causing a release of carbon.

It is surprising that for his patient and highly significant work Keeling was not recognized with a Nobel prize because his work is generally acknowledged as one of the highest scientific achievements of twentieth century science. The graph he recorded is known as the famous 'Keeling curve' or more popularly the 'hockeystick curve' (Mann, 2013).

The CO_2 levels of 316 ppm recorded in 1958 had reached 384 ppm by March 2007 and by May 2008 387ppm. 2008 was followed by record emissions for the successive years 2010-2011 (Science, 2011; Science, 2012). In 2009 the economic crisis caused a drop in emissions (Nature, 2011).

CO_2 has been attributed with a global warming potential (GWP) of 1 and other greenhouse gases are scaled to CO_2. It was initially thought that methane (CH_4) had a GWP of about 20 times of CO_2 (Weart, 2003), however, recent research by Drew Shindell and his colleagues confirm that CH_4 has a much stronger GWP especially when aerosols are also present in the atmosphere. CH_4 without the presence of aerosols has a GWP of 79 and a GWP of 105 with aerosols. Aersols are normally present in the atmosphere from a variety of sources of both natural and anthropogenic origin.

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25.61 Greenpeace

(q.v. 1970, + / - 1 year, Friends of the Earth)

The world renown organisation Greenpeace was founded in 1970-71. The USA was planning to carry out a second nuclear weapons test on one of the Aleutian Islands called Amchitka. A group of environmental activists planned to sail into the testing zone so as to hinder the test. In 1970 they organised a pop concert to raise funds for the purchase of a boat, but on its voyage to Amchitka it was unfortunately intercepted by the US navy. Although, at the time it seemed that the voyage was a disaster the action, nonetheless, caused a public stir. The boat was "*The Greenpeace*" and the rest of story, as they say, is history. (1.)

In 2011 Greenpeace commemorated 40 years of protecting the planet with the publication of *the Greenpeace chronicles* (2.) describing the organization's history. In addition its webpage (3.) provides a full account of its current concerns and activities. The publicity that

Greenpeace activities have achieved has made Greenpeace a household name around the world.

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25.62 Gross Domestic Product (GDP)

(q.v. Club of Rome, Bhutan, Economics, Natural Capital)
Peter Stebbing (24.10.2014)

The World Bank (2014) defines *"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources."*

At a national level, the Cambridge University economist, Ha-Joon Chang (2014) writes that GDP *"... is. roughly speaking, the total monetary value of what has been produced within a country over a particular period of time – usually a year, but also a quarter ... we measure output – or product – by value added. Value added is the value of a producers output minus the intermediate inputs it has used. A bakery may earn £150,000 a year by selling bread and pastries, but if it has paid £100,000 in order to buy various intermediate inputs – raw materials (e.g., flour, butter, eggs, sugar) fuel, electricity and so on – it has only added £50,000 of value to those inputs."*

John Lanchester (2014) explains GDP a little differently and that it is *"The measure of all the goods and services produced inside a country."* However, Lanchester expands on his simple definition with an enlightening illustration: *"Imagine for a moment that you come across an unexpected ten pounds* [or dollars or ...] *... you go out and spend it all at once, on say, two pairs of woolly socks. The person from the sock shop then takes your tenner and spends it on wine, and the wine merchant spends it on tickets to see The Bitter Tears of Petra von Kant, and the owner of the cinema spends it on chocolate, and the sweet shop owner spends it on a bus ticket, and the owner of the bus company deposits it in the bank. That initial ten pounds has been spent six times, and has generated £60 of economic activity. In a sense, no one is better off; and yet, that movement of money makes everyone better off. To put it another way, that first tenner has contributed £60 to Britain's GDP. Seen in this way, GDP can be thought of as a measure not so much of size – how much money we have, how much money the economy contains – as a measure of velocity. It measures the movement of money through and around the economy; it measures activity."*

If we recall that Dr Shiva (chapter 11) said that *"if you produce what you consume, you don't produce."* We can now understand that a farming family or a national economy that is self-sufficient producing only what it needs for itself therefore has zero GDP. Self-sufficiency is incompatible with the western growth economy which is based on production in excess of its own consumption and therefore drives growth and the production of more than what we need. It is unsustainable.

Therefore, GDP is a fundamentally flawed concept for achieving a sustainable future.

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25.63 Happiness is more sustainable than consumerism: have less & be more

(q.v. Bhutan, Fromm, GDP)

The pursuit of happiness is a fundamental human goal

The UN Secretary-General Ban Ki-moon speaking at the High Level Meeting on *"Happiness and Well-being: Defining a new economic paradigm"* convened during the sixty-sixth session of the General Assembly stated that: *"Happiness may have different meanings for different people. But we can all agree that it means working to end conflict, poverty and other unfortunate conditions in which so many of our fellow human beings live."*

The Secretary General also stated that the world *"needs a new economic paradigm that recognizes the par-*

ity between the three pillars of sustainable development. Social, economic and environmental well-being are indivisible. Together they define gross global happiness." The meeting was convened following an initiative of Bhutan, a country which recognized the supremacy of national happiness over national income since the early 1970s and famously adopted the goal of Gross National Happiness instead of Gross National Product.

The General Assembly of the United Nations in its resolution 66/281 of 12 July 2012 proclaimed "*20 March the International Day of Happiness*" recognizing the relevance of happiness and well-being as universal goals and aspirations in the lives of human beings around the world and the importance of their recognition in public policy objectives.

The United Nations invites Member States, international and regional organizations, as well as civil society, including non-governmental organizations and individuals, to observe the *International Day of Happiness* in an appropriate manner, as well as through education and public awareness-raising activities.

Manfred Spitzer (2007) in a lecture given to the Cumulus Conference in Schwäbisch Gmünd, Germany, presented the psychological problem of satiation or sensory habituation and consumerism with the example of a new car. After possessing it for six months the owner has learnt all its attributes and enjoys driving, owning and possessing the 'new' car, however, after a year the owner has got used to all the 'new' car's features and maybe discovered some shortcomings. Another year later and the car's novelty has completely worn off and the owner is on the look out for a newer model, imagining how much happier he/she will be when they have it. However, the problem has as much if not more to do with the way in which the brain works, it becomes satiated or desensitized to a continuing stimulus: for example, a ticking clock is no longer heard after a while. Consequently, following satiation the brain enjoys contrast and that in every sense – it is the basis of perception. One of the drivers of style and fashion works on this principle. A 'style' which for a long time was repudiated such as wearing socks with sandals (Mowbray, 2014) can be hyped into fashion possessing no other quality than novelty and a contrast to what went before. If there has been enough promotion for the new fashion it becomes known (also a kudos factor) and acceptable despite being previously rejected. If consumerism creates little more than an ephemeral happiness, if at all, then how does this affect how we think about design?

Happiness is not a subject which receives very much attention in academia, although it underlies our daily being, whoever we are. Nonetheless, it is now receiving more attention. There is now empirical evidence which supports what creates happiness. Dr Mark Williamson, the director of Action for Happiness (2014), reports that at Action for Happiness (2014) they have identified 10 keys to a happier life, they are cited here:

"1. Do things for others

Caring about others is fundamental to our happiness. Helping other people is not only good for them; it's good for us too. It makes us happier and can help to improve our health. Giving also creates stronger connections between people and helps to build a happier society for everyone. It's not all about money - we can also give our time, ideas and energy ...

2. Connect with people

Our relationships with other people are the most important thing for our happiness. People with strong relationships are happier, healthier and live longer. Our close relationships with family and friends provide love, meaning, support and increase our feelings of self-worth. Our broader social networks bring a sense of belonging.

3. Take care of your body

Our body and mind are connected. Being active makes us happier as well as healthier. It instantly improves our mood and can even lift us out of depression. We don't all have to run marathons - there are simple things we can do to be more active each day. We can also boost our wellbeing by spending time outdoors, eating healthily, unplugging from technology and getting enough sleep. Regular exercise can lift you out of depression.

4. Notice the world around you

Have you ever felt there must be more to life? Good news – there is. And it's right here in front of us. We just need to stop and take notice. Learning to be more mindful and aware does wonders for our wellbeing, whether it's on our walk to work, in the way we eat or in our relationships. It helps us get in tune with our feelings ...

5. Keep learning

Learning affects our wellbeing in lots of positive ways. It exposes us to new ideas and helps us stay curious and engaged. It also gives us a sense of accomplishment and helps boost our self-confidence and resilience. There are many ways to learn new things throughout our lives, not just through formal qualifications. We can share a skill with friends, join a club, learn to sing, play a new sport and so much more.

6. Have goals to look forward to

Feeling good about the future is really important for our happiness. We all need goals to motivate us and these have to be challenging enough to excite us, but also achievable. If we try to attempt the impossible, this creates unnecessary stress. Choosing meaningful but realistic goals gives our lives direction and brings a sense of accomplishment and satisfaction when we achieve them.

7. Find ways to bounce back

All of us have times of stress, loss, failure or trauma in our lives. How we respond to these events has a big impact on our wellbeing. We often cannot choose what happens to us, but we can choose how we react to what happens. In practice it's not always easy, but one of the most exciting findings from recent research is that resilience, like many other life skills, can be learned.

8. Take a positive approach

Positive emotions – like joy, gratitude, contentment, inspiration and pride – don't just feel good when we experience them. They also help us perform better, broaden our perception, increase our resilience and improve our physical health. So although we need to be realistic about life's ups and downs, it helps to focus on the good aspects of any situation – the glass half full rather than the glass half empty.

9. Be comfortable with who you are

Nobody's perfect. But so often we compare a negative view of ourselves with an unrealistic view of other people. Dwelling on our flaws – what we're not rather than what we've got – makes it much harder to be happy. Learning to accept ourselves, warts and all, and being kinder to ourselves when things go wrong increases our enjoyment of life, our resilience and our wellbeing. It also helps us accept others as they are.

10. Be part of something bigger

People who have meaning and purpose in their lives are happier, feel more in control and get more out of what they do. They also experience less stress, anxiety and depression. But where do we find meaning and purpose? It might come from doing a job that makes a difference, our religious or spiritual beliefs, or our family. The answers vary for each of us but they all involve being connected to something bigger than ourselves" (Williamson, 2014).

I have no hesitation in making this extensive quote because it shows how happiness, concern for others and ourselves does not automatically require extensive consumerism. Furthermore, the State of Bhutan (q.v.) does not use Gross Domestic Product as a measure of its economy but another measure, Gross Domestic Happiness. Bhutan's strategy is based on achieving what it calls the 4 pillars of GNH (Gross National Happiness)

1. Sustainable and equitable socio-economic development
2. Conservation of the environment
3. Preservation and promotion of culture
4. Good governance

In assessing GNH, the spiritual, physical, social and the environmental health of its citizens and natural environment are taken into consideration. *"Bhutan's stark warning that the rest of the world is on an environmental and economical suicide path is starting to gain traction. Last year the UN adopted Bhutan's call for a holistic approach to development, a move endorsed by 68 countries. A UN panel is now considering ways that Bhutan's GNH model can be replicated across the globe"* (Kelly, 2012).

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25.64 Hockey Stick Curve or graph, Keeling curve

(q.v. climate change, 'Dashboard' for sustainability)

The "hockey-stick" curve is the informal name which has been given to the curved graph of the increasing concentration of carbon dioxide, CO_2 in the atmosphere due to human emissions.

CO_2 is measured in the atmosphere in parts per million (ppm). The CO_2 in the atmosphere prior to the beginning of the industrial revolution, around 1850, was about 280 ppm. Prior to that and going back to the last ice age, 20,000 years ago the CO_2 concentration in the atmosphere remained within a range of 260-290 ppm. In 1958, Charles Keeling started to measure the CO_2 concentration in the atmosphere, first in the Antarctic and then from Mauna Loa, Hawaii, in the Pacific so as to be far away from human activities. Keeling recorded an annual drop and rise reflecting the seasonal uptake of CO_2 in the summer by biomass causing atmospheric CO_2 to drop and its release from dead biomass in the winter causing a rise in the CO_2. When Keeling began his measurements, the CO_2 concentration was already about 315 ppm. Keeling persisted in his recording of CO_2 in the atmosphere and following his death measurements were continued by his son, Ralph Keeling. In 2007 CO_2 concentration had reached 383ppm and in 2013 CO_2 concentrations touched 400 ppm. Writing in 2008 Walker and King (2008) noted that there has *"not been a single moment in the past 650,000 years when carbon dioxide has been anything as high as it is today."*

The "hockey stick" curve has become a powerful icon, easy to understand and has become the red rag to the strong anti-climate change lobby (counter-climate-change movement) in the United States. The spirit of private enterprise in the USA is virtually sacrosanct and unfortunately, due in part to the cold war, those who do anything likely to inhibit private enterprise and profits are regarded as having socialist tendencies or may even be communists and are therefore to be discredited.

One scientist who has borne the brunt of political and commercial attack is Dr Michael Mann who has been at the centre of this conflict of corrupt commercial interest against scientific fact because he has done much of the science to validate the "hockey stick" curve. He has written his account of the conflict in *The Hockey Stick Wars: Dispatches from the Front Lines* (Mann, 2013). Another account by Oreskes and Conway (2010) describe how a few scientists, working for the tobacco industry, perverted the facts concerning the relationship between smoking and cancer in the interests of the tobacco companies. Similar practices were continued in refuting climate change. In addition, during the first decade of this century, large corporations invested billions of dollars (Brulle, 2013) to create the counter climate change movement aimed at obscuring the truth underlying CO_2 emissions and global warming. It has been estimated that these large corporations effectively delayed the implementation of legislation to control CO_2 emissions by a decade (Monbiot, 2006).

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25.65 The Honeybee Network

(q.v. Chapter 2.8, Afrigadget)

Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)

"SRISTI is a non-governmental organization set up to strengthen the creativity of grassroots inventors, innovators and ecopreneurs engaged in conserving biodiversity and developing eco-friendly solutions to local problems. On the SRISTI website one can read about its activities and

participate in them, download its newsletter 'honeybee' and research papers and much more …"

The Honeybee Network was set up in 1990 by Prof Anil Gupta after realizing that innovations made by many people, for example rural farmers in India, might be documented, published and disseminated for the benefit of many others. In the meantime the original creators, often uninformed of the publicity their ideas had received were unable to benefit from their innovation and remained poor despite the contribution they had made to the well-being of others. It was for this unsustainable asymmetry in the spread of innovations that Prof Gupta set up the Honeybee Network in order to ensure that the inventors were properly protected and rewarded for their "deviant research" as Prof Gupta calls their innovations.

In order to find such innovations Prof Gupta goes twice a year on long walks called "Shodh Yatra" (Sanskrit for "walk to find knowledge") throughout the farming regions of India stopping in villages and talking with the farmers. In addition local language newspapers, are contacted, multimedia presentations are used as well as other means to find deviant researchers and their inventions. Once located and their innovation examined the Honeybee Network connects them with others as well as scientists and academics who can test the invention and help in organizing business plans and patents. The Network's 'Honeybee' quarterly journal promotes both the inventors and their innovations and is published seven Indian languages (Hindi, Gujarati, Tamil, Kannada, Telugu, Malayalam and Oriya) as well as English. The *"Honeybee"* journal has been published for over 20 years and reported on over a *"100,000 ideas, innovations and traditional knowledge practices."*

The inventions range from a machine for peeling arecanuts invented by Narsimha Bhandari (Honeybee, Oct 2009 - March 2010, vol 20, no 4, p18) to the herbal formulations of various insecticides.

The creative significance of necessity and limited means

The significance of these inventions is that they are created out of necessity with very limited means, quite a different strategy to the way design is taught in developing countries with its endless resources and materials. They are therefore of very great significance for developing countries persuing ever more industrialized solutions with damaging consequences for the environment and biodiversity. It begs the question for design with limited means.

The principle of limited means was expounded by the Greeks who *"… argued that all machines can be constructed by combining six elementary mechanism: namely the lever, screw, inclined plane, wedge, wheel and pulley," Holland says. "In an intuitive way, this leads me to look at emergence in terms of elementary mechanisms and procedures for combining them. It's the interaction among these mechanisms, or building blocks, that generates emergence." Lewin and Regine in writing about Holland's work continue that "Emergence is ubiquitous in nature. It is what turns the simple interactions between pairs of ants into complex colony-wide behaviours. In every case, the whole is so much more than the sum of the parts. Holland describes the phenomenon as "much coming from little"*, (Lewin, & Regine, 1998).

John Holland in his book Emergence (1998) (which Lewin and Regine reviewed) propounds the theory that the whole is greater than the sum of its parts and in his book describes how a small number of rules or laws can generate very complex systems. It is with these ideas in mind that innovation could be promoted in developing countries in design education with more limited means rather than with the surfeit available throughout universities and design schools.

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25.66 Horses

(q.v. CSA, resilience, DESIS)

In August 2009 the BBC broadcast a program (1.) about the farm of Andrew and Rachel Brown at Clastone Down, Wiltshire, England, where the Browns had decided to replace their quadbikes (ATVs) with Argentinian Criollo horses for managing their cattle. The Browns *"think this traditional South American technique not only benefits the cattle, but the land and wildlife too."*

This is a very sustainable strategy for many reasons including the fact that horses do not compact the soil structure as machinery does and horse waste is also useful whereas that of quad bikes is polluting. However, without being romantic about the replacement of the horse by technology there is good reason to think that the horse may well return in some numbers for draft purposes and agriculture.

As a large portion of fossil fuel resources must remain unused in order to keep climate change below 2°C, a sustainable strategy for farming would be to adopt a mixed haulage/draft strategy involving both horses and tractors. It is unlikely that horses would return in the numbers reached before the First World War because it would be a competitor for agricultural land for growing horse fodder, growing food for human consumption as well as biofuels. From 1910 to 1920 *"at least one-fifth of US farmland had to be devoted to cultivation for horse feed!"* Furthermore, *"One well-fed American horse preempted cultivation of food grains capable to sustain about six people – but it could work at a rate at least ten times higher than an average man, offering a substantial energy advantage"* (Smil, 1999). However, the introduction of the internal combustion engine and with it the tractor, even the early ones, *"could replace at least ten horses"* bringing about the demise of the horse age.

A sustainable and resilient answer to the unsustainable agro-industry is to produce food by Community Supported Agriculture (CSA). These CSAs are small farms or smallholdings farming sustainably, organically and ecologically, supporting biodiversity and they frequently maintain horses for haulage, for example Chagfoods in Devon, England.

Working horses in this context could make a significant contribution to a sustainable future as they support and require an infrastructure which could re-emerge as the unsustainable agro-industry begins to founder. Other branches of land management where horses still play a minimal role include forestry and woodlands (2.). Today forestry employs heavy machinery, however, horses being more manouverable could play a larger role because being lighter they neither cause compaction of the soil structure nor damage the tree roots which grow close to the surface.

The role of horses in farming is being seriously reconsidered, for example the Essex Farm Institute, Essex, NY 12936, in the USA is making a *"quantitative analysis of plowing and cultivation using draft horses."* (3.)

The Amish community in the USA use horses for both farming and transport. They are also used inside greenhouses where machinery is difficult to manouvre. Furthermore, horses are worked in vines and orchards and research shows that horsepower is economical and feasible on small farms and horticultural holdings. (4.)

Horses could also be important in other ways in the community, for example animal therapy and helping children to establish contact and an understanding of nature and animals. Reconnecting children with nature is a sustainable strategy for the future stewardship of the biosphere (see chapter 1.15).

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25.67 Incredible Edible, Todmorden, West Yorkshire, UK

(q.v. resilience, DESIS, transition towns)

Incredible Edible is a social movement which was started in 2008 in the town of Todmorden, England. It was at the time when food prices were significantly increasing around the world due to the growth of crops for producing bio-fuels. The Incredible-Edible Todmorden movement was founded by two ladies Mary Clear and Pam Warhurst to grow and campaign for local food. Their civil action began by planting vacant spaces around the town with vegetables which anyone could pick for free.

"The mission is to make Todmorden self-sufficient in vegetables by 2018. They began with guerrilla gardening: sowing rosemary at the railway station, fennel in the car park, carrots in the graveyard. Today, it is exploding with food initiatives involving and linking community, schools and businesses. All the schools grow their own, some keep chickens, one is planning to host an innovative fish farm. The surgery has an apothecary garden at the rear, there's an edible walking trail, a bee group, an egg map with 50-plus local producers. The area's farmers support them and it's the perfect promotional vehicle for the town's new cheesemaker. They now employ two 'food inspirers' to help with teaching, learning, cooking, growing, spreading the message …" (Country Living, 2011)

The philosophy model of Incredible-Edible embraces three pillars:

Learning: > Earth Care: > cradle to cradle
Community: > People Care: > all inclusive
Business: > Fair share: > including farmers

The initiative has been enormously successful expanding out into the surrounding community in many different ways:

- Propaganda gardens which have been set up all over the town encouraging people to think about their food in new ways. When should it be harvested, how could it be stored, bottled or preserved etc. The result has been to increase people's knowledge about food rather than to simply purchase out of season foods imported from countries all around the planet.
- Another result has been the stronger integration of people within the community and the creation of jobs.
- The local school is including land based training into its curriculum.
- Two companies have been set up including Incredible-Edible Growing Ltd.
- The initiative has, according to the local police, also made the locality a safer place to live in.
- The initiative has also raised and planted a thousand fruit trees.
- The initiative has provided an inspiring model now being copied and adopted by other communities, for example the town of Cancun in Mexico.
- etc.

The success of the Incredible-Edible initiative has built into the community a resilience to future uncertainties such as the affects of peak resources, energy supply and climate change etc. The Incredible-Edible Todmorden example and its many spin-offs provides a tangible example of design for social innovation and sustainability (DESIS).

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25.68 Indigenous & Traditional knowledge & innovations

(q.v. Satoyama, Honeybee network, Afrigadget, traditional Japanese wood joinery, Kogi people)

The American space program spent millions of dollars developing a biro to write in zero gravity whilst the Russians took pencils is an apocryphal story which, in part at least, illustrates the problem of the consumer society. There are also very often simpler and more sustainable ways of doing things.

The traditional knowledge and the innovations of indigenous peoples are of inestimable value for contributing towards a sustainable future. As yet this knowledge has been little recognized or simply ignored because the peoples themselves have been marginalized by mainstream western culture and corporate interests. This was well illustrated when in March 2010 the Canadian government was planning a meeting of foreign ministers of the five states bordering on the Arctic Ocean *"(Canada, Russia, the US, Norway and Denmark/Greenland) …"to encourage new thinking on responsible development"* and *"reinforce ongoing collaboration in the region"*. But *"To their dismay, Arctic indigenous people's organizations, including the Sami, Inuit and Inuvialuit, were not invited."* (Tisdall, 2010). This approach to achieving a sustainable future is incredibly arrogant and obviously stupid. It is particularly so if we consider the enormous knowledge already possessed by peoples who have lived in these regions for more than a thousand years; their diverse cultures, adaptations to their environment with the variety of habitats and harsh seasons is of deep significance.

A tragic example of cultural genocide comes from Western Australia which is forcing over a hundred small Aboriginal communities scattered across the outback to move into larger towns. The reason for the reversal of the policy of the past 50 years which encouraged Aborigines to return to their ancestral lands is that the government of Western Australia claims it can no longer provide basic welfare services to remote Aboriginal communities following cuts by the central government. The movement of about 12,000 Aboriginal people will enable them to have access to state health, education and welfare services.

However, it will be much more difficult for them to preserve their own languages and cultures in the urban environment as they had previously been able to do in their much smaller communities (Lagan, 2014). This further degradation of the Aboriginal people will accelerate the loss of knowledge about life and living in the dry and inhospitable 'outback' which covers most of Australia. The cutting of welfare support is part of the broader strategy of neo-liberal capitalism including the cutting of administrative costs due to "*A lack of interest in, and a failure to recognize the value of, the Aboriginal law, tradition and culture associated with residence on and management of traditional lands*" (pers. comm. O'Faircheallaigh, 2014).

An important paper by three Spanish researchers: Gómez-Baggethun, Corbera and Reyes-García (2013) entitled: *Traditional ecological knowledge and global environmental change: research findings and policy implications* provides a valuable starting point for exploring the contribution that traditional ecological knowledge can make towards helping the world adapt to environmental change. The paper "*addresses two main research themes. The first theme concerns the resilience of Traditional Ecological Knowledge (hereafter TEK) and the conditions that might explain its loss or persistence in the face of global change. The second theme relates to new findings regarding the way in which TEK strengthens community resilience to respond to the multiple stressors of global environmental change. Those themes are analyzed using case studies from Africa, Asia, America and Europe. Theoretical insights and empirical findings from the studies suggest that despite the generalized worldwide trend of TEK erosion, substantial pockets of TEK persist in both developing and developed countries. A common trend on the studies presented here is hybridization, where traditional knowledge, practices, and beliefs are merged with novel forms of knowledge and technologies to create new knowledge systems. The findings also reinforce previous hypotheses pointing at the importance of TEK systems as reservoirs of experiential knowledge that can provide important insights for the design of adaptation and mitigation strategies to cope with global environmental change. Based on the results from papers in this feature, we discuss policy directions that might help to promote maintenance and restoration of living TEK systems as sources of social-ecological resilience*" (Gómez-Baggethun, Corbera, & Reyes-García, 2013)

In 2013 the Guttmacher Institute conducted a survey into contraception in the USA and found that of the 6.7 million pregnancies per year a "staggering 49%" were unintended! "*According to a 2005 survey of 9000 men in four continents, 55% said they would be interested in a male pill or something similar*" (Lewis, 2014). The tribesmen of the province of Papua in Indonesia chew the leaves of the gandarusa plant *(Justicia gendarussa)* which enables them to have sex without making their partners pregnant. Indonesia's scientists investigated gandarusa's properties and after identifying the contraceptive compound synthetically manufacture it and it is now available as a pill. Tests had shown the pill to be 99.96% successful as a contraceptive and furthermore only 3 days after discontinuing the pill normal fertility returned.

Why is the knowledge of indigenous peoples ignored when it is so valuable? The Indigenous peoples living in different regions and climates all around the world, solve a diversity of problems with low technologies and / or adaptive behaviours. Their philosophies, solutions, designs and strategies embedded within their cultures could provide other peoples with tools for adapting to climate change and for developing more sustainable strategies.

Unfortunately, the western consumer life style is becoming the life-style role-model for all peoples as they achieve a degree of affluency. This is well illustrated on the one hand by the populations of India and China which are now becoming more affluent and moving (unsustainably) towards the western meat-rich diet. Simultaneously, a 95% increase of deaths by cancer is projected to occur between 2002-2020 for Southeast Asia (Gorman, 2010). How can people learn that the western life-style role model is a recipe for bad health and an unsustainable future?

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1. A general unwillingness to recognize the right of Aboriginal people to live lives different to the 'mainstream';
2. A lack of interest in, and a failure to recognize the value of, the Aboriginal law, tradition and culture associated with residence on and management of traditional lands;
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25.69 Indigenous Peoples challenged by Consumerism

(q.v. Tragedy of the Commons, Indigenous Knowledge)

All around the world indigenous peoples are challenged by multinational corporations, politicians and sometimes others because their lands hold reserves of resources wanted to source global consumerism. One of the most recent and awful examples of consumerist greed and exploitation is the case in Tanzania which *"has been accused of reneging on its promise to 40,000 Masai pastoralists by going ahead with plans to evict them and turn their ancestral land into a reserve for the royal family of Dubai to hunt big game … the Masai have been ordered to quit their traditional lands by the end of the year … They insist the sale of the land would rob them of their heritage and directly or indirectly affect the livelihoods of 80,000 people. The area is crucial for grazing livestock on which the nomadic Masai depend … Unlike last year, the government is offering compensation of 1 billion shillings (£369,350), not to be paid directly but to be channeled into socio-economic development projects. The Masai have dismissed the offer"* (Smith, 2014).

Consumerism is driving cultural genocide around the World. *"An aggressive drive is taking place to extract the last remaining resources from indigenous territories. There is a crisis of human rights. There are more and more arrests, killings and abuses. This is happening in Russia, Canada, the Philippines, Cambodia, Mongolia, Nigeria, the Amazon, all over Latin America, Papua New Guinea and Africa. It is global. We are seeing a human rights emergency. A battle is taking place for natural resources everywhere: Much of the world's natural capital - oil, gas, timber, minerals - lies on or beneath lands occupied by indigenous people,"* says Victoria Tauli-Corpus, the UN chair on Indigenous Issues (Vidal, 2009).

Vidal (2009) provided a summary of the land grab flashpoints around the world:

"**ARIZONA:** The Navajo nation is fighting uranium mining through the US courts. Radiation levels are 450 times normal levels. Other uranium mines are opposed by indigenous groups in Australia, India, Canada, Niger and Botswana.

BOTSWANA: The Bushman of the Kalahari desert have been progressively pushed out of their traditional lands by the state to make way for mining.

BRAZIL, PARAGUAY, PERU: Five "un-contacted" tribes living deep in the forests of Peru, Brazil and Paraguay are at risk of extinction as oil companies, colonists and loggers invade their territories, says Survival International.

CANADA: The giant oil tar fields in Alberta are some of the most polluting in the world, and will stretch over thousands of square kilometers. They are the centre of a legal battle between oil companies and the Beaver Lake Cree nation and other indigenous groups.

COLOMBIA: Oil companies are moving into the western Amazon and prospecting indigenous land. Tribes are caught in the crossfire of a civil war between the state and guerillas.

CONGO: Pygmy groups in the rainforest are threatened by logging and mining companies.

GUATEMALA: Thousands of indigenous people have been forced to move to make way for giant dams and other developments. Indigenous leaders are regularly faced with threats of assassination by the authorities. Death squads have re-emerged.

INDONESIA: Palm oil companies in Sumatra have been expanding into the forests and grabbing land from indigenous communities. This, says OXFAM, is leading to conflict and more poverty.

KENYA: The indigenous Ogiek people who have lived for centuries in the Mau forest are being forced out to make way for logging, paper and tea companies.

NIGERIA: The oil producing Niger Delta which accounts for 4% of all the world's oil, is now heavily militarized as ethnic militia groups resort to kidnapping and violence in response to generations of abject poverty.

PHILIPPINES: Tribal lands are being militarized and repression of indigenous groups is increasing as giant coal, gold and copper mines destroy traditional water sources and fields.

WEST PAPUA: Companies have dug around $100bn of copper and gold from West Papua in 40 years, but while the Indonesian government has richly benefited, local tribes have been dispossessed of land and livelihoods" (Vidal, J., 2009).

The Brazilian federal agency, FUNAI, is concerned with the protection of the indigenous peoples and isolated tribes in the Amazon rainforest. Its basic strategy is to maintain *"no contact unless groups face extinction"* (Pringle, 2015) because these tribes are so susceptible to western pathogens. FUNAI is crrently, substantially underfunded receiving only 20% of what it needs. FUNAI manages many frontier outstations to protect these groups but it is not able to manage more than half of these outstations due to being underfunded. Unfortunately, it appears that Dilma Rousseff's government *"is demarcating very little land for indigenous groups and has largely abandoned its responsibilities to them, placing their lives in danger, primarily because it "sees the Indians as hampering the agricultual business, hampering the expansion of mining, and hampering the extraction of natural resources"" (Pringle, 2015). Ms Rousseff appointed Katiá Abreu (renown as Brazil's 'chainsaw queen') as her minister for agriculture, much to the concern of environmentalists. "Abreu is a leading figure in the "ruralista" lobby, which prompted the government to weaken Brazil's forest code. In congressional debates and in her feisty newspaper column, she has called for more roads through the Amazon, congressional control over demarcation of indigenous reserves, more efficient monocultures, and the approval of genetically modified "terminator seeds""* (Watts, 2014). The *"highly coveted commodity in Brazil today: land ... Once the land is protected, the Brazilian government can no longer auction it off to public and private development enterprises"* (Pringle, 2015). Consequently, Fearnside (2015) reports that: *"Creation of new protected areas has been essentially paralysed, existing reserves continue to have their official status removed, and government expenditure on enforcing environmental laws has been cut by 72%. Furthermore political appointments [e.g. Ms Katiá Abreu] are sending an anti-environmental signal to deforsters, and plans for Amazonian roads continue as fast as money allows."* In addition a new deal has been agreed for feasibility studies for a 5,300 km transcontinental railroad that would cut through the Amazon to connect ports on the Atlantic and Pacific coasts. A memorandum was signed last year between China, Brazil and Peru and in May, 2015, China and Brazil it was agreed to launch the feasibility studies (Seven Days, 2015).

Tragically, the value of land does not compare with *"The isolated people who once preserved traditional knowledge of Amazonian plants as well as a rich diversity of cultures and languages"* (Pringle, 2015).

This worldwide tragedy, currently taking place, illustrates ruthless political and corporate (sometimes criminal) power and its deadly greed for immediate profit by feeding consumerism.

The situation is a short term win against a loose / loose one because the losses are forever. The short term win is that a company makes its annual profit. The eternal losses can include:

› the loss and break up of a part of a biome together with its sustainably maintaining and interacting human inhabitants.
› the loss of a culture with its language due to dispersal of the communities.
› the loss of the knowledge associated with the land.
› the loss of the medicinal plants.
› the loss of biodiversity and ecosystem services.

Solutions

Protecting indigenous lands which could provide long term sustainable benefits for all, requires carefully planned cooperation. Unfortunately, this rarely occurs because indigenous peoples do not know how to legally defend their rights against multi-national firms with government licenses. Consequently, there are many cases which end in protest, violence and murder.

Managing Forests

A study which investigated and compared the management of forests by local people and governments has found that forests managed by local communities sequestered more carbon (as a measure of the number of trees) than those managed by government agencies (Pearce, 2009). This was because governments frequently license destructive logging companies unconcerned about the forests' future. The researchers Ashwini Chhatre and Arun Agrawal claim that *"communities are perfectly capable of managing their resource sustainably"* and do not automatically succumb to the *"tragedy of the commons"* (qv). The findings are consistent with what is known about other forests for example in the eastern Amazon in Brazil where the indigenous reserve, the largest protected forest in the world, is run by the Kayapo people (Pearce, 2009). The work of Elinor Ostrom (2012) who won the Nobel Prize for economics 2009, confirms that local peoples are more capable of the sustainable management of natural resources (forests and fisheries etc.) than by remote governance.

The Ecuador solution

Ecuador has oil reserves of 4.5 billion barrels of which 20% (960 million barrels) are in the Yasuni Park in Ecuador's Amazonian rainforest. However, the 1.2m km² Yasuni Park has astounded biologists for the sheer number and diversity of its species and thought to be the most biodiverse location on the Earth. At least 1,500 species of plants have been identified along with 400 fish species and more species of birds than occur in Europe. There are plants from which soap can be made, and others which could provide medicines for heart and kidney diseases and yet others from which contraceptives could be made. Perhaps more amazing is the discovery of a mushroom capable of digesting polyurethane.

Albert Acosta, a committed ecologist, but previously the minister for oil and mines when oil was discovered in the Yasuni Park, has prepared two plans for oil in the Park. The first, known as "Plan A" was to leave the oil in the ground for perpetuity in return for half its value (about $3.6bn). This was the first time ever that any nation had proposed to leave a resource untouched. Meanwhile, "Plan B" was to give a contract to a Chinese company. A poll has confirmed that 95% of Ecuadorians support Plan A and rather preserve the Yasuni Park in its pristine condition.

In 2010, Rafael Correa, the president of Ecuador, has guaranteed that Ecuador will not extract the oil so long as over the next 13 years the world donates $3.6bn. So far the scheme appears to be working and the UN has established the Yasuni fund which has received or been pledged $300m (Vidal, 2013).

Tragically, the world was not prepared to save the pristine rainforest: *"Drilling for oil in a part of the Amazon rainforest considered one of the most biodiverse hotspots on the planet is to go ahead less than a year after Ecuador's president lifted a moratorium on oil drilling there. Last August, Rafael Correa scrapped a pioneering scheme, the Yasuni Ishpingo-Tambococha-Tipuntini (ITT) initiative, to keep oil in the ground under a corner of the Yasuni national park in return for donations from the international community. He said only $13m (£8m) of the $3.6bn goal had been given, and that "the world has failed us", giving the green light to drilling"* (Vaughan, 2014).

In Indonesia indigenous communities are demarcating their ancestral lands using GPS technology; a preliminary strategy which could help to mitigate the impact of global warming. Community mapmaking has already been a means of showing where communities are and that they want to protect their lands. Indonesia has dense forests which are also the home for between 50 to 70 million indigenous peoples as well as 10% of all known plant species, (IRIN, 2014).

There is much that design activity could do to help.

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25.70 The Intergovermental Panel on Climate Change (IPCC)

(q.v. Eco-conflict, Climate Change, Eco-Refugees)

The IPCC is the most authorative body assessing climate change. As a scientific body of scientists worldwide it has been cautious in making its assessments consistent with scientific procedures. In March 2014, the IPCC published its first update since the 2007 report since when global warming can no longer be seen as vague threat that will occur sometime in the future. Since 2007, CO_2 emissions have continued to break previous records and the readings of emissions on Mauna Loa, Hawaii, continues upward without a glitch. "*… the report's authors say. "It's about people now," said Virginia Burkett, the chief scientist for global change at the US geological survey and one of the report's authors. "It's more relevant to the man on the street. It's more relevant to communities because the impacts are directly affecting people – not just butterflies and sea ice"* (Goldenberg, 2014). The impacts of climate change are now occurring on all continents as well as affecting the production of food. "*"All aspects of food security are potentially affected by climate change," the report said … Overall, the report said, "Negative impacts of climate change on crop yields have been more common than positive impacts." Scientists and campaigners pointed to the finding as a defining feature of the report … The report also warned for the first time that climate change, combined with poverty and economic shocks, could lead to war and drive people to leave their homes. "Climate change can indirectly increase risks of violent conflicts," the report said. It also warned that hundreds of millions of people in south Asia and south-east Asia will be affected by coastal flooding and land loss by 2100""* (Goldenberg, 2014).

The description of the IPCC which follows is from its own webpage: *"The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC.*

"The IPCC is a scientific body under the auspices of the United Nations (UN). It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.

Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. Re-

view is an essential part of the IPCC process, to ensure an objective and complete assessment of current information. IPCC aims to reflect a range of views and expertise. The Secretariat coordinates all the IPCC work and liaises with Governments. It is supported by WMO and UNEP and hosted at WMO headquarters in Geneva.

The IPCC is an intergovernmental body. It is open to all member countries of the United Nations (UN) and WMO. Currently 195 countries are members of the IPCC. Governments participate in the review process and the plenary Sessions, where main decisions about the IPCC work programme are taken and reports are accepted, adopted and approved. The IPCC Bureau Members, including the Chair, are also elected during the plenary Sessions.

Because of its scientific and intergovernmental nature, the IPCC embodies a unique opportunity to provide rigorous and balanced scientific information to decision makers. By endorsing the IPCC reports, governments acknowledge the authority of their scientific content. The work of the organization is therefore policy-relevant and yet policy-neutral, never policy-prescriptive." (1.)

"The Intergovernmental Panel on Climate Change and Albert Arnold (Al) Gore Jr. were awarded the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change". (2.)

The IPCC web site provides an invaluable range of reports on climate change and its impacts and recommendations for policy makers. Short editions of the reports are provided as summaries for policy makers and are invaluable for anticipating future design needs and today's curricular content for design education.

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Source

IPCC web site is at: http://www.ipcc.ch/

(1.) http://www.ipcc.ch/organization/organization.shtml

(2.) http://www.ipcc.ch/organization/organization_history.shtml

25.71 Keystone species

(q.v. ecosystem, ecosystem services, Gaia theory)

A keystone species is one that plays a crucial ('keystone) role in the maintenance of an ecosystem so that, if for some reason the keystone species should become extinct then its loss causes substantial changes or even collapse of the ecosystem.

The World Wildlife Fund web page explains that:

- *"A keystone species is a species that plays an essential role in the structure, functioning or productivity of a habitat or ecosystem at a defined level (habitat, soil, seed dispersal, etc.).*
- *Disappearance of such species may lead to significant ecosystem change or dysfunction which may have knock on effects on a broader scale. Examples include the elephant's role in maintaining habitat structure, and bats and insects in pollination.*
- *By focusing on keystone species, conservation actions for that species may help to preserve the structure and function of a wide range of habitats which are linked with that species during its life cycle"* (WWF, n.d.).

A classic example of a keystone species is the Californian fur or sea otter which lives along the coasts of California and the western USA. The fur otter was much prized for its luxurious fur and hunted nearly to extinction from the 1700s until about the beginning of the 1900s. Then by 1911 only about a few thousand remained and commercial hunting was stopped (Isabella, 2014). The sea otter feeds on sea urchins which in their turn feed on the kelp algae. The absence of sea otters allowed the sea urchins, having no predator to check their numbers, to multiply into swarms which decimated the algae and the giant kelp. The Californian giant kelp *(Macrocystis pyrifera)* has very long fronds growing by as much as 60cm a day and can reach lengths of upto 45 meters. The giant kelp algae growing close together create dense underwater kelp forests which provide an enormously productive ecosystem and habitat supporting myriad invertebrate and vertebrate species as well as providing a nursery habitat for many species of fish (Juniper, 2013). The kelp itself is harvested for alginate, and a variety of minerals including iodine and potassium and in addition, is also a source of food (National Ocean Service, 2013). Happily, the sea otter population has been re-established and the kelp 'forests' have also recovered and the sea otter population has now extended its range along the west coast of Canada. This example of a 'keystone' species illustrates how humans create ecological problems by removing one species whose role within an ecosystem is unknown but becomes fully recognized only when absent.

Today the sea otter population is booming and having a dramatic effect by enriching the coastal waters of west Canada. The ecological impact of the reintroduction of wolves into the Yellowstone Park in the USA after an absence of 70 years also has had unprecedented results and confirmed the "keystone" role of wolves on the Park's ecosystem. The wolves prey on the herds of elk which feed on the aspen. However, the presence of wolves makes the elk too fearful to linger in the aspen groves. Consequently, more aspen survive beyond the sapling phase and grow to maturity. The increase of aspen has stabilized the Lamar Valley flood plain halting erosion of the soil which was being washed away. The decrease in elk numbers due to predation by the wolves resulted in the return of other tree species such as willow, cottonwoods and bushes. However, the aspen are also a keystone species since their recovery resulted in the return of song bird species. Moreover, the trees growing near the river provided wood for beavers to create dams which in turn created new aquatic habitats for other species such as muskrats. The re-establishment of the trees, perhaps more surprisingly, changed the 'behaviour' of the rivers because the trees stabilized the river banks. In addition as more trees were able to grow, the top soil became stabilized elsewhere in the Park which in turn contributed to the recovery and richness of the ecosystem (Morell, 2007; Monbiot, 2013).

Another mammal, which is also a keystone species is the African elephant which "*dramatically affect their landscape. They are seed dispersers and influence forest composition, creating clearings to boost tree regrowth and reducing cover to create suitable habitat for browsing and grazing animals*" (WWF, n.d.).

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25.72 The Kogi People, holistic thinkers

(q.v. Gaia theory, Indigenous knowledge)

The Kogi people of the Taironas, Colombia, are a group who have deliberately maintained their isolation from the developed world, living in communities on an isolated mountain surrounded by dense jungle. "*Here an ancient priesthood still rules, in cities more than a thousand years old. They have preserved the culture and philosophy of a culture lost everywhere else: the civilization of Chibchas, the people of El Dorado. After centuries of deliberate isolation, these people, the Kogi, have decided that the time has come to speak to us. They call themselves the Elder Brothers of the human race, and are convinced that our ignorance and greed will destroy the balance of life on Earth in the next few years. They believe that the only hope is for us to change our ways, and so they have set out to teach us what they know about the balance between mankind, nature and the spiritual world.*

This book [The Heart of the World, Ereira, 1990] *is their warning and their message. It makes sense of much that was not known or understood of the pre-Columbian* *civilizations of America. And it is a desperate attempt to make us understand the consequences of our own way of living."*

Alan Ereira has been the producer-director of the two films on which he collaborated with the Kogi, the Elder Brothers. The first film, *From the Heart of the World – the Elder Brothers' Warning* (1990) was a warning to the peoples of the rest of the world, the Younger Brothers as we are called by the Kogi, to change course from our unsustainable lifestyle. However, observing that we, the Younger Brothers, had not changed our ways and recognizing that their warning had gone unheeded the Elder Brothers wanted to make a second film with Alan Ereira. In the second film, Aluna (2014) the Kogi Mamas (priests) show their perception of how the world is interconnected.

The CD of the film *Aluna* also contains a valuable commentary by Alan Ereira in which he answers nine questions to help viewers understand the Mamas' way of thinking.

The reason Kogi thinking is so remarkable is because they view the world as a single organic living entity like a medical body. Indeed, because their view is like a 'medical' philosophy, it is obvious that causing harm in one part of the body will result in problems elsewhere. For example, cutting off a person's foot affects the rest of their being. This lies at the core of the Kogi's perception of the world and that it is a totally interconnected entity. Therefore, it is obvious to them that if you build a big project at a river mouth it will cause problems all the way back upstream to the source. Such actions will not only affect the environment but also our health due to the interconnectedness of everything. The Kogi perception of interconnectedness between everything makes it very hard for them to understand our simplicity and ignorance about connectedness. The Aluna film therefore attempts to show how an action can harm everything in every way. The Kogi see the World as it is rather than with the fractured and disconnected perception with which we handle it. Furthermore, the western way is to study subjects in isolation as disconnected components for which we have specialists. The developed world is one in which knowledge is fragmented and disconnected.

Consequently, as Alan Ereira explains, we are a civilization that goes blithely on, doing this, building that, regardless of the consequences. Our disconnected, specialist way of thinking enables us to think that *"Since I cannot prove that what I am going to do may cause harm, I'll go ahead and do it anyway."* So we pollute because we do not have the evidence yet that it may be harmful. Alan Ereira says we lack caution because it is more profitable not to have it.

One question posed to Alan Ereira which he answered in his talk was how did the Kogi acquire their holistic perception? Ereira replied that the question should really be the other way round: *'when did the developed world loose a holistic perception?'* Ereira's answer is that peoples living in the developed world lost their holistic perception with their development from hunter-gatherers to an agricultural and finally into an industrial society in which the fractured or specialist way of thinking is very successful. It is notable that in quite a different philosophy to the Kogi, Zen Buddhism, also recognises the holistic perception, the indivisibility of the world. Alan Watts draws attention to the problem of a perception which fractures the world and knowledge into abstract categories for the convenience of their management. However, the perception of Zen Buddhism (Watts, 1971) like the Kogi, is a holistic perception of the world.

Ereira passes on the Kogi Mamas advice that we need to learn to be awake, to feel and to truly see what is going on around us.

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Source

Aluna, (2014) by Revelation Films the second film by Alan Ereira

"ALUNA is made by and with the KOGI, a genuine lost civilization hidden on an isolated triangular pyramid mountain in the Sierra Nevada de Santa Marta, Colombia, nearly five miles high, on the Colombian-Caribbean coast. The Kogi say that without thought, nothing could exist. This is a problem, because we are not just plundering the world, we are dumbing it down, destroying both the physical structure and the thought underpinning existence. The Kogi believe that they live in order to care for the world and keep its natural order functioning, but they recognized some years ago that this task was being made impossible by our mining and deforestation. In 1990 they emerged to work with Alan Ereira, making a 90-minute film for BBC1 in which they dramatically warned of our need to change course. Then they withdrew again ...

The first film had a stunning global impact, and is now probably the most celebrated film ever made about a tribal people. It was repeated on BBC2 immediately after its first showing, and then in many other countries – some 30 times in the US last year, not bad for a 20-year-old documentary!" (accessed at: http://www.alunathemovie.com/)

From the Heart of the World – the Elder Brothers' Warning (1990); the first film by Alan Ereira.
(accessed at https://www.youtube.com/watch?v=U2tIVwGwiDc).

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25.73 Life-Cycle Assessment (LCA) or Life-Cycle Analysis

(q.v. MIPS, SIPS)

Life cycle analysis is a strategy for identifying and assessing the impacts on the environment, of a product, service or process. *"It identifies and assesses the potential for environmental improvement of products during each phase of the product lifecycle. An LCA is based on a systematic inventory of all material and energy flows, which enter and leave a product system. The product system encompasses all processes along a product's and all its components' life cycle which are necessary to fulfill a defined function. The environmental impacts associated with the product system (caused by its energy and material flows) are assessed. It is important to consider the complete product system and all relevant aspects that have an influence on the environment during the different phases of the product's life cycle, e.g. from the extraction of raw materials, production, distribution, usage and end of life.*

The methodology of LCA has been internationally harmonized to increase its comparability and credibility. The International Society for Ecotoxicology and Chemistry SETAC (Society of Environmental Chemistry and Toxicology, 1991) provided a basis for discussion which was taken up by the International Standards Organization (ISO) within the ISO 14000 standards family." (Tischner, et al. 2000)

This is achieved in four stages by:

"*(1.) Scope and Goal definition*
(2.) LCA Inventory
(3.) Assessment of the environmental impacts connected to the items of the inventory.
(4.) Interpretation." (Tischner, et al. 2000)

The US Environmental Protection Agency (EPA) provides a comprehensive account of the Life Cycle Assessment procedure on its web page (1.)

An LCA is complicated and a time consuming procedure, however, a number of programmes exist which are suitable for designers and design students and we introduce three here:

Greenfly

Greenfly *"is a user-friendly design support tool focused on real-world design projects. Greenfly incorporates life-cycle modeling and EcoDesign strategies with easy to use, cutting-edge web technology. Greenfly shows the environmental impacts of your design choices through strong graphical representation and helps you improve and communicate your product sustainability decisions. Greenfly enables you to maximize life cycle environmental performance within a scientifically robust framework."* The Greenfly (2.) web page address is: http://www.greenfly-online.org/

SimaPro

SimaPro claims to be the world's most widely used LCA program and a short introduction to the SimaPro 7 program (3.) and its demonstration Manual is available at: http://www.simapro.de/uploads/media/DemoManual_01.pdf

However, in November 2013 an update was released, SimaPro 8 with Ecoinvent 3. Further information about the SimaPro LCA programmes are available at SimaPro UK: www.simapro.co.uk

GaBi

The producers of GaBi on their web page (5.) (http://www.gabi-software.com/uk-ireland/index/) also claim that their product is the leading Life Cycle Assessment software programme and write that it can: *"Identify what determines the best sustainability designs by assessing every attribute: energy, water and resources used, environmental emissions, social impacts.*

 # 1 LCA Software
GaBi is THE Product Sustainability Solution that combines modeling and reporting software, data content and expertise to help save money, enhance your brand and reduce your risk … . GaBi is the most trusted product sustainability solution for Life Cycle Assessment with over 10,000 users including Fortune 500 companies, leading industry associations and innovative SMEs."

GaBi is aimed at business rather than education and the PE introductory video (6.) (http://www.gabi-software.com/uk-ireland/software/gabi-software/) makes a powerful summary as to why LCA should be implemented into the design and manufacture of products.

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(4.) SimPro further information (accessed 18.12.2013) at: www.simapro.co.uk
(5.) GaBi is for companies (accessed 18.12.2013) and their web address is: http://www.gabi-software.com/uk-ireland/index/
(6.) http://www.gabi-software.com/uk-ireland/software/gabi-software/

25.74 Millenium Development Goals (MDGs)

(q.v. globalisation, Eco-refugees)

The Millenium Development Goals were agreed in the year 2000 at the United Nations' Millenium Summit in New York. In order that these goals could be achieved, targets were identified and set which should be reached by 2015, these targets were: "Millenium Development Goals and beyond 2015

Goal 1 Eradicate extreme poverty and hunger

Target 1.A Halve, between 1990 and 2015, the proportion of people whose income is less than $1.25 a day.

Target 1.B Achieve full and productive employment and decent work for all, including women and young people.

Target 1.C Halve, between 1990 and 2015, the proportion of people who suffer from hunger.

Goal 2 Achieve universal primary education

Target 2.A Ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling.

Goal 3 Promote gender equality and empower women

Target 3.A Eliminate gender disparity in primary and secondary education, preferably by 2005, and in all levels of education no later than 2015.

Goal 4 Reduce child mortality

Target 4.A Reduce by two thirds, between 1990 and 2015, the under-five mortality rate.

Goal 5 Improve maternal health

Target 5.A Reduce by three quarters, between 1990 and 2015, the maternal mortality ratio.

Target 5.B Achieve, by 2015, universal access to reproductive health

Goal 6 Combat HIV and AIDS, malaria & other diseases

Target 6.A Have halted by 2015 and begun to reverse the spread of HIV/AIDS

Target 6.B Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it.

Target 6.C Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases

Goal 7 Ensure environmental sustainability.

Target 7.A Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources

Target 7.B Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss

Target 7.C Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation

Target 7.D Achieve, by 2020, a significant improvement in the lives of at least 100 million slum dwellers

GOAL 8 Develop a global partnership for development

Target 8.A Develop further an open, rule-based, predictable, non-discriminatory trading and financial system

Target 8.B Address the special needs of least developed countries

Target 8.C Address the special needs of landlocked developing countries and small island developing States"

(source: http://www.un.org/millenniumgoals/)

Globalisation means that we can no longer be unaware and ignore what is happening to all people around the World. In our perception of globalisation, we can recognise the interconnectedness of the world. This is essential because the interconnectedness means that we can anticipate the increase of problems spreading from unresolved Millenium Goals, for example health. Poverty and a lack of sanitation can increase the likelihood of a viral disease which could easily spread around our globalised world. The continuing desertification will create less land for growing food and increase the numbers of eco-refugees creating pressures in other lands.

The design curriculum for the 21st century must embrace non-commercial 'wicked problems' of the Millenium Goals. 'Non-commercial' here refers to the lack of a commercial client to finance the resolution of these problems according to the old design paradigm. These problems maybe non-commercial in the short term, but not in the long term, and for them to remain unresolved will be absolutely unsustainable. The educational experience for students to work on such problems will greatly enhance their development and insight for working on a greater diversity of problems.

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25.75 MIPS

(q.v. GDP, externalities, TEEB, ecological rucksack)

Historically, industry has not taken into account the costs of the environmental damage it causes whilst creating its products and profits. A Trucost report for the year 2008 showed that the top 3000 publicly quoted companies had created profits of $6 trillion but at an estimated cost of damage to the environment of $2.2 trillion. As we know from the way GDP is calculated this cost is not fed back into the GDP equation.

The Trucost Agency (2013) reported that commerce and business's "*global top 100 environmental externalities are costing the economy world-wide around $4.7 trillion a year in terms of the economic costs of greenhouse gas emissions, loss of natural resources, loss of nature-based services such as carbon storage by forests, climate change and air pollution-related health costs.*" Clearly, this is not sustainable.

"*The much-discussed marriage of economics and ecology can only occur if both the value and the load-bearing capacity of the biosphere are understandable and accountable ...*" and consequently "*The ecological currency must be tradeable*" (Schmidt-Bleek,1993). One strategy would be to get polluters to pay, but how much? Richard Mattison, the leader of Trucost's report for the year 2008 and Trucost's chief operating officer said that "*What we are talking about is a completely a new paradigm ... markets are not fully aware of these risks, and don't know how to deal with them.*" (Jowit, 2010).

It is therefore interesting that already 20 years earlier that Friedrich Schmidt-Bleek, the then leader of the Institute of Climate, Environment and Energy in Wuppertal proposed "*an environmental pressure indicator to support dematerialization in industrialized countries*" (Wuppertal,2003). Schmidt-Bleek developed MIPS, a "*measure for the environmental stress intensity of any product ... MIPS stands for material intensity per unit of service*" (Schmidt-Bleek, 1993) and "*is the life cycle-wide input of natural material (MI) which is employed in order to fulfill a human desire or need (S) by technical means*" (Schmidt-Bleek, 2008).

Schmidt-Bleek (2003) writes that "*This measure must, even though it should be simple, generate rough estimates. In other words it should be able to consistently give a fairly accurate approximation of the intensity of the environmental stresses involved. Specifically, such a measure should meet the following conditions:*

1. *It should be simple, yet reflect important factors influencing the environment.*
2. *It should be based on characteristics which are common to all processes, products and services.*
3. *The selected characteristics should be straightforwardly measurable and subject to quantification.*
4. *The use of this measure should be cost-effective.*

5. *The measure should permit the transparent and reproducible estimation of environmental stress potentials of all conceivable plans, processes, goods and services from the cradle to the cradle.*
6. *Its use should always lead to directionally stable results.*
7. *The measure should form a bridge to market activities.*
8. *It should be usable on all levels: locally, regionally and globally"* (Schmidt-Bleek, 2003).

In making a MIPS calculation the material requirements are divided into different stages of the service yielding product across its life cycle such as: manufacturing, using, repairing, re-using, distribution, transportation and disposal. Meanwhile, the assessment of the material inputs are classified into five different groups:

› *"abiotic raw materials*
› *biotic raw material*
› *soil*
› *water*
› *air"* (Tischner, et al. 2000)

The aim is to keep the values in each group, the ecological rucksacks, *"as small as possible. This can be achieved by reducing the materials and energy input required for a given service unit (dematerialization)"* (Tischner, et al. 2000).

The MIPS analysis requires the collection of information about different materials and a database at the Wuppertal Institute can be accessed for information about the ecological rucksacks of different raw materials, logistics, etc. (http://wupperinst.org). The use of the MIPS analysis is described by Ursula Tischner et al (2000) in their book *How to do EcoDesign*?

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25.76 Mitigative Design

(q.v. Adaptive design, Decomplexifying Design, Planetary boundaries)

Mitigation is defined as actions to reduce the severity or seriousness of something. If we are to secure a sustainable future we will need to change our behaviours so as to mitigate or reduce the problems we are creating such as loss of biodiversity, climate warming and nitrogen pollution and our exceeding the planetary boundaries (qv). A good example of mitigative design or action would be to cease burning all fossil fuels since that will stop the severity of the problems of global warming.

Kruse (2006) identifies three kinds of action for mitigation of anthropogenic impacts and therefore mitigative design by the strategies of avoidance, reduction or delay.

"(A) compensate for negative effects of human behaviour directly in the ecosphere (correctional measures, e.g. renaturation of damaged areas).
(B) prevent the occurrence of such effects (preventive measures, e.g. regulations to reduce emissions), or
(C) influence human/social systems directly (e.g. development of alternative technologies, stimulating or changing of environmental concern, facilitation of a value change)."

In contrast to mitigative design, adaptive design (qv) is concerned with addressing the consequences resulting from global warming, for example: protecting cities from rising sea-levels due to global warming, etc.

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25.77 Natural Capital

(q.v. economic growth, ecosystem services, TRUCOST)

In the Barbara Weinstock lecture which Amory Lovins gave at Berkeley (1.) entitled *Natural capitalism,* *The Next Industrial Revolution*, he states that there are four kinds of capital and they are:

1. Money (financial capital).
2. Goods (physical or manufactured capital: buildings & equipment).
3. People (human capital: culture & community).
4. Nature (natural capital: natural resources and ecosystem services).

The industrial neo-liberal capitalism normally operates with the first two kinds of capital and frequently liquidates the capitals on which it actually depends, namely people and nature. Lovins succinctly states that: *"without people there is no economy and without nature there are no people."*

In the book *Natural capitalism; the next industrial revolution*, for which Lovins was a co-author, natural capital was defined as *"... the sum total of the ecological systems that support life, different from human-made capital in that natural capital cannot be produced by human activity"* (Hawken. Lovins & Lovins, 2004).

Another definition of natural capital was provided by the TRUCOST Agency as *"The finite stock of natural assets (air, water and land) from which goods and services flow to benefit society and the economy. It is made up of ecosystems (providing renewable resources and services), and non-renewable deposits of fossil fuels and minerals"* (Trucost, 2013).

The conventional policies of continued economic growth and GDP are fundamentally flawed because the Earth and its resources are finite and because the World Bank's and many economists' and politicians' definition of GDP does not embrace this simple fact. The World Bank (2014) defines *"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources."* However, not all economists agree with the World Bank, the economic establishment and myopic politicians. Edward Barbier (2014) warns that *"Economic indicators that omit the depletion and degradation of natural resources and ecosystems are misleading."* Barbier clearly describes our dilemma: *"Two global trends are noticeable. First, the decline in natural capital has been five times greater on average in developing economies than in the eight richest countries. Second, natural capital depreciation in all countries has risen significantly since the 1990s. There was a dip during the global recession of 2008–09, but as the world economy has recovered, so has the rate of resource use.*

Ecological capital, too, is clearly endangered by current patterns of economic development. Over the past 50 years, ecosystems have been modified more rapidly and extensively than in any comparable period in human history, largely to meet burgeoning demands for food, fresh water, timber, fiber and fuel. According to the worldwide Millennium Ecosystem Assessment, approximately 60% of major global ecosystem services have been degraded or used unsustainably, including fresh water, wild fisheries, air and water purification, and the regulation of regional and local climate, natural hazards and pests.

Unfortunately, ecological capital, being unique, poorly understood and difficult to measure, tends to be undervalued." Once species become extinct and ecosystems collapse it will be impossible to recreate those systems to provide again lost ecosystem services.

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For more information on natural capital go to www.naturalcapitalproject.org/

25.78 Net Primary Production (NPP)

(q.v. Ecosystem Services)

Net Primary Production (NPP) is the total biomass (fixed carbon) produced by photosynthesis by plants and algae (principally phytoplankton). Plants utilize sunlight to convert carbon dioxide and water into sugar and oxygen by photosynthesis. The formula is written as follows: $6CO_2 + 6H_2O$ > (plus the red and blue light from sunlight) > $C_6H_{12}O_6 + 6O_2$

Photosynthesis provides not only all the biomass on which all higher organisms depend (including humans) but also another essential requirement for life as we know it: oxygen. The amount of carbon which results from photosynthesis is estimated to be about 104.9 petagrams per year (A petagram = 1,000,000,000,000 kilograms) or 104,900,000,000,000 kilograms with approximately equal proportions being produced on land and in the oceans (Field, et al, 2010).

Over half of the world's NPP occurs in the tropics (Melillo, et al, 1993) where evergreen trees are the major contributors. Clearly, deforestation is of great concern for a sustainable future; firstly forests are 'sinks' for CO_2, which is to say that they sequester or extract CO_2 from the atmosphere, secondly, photosynthesis provides oxygen without which we cannot live. Dr Ralph Keeling, whose father, Charles Keeling is famous for revealing the increasing content of CO_2 in the atmosphere (the famous hockey stick curve) has recorded the falling levels of oxygen (http://scrippso2.ucsd.edu/) due to the burning of fossil fuels. The loss is equivalent to loosing 19 O_2 molecules out of every million O_2 per year.

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25.79 Nudge theory

(q.v. fun theory, behaviour change, particle design, WEEE)

Nudge theory is a subject which was spawned within the field of behavioural economics and started to grow in the 1960s. It is concerned with understanding how both individuals and organisations make decisions. However, it came very much to the fore in 2008 when Thaler and Sunstein published their book, simply called nudge.

Nudge theory works like this. In many situations there are a range of choices from which a person can choose a course of action, what is termed the "choice architecture". The choice architecture can be arranged so as to influence the choices people might make. One of the most frequent situations we all encounter concerns how food is displayed in an institutional self-service cafeteria. For example, healthy food, such as vegetables and fruit can be presented at eye level and arranged so that it is easily accessible whilst unhealthier foods such as chips or cheese can be located so that accessing a portion is physically difficult. Therefore, while chips and cheese remain options the physical arrangement requires more effort so that people tend to help themselves to the 'easier to reach' healthy foods on display.

The administration at Schipol airport was concerned about the cleaning costs of the men's lavatories because men tended not to concentrate whilst urinating and often peed around the urinal causing the need for more cleaning. Aad Kieboom, an economist, came up with the idea of having a black fly etched into the ceramic of the urinal with the result that spillage was reduced by about 80% which significantly reduced the cleaning costs. This strategy is called "soft paternalism" because neither the examples of the cafeteria nor the urinal forces anyone to behave in a particular way (Chalabi, 2013).

In 2010 the British Government became the first in the world to set up the Behavioural Insights Team (BIT or "nudge unit"). The Team (UK Government, 2012; Sources: 1. & 2.) developed a number of strategies for recovering money from the public such as taxes and fines. For example people who had not paid their city tax (rates: payments for rubbish removal etc.) were sent letters not only requesting the payment to be made but also stating that *'most people in their town had already paid their tax'* which increased the public's response by 15%.

A behavioural psychologist Mr Gyani working at BIT is developing a strategy to help unemployed people back to work. In a pilot test a 28 year old unemployed man who had not been in work for most of his working life was asked to write for 20 minutes about his feelings about being unemployed after seeing a job adviser each week. Each week his writing became less jumbled and more structured and within a month he got a full time job. Whilst the pilot test is by no means conclusive, a larger trial is now taking place across Britain to see if the strategy can really help people to find employment (Bennhold, 2013). So far the Behavioural Insights Team "*... has been nudging people to pay taxes on time, insulate their attics, sign up for organ donation, stop smoking during pregnancy and give to charity – and has saved* *the taxpayer tens of millions of pounds … Britain is the first country that has mainstreamed this on a national level"* (Bennhold, 2013).

Nudge theory has a lot of potential for innovating both sustainable designs and improving the public's response regarding sustainability behaviours, for example in recycling white goods and WEEE. Can design students learn to implement "nudge" strategies into their designs and interfaces so as to promote more sustainable behaviours?

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25.80 O2 Global Network

(q.v. First things first, Do Good Design)

The O2 Global Network was established in 1988 by designers who were becoming increasingly concerned about the resources (rainforest woods) being used in design products. The challenge they identified was how to foster sustainability while maintaining a good quality of life. They did not want to "*go back to the Earth*" but rather accept the challenge of sustainable design. They founded O2 to *"to inform, inspire and connect people interested in sustainable design"* and pass on that knowledge(1). This international network has members operating in all areas of design throughout academic and professional institutions. It has over 1800 members with 84 O2 liaisons spread across 6 continents in 54 countries organized into hubs, groups and liaisons and members promote, teach and implement sustainable design practice.

In 1994 the O2 Global Network foundation was established to keep its membership fully linked through the electronic media. It challenges everyone *"to engage in sustainable design. Go visit the O2 Website. Get in touch with us through e-mail (global@o2.org) and subscribe to the mailing list."* (1)

The O2 website provides not only a rich source of contacts and links but also a key book list, tools, design examples and of course how to join O2.

Due to the commercial use of O2 you may find it difficult to get into the correct web-site. Hopefully, you should be able to access the correct web page using the addresses below.

Source

http://www.o2.org/index.php

O2 website (www.o2.org)

O2 mailing list (http://groups.yahoo.com/group/o2mailinglist/)

O2 LinkedIn group (http://www.linkedin.com/groups?home=&gid=2162795&trk=anet_ug_hm)

25.81 Open Access Manifesto

Thor Benson published the *Guerilla Open Access Manifesto* on the Truthdig website in an article entitled "*Greed Is a Paywall Blocking Human Knowledge.*" Benson draws attention to the fact that significant articles which have been extensively cited should be freely available because of their significance. Benson writes *"papers like American biochemist Oliver Lowry's 1951 "Protein measurement with the folin phenol reagent," which was published by Nature, has been cited over 300,000 times. When a study has been cited that much, it should be available to the public because of its significance. There is no reason, except for the pursuit of profit, to not make this type of content freely available so research into the topic can be available to any and all readers.*

The corporations that ask for a toll to cross the information gap are ultimately thwarting the growth of knowledge. … A kid living in the ghetto should have just as much opportunity to educate him- or herself as a kid in Beverly Hills, and open access to information can make that possible."

Aaron Swartz was a 'geek' and immensely gifted programmer who developed an interest in politics. He thought that it was unfair that academic papers from publicly funded research should be hidden behind paywalls. He developed ways of downloading papers and data mining medical research papers to uncover links between pharmaceutical companies and the authors of scientific papers. It was when he downloaded papers from the JSTOR digital library that he was arrested, and indicted on a number of charges with a potential jail sentence of 35 years. He was so depressed by this turn of events after having been vindictively persued and prosecuted that he hanged himself on 11 January, 2013. Aaron Swartz has been praised as *"the most technologically-gifted political activist in history. He looked for instances of manifest unfairness and developed software to remedy it"* (Naughton, 2015).

Here is Aaron Swartz"s Guerilla Open Access Manifesto

"Information is power. But like all power, there are those who want to keep it for themselves. The world's entire scientific and cultural heritage, published over centuries in books and journals, is increasingly being digitized and locked up by a handful of private corporations. Want to read the papers featuring the most famous results of the sciences? You'll need to send enormous amounts to publishers like Reed Elsevier.

There are those struggling to change this. The Open Access Movement has fought valiantly to ensure that scientists do not sign their copyrights away but instead ensure their work is published on the Internet, under terms that allow anyone to access it. But even under the best scenarios, their work will only apply to things published in the future. Everything up until now will have been lost.

That is too high a price to pay. Forcing academics to pay money to read the work of their colleagues? Scanning entire libraries but only allowing the folks at Google to read them? Providing scientific articles to those at elite universities in the First World, but not to children in the Global South? It's outrageous and unacceptable.

"I agree," many say, "but what can we do? The companies hold the copyrights, they make enormous amounts of money by charging for access, and it's perfectly legal – there's nothing we can do to stop them." But there is something we can do, something that's already being done: we can fight back.

Those with access to these resources – students, librarians, scientists – you have been given a privilege. You get to feed at this banquet of knowledge while the rest of the world is locked out. But you need not – indeed, morally, you cannot – keep this privilege for yourselves. You have a duty to share it with the world. And you have: trading passwords with colleagues, filling download requests for friends.

Meanwhile, those who have been locked out are not standing idly by. You have been sneaking through holes and climbing over fences, liberating the information locked up by the publishers and sharing them with your friends.

But all of this action goes on in the dark, hidden underground. It's called stealing or piracy, as if sharing a wealth of knowledge were the moral equivalent of plundering a ship and murdering its crew. But sharing isn't immoral – it's a moral imperative. Only those blinded by greed would refuse to let a friend make a copy.

Large corporations, of course, are blinded by greed. The laws under which they operate require it – their shareholders would revolt at anything less. And the politicians they have bought off back them, passing laws giving them the exclusive power to decide who can make copies.

There is no justice in following unjust laws. It's time to come into the light and, in the grand tradition of civil disobedience, declare our opposition to this private theft of public culture.

We need to take information, wherever it is stored, make our copies and share them with the world. We need to take stuff that's out of copyright and add it to the archive. We need to buy secret databases and put them on the Web. We need to download scientific journals and upload them to file sharing networks. We need to fight for Guerilla Open Access.

With enough of us, around the world, we'll not just send a strong message opposing the privatization of knowledge – we'll make it a thing of the past. Will you join us?" Aaron Swartz, July 2008, Eremo, Italy

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25.82 Ostrom Elinor and sustainable resource management

(q.v. tragedy of the commons)

In 2009 Elinor Ostrom was the first woman to win the Nobel Prize for economics in recognition for her work on the governance of common pool resources. Common pool resources are resources which are available to everyone or at least many, such as ocean fisheries and some forests such as the Amazon rainforest. The history of the European fisheries policies has clearly demonstrated that government regulation has not been a panacea for fisheries management and resulted in the collapse of many fish stocks. The problem then is how to ensure the sustainability of renewable resources.

Elinor Ostrom (2012) confirmed that local communities do not necessarily require government legislation or privatization to protect renewable resources such as fisheries. Through precise observation Ostrom confirmed that *"the tragedy of the commons"* (Hardin, 1968) can be avoided. *"In the words of Mark Pennington:* '[Professor Ostrom's] *book* Governing the Commons *is a superb testament to the understanding that can be gained when economists observe in close-up detail how people craft arrangements to solve problems in ways often beyond the imagination of textbook theorists … In particular, communities are often able to find stable and effective ways to define the boundaries of a common-pool resource, define the rules for its use and effectively enforce those rules … Elinor Ostrom's work in this field, for which she won the Nobel Prize in economics in 2009, was grounded in the detailed empirical study of how communities managed common-pool resources in practice." Ostrom's work revealed that "there are principles that we can draw from the detailed study of the salient features of different cases to help us understand how different common-pool resources might be best managed; which rules systems and systems of organization have the best chance of success or failure; and so on … In developing a viable approach to the management of the commons, it is important, among other things, that a resource can be clearly defined and that the rules governing the use of the resource are adapted to local conditions. This suggests that rules imposed from outside, such as by government agencies, are unlikely to be successful.*

There are important areas of natural resource management where Elinor Ostrom's ideas should be adopted to avoid environmental catastrophe. Perhaps the most obvious example relevant to the UK is in European Union fisheries policy" (Institute of Economic Affairs, 2010).

Ostrom's work confirms the value of subsidiarity (the delegation of responsibility to the grass roots or lowest levels of social organisation) as a sustainable strategy with wide applications for the ecological maintenance of our renewable resources. Consequently, instead of fishing quotas being decided by the EU; they should be managed by fishing communities responsible for the region of the sea they fish. It has been found that: *"Community cohesion founded on norms, trust, communication, and connectedness in networks and groups was also an important global attribute leading to successful fisheries co-management"* (Gutiérrez, et al. 2011).

Elinor Ostrom maintained that one cannot categorically say that a government or a local community are necessarily the best managers of a commons. Ostrom states that *"We need to recognize that the governance systems that actually have worked in practice fit the diversity of ecological conditions that exist in a fishery, irrigation system or pasture, as well as the social systems. There is a huge diversity out there, and the range of governance systems that work reflects that diversity. We have found that government, private and community based mechanisms all work in some settings … but we cannot simply say that the community is, or is not, the best; that the government is, or is not the best; or that the market is, or is not the best. It all depends on the nature of the problem that we are trying to solve." In other words there is no 'best way' of doing something and that the way forward lies in the detail of the problem since no two problems are the same. The second challenge that Elinor Ostrom identified was the need for "developing a multidisciplinary, multi-tier framework for analyzing sustainable social-ecological systems that people across disciplines can use. We need to build better theories for explaining and predicting behaviour. We need to find ways of collecting data over time, but we have got to learn which variables we should be studying in a consistent way … And we need to understand design principles and why they work"* (Ostrom, 2012).

For example, some of the indigenous groups living in rain forests in India, Indonesia and the Amazon would make better caretakers of the forests than any others because "*Indigenous people have high stakes in protecting biodiversity because they depend on its survival for their own, hunting and gathering non-timber forest products for their daily needs, according to Nicole Girard, Asia program coordinator for Minority Rights Group International, a UK-based charity. "Once their resources are threatened by either development projects or climate change, the impact is felt more directly and more acutely than by those in cities," Girard adds.*

Over the generations they have learned to live sustainably and have a keen understanding of a forest's limitations, making them the ideal caretakers of forested land. For example, a traditional fire-prevention practice preserves eco-system functioning by creating barriers to contain flames, protecting the deepest and most essential parts of the forest, Tauli-Corpuz explains. Fonseca points out that "indigenous peoples' rights to forests have long been recognized as a crucial component to maintain the environment and address climate change" (IRIN, 2015).

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25.83 Overshoot

(q.v. Global Footprint Network, Planetary Boundaries, Climate Change, Tipping point)

In their landmark book, *Limits to Growth*, Meadows et al. (1974) applied the concept they called "overshoot" to sustainability.

Supposing you are driving towards a road junction controlled by traffic lights. Normally, on seeing that the lights turn to red you stop at the lights. No danger; and when the lights turn to green, you drive cross the junction and on your way. However, what happens in a fog? Maybe you do not see the lights change to red or even recognize that there is a junction and unknowingly you start to cross the junction – you are now in *overshoot* with great danger of a collision from cars crossing the junction from the left and right.

The car and a driver make up a system and if a signal to stop is not seen or ignored by the driver then the car will overshoot and the same phenomenon can happen in much larger systems where feedback is required to maintain a system's balance. Consequently, Meadows, et al (2004) write that "*There is often a delay of many years between the date when a problem is first observed and the date when all important players agree on it and accept a common plan for action.*"

So overshoot is the result of a delayed response to a problem that causes the effects to become worse (MacKenzie, 2012). An excellent example occurred with the discovery that chloroflourocarbons (CFCs) were damaging the ozone layer.

If we take the example of climate change we can see that knowledge about global warming has been known about for many years. However, worldwide coherent action has been impossible to achieve due the democratic processes and the part played by those (notably in the fossil fuel industries) who wanted to deny global warming. Meanwhile, recent years (2008, 2010 & 2011) have seen record CO_2 emissions instead of a reduction in emissions.

It has recently emerged that billionaires have anonymously donated $118m to two agencies which support anti-climate groups. "*By 2010, the "dark money" amounted to $118m distributed to 102 thinktanks or action groups that have a record of denying the existence of a human factor in climate change, or opposing environmental regulations … Those same groups are now mobilizing against Obama's efforts to act on climate change in his second term.*"

It is called 'dark money' since these groups receive money from untraceable sources and "*… there is no transparency, no accountability for the money.*" (Goldenberg, S., 2013) In fact the picture is worse, at the end of 2013 a paper published by Brulle describes how from 2003 to 2010 an average of $900,000,000 (yes, 9 hundred million dollars) was paid annually to 'think tanks' to create a counter-climate-change movement to deter legislation against greenhouse gas (GHG) emissions and confuse the public.

In 2007 the Arctic reached its tipping point and went into a positive feedback meltdown since it appears that during the summer season more of the ice melts to an ever greater extent and is unable to fully recover its area during the winter. Consequently, the sea absorbs more of the sun's warmth because there is insufficient ice to reflect the sun's rays back into space.

Meadows et al (1972) worked with the computer model, World3, which projected that initially the population and industry would grow exponentially and then start to slow and finally stop altogether because food would become scarce, the resources would run out and pollution would soar. In different computer runs of the World3 program instead of the population and industry stabilizing after peaking they went into sudden and uncontrollable decline. The reason for the decline in the model was the complex feedbacks between subsystems for example between industry, health, agriculture and pollution. The crash was due to the lack of response by hypothetical people to deal with problems arising within the different subsystems and who instead continued consuming and polluting beyond what could be sustained.

The Limits to Growth was badly misunderstood and heavily criticized when it was published, especially by economists, who anticipated technological innovations would fix the arising problems. However, one of its authors, Randers, says the book's real message was to draw attention to human delays in responding to situations before it was too late. The book's message was not to say that humans were doomed but that humans have the potential to avert catastrophe if they act as soon as possible.

Whatever criticisms there may have been when *The Limits to Growth* was originally published the human response to climate change has been one of enormous and dangerous procrastination. If one equates the timespan of a year and human consumption of the renewable resources provided by nature then, according to the Global Footprint Network we had consumed the resources for 2013 by 20 August which this year is called Overshoot day. Furthermore, from that date we are living on the natural capital that generates our annual income of natural resources. Twenty years previously in 1993 Earth Overshoot day was 21 October and in 2003 it occurred on 22 September. Today we need 1.5 Earths to support the 7 billion inhabitants sustainably. However, if all of the Earth's inhabitants were to live like Americans then four to five more Earths would be required (Ehrlich & Ehrlich, 2013).

It almost seems that we are unable to recognize that the traffic lights are red!

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25.84 Ozone Hole

(q.v. CFCs, IPCC, Climate Change)

The stratospheric ozone layer, which extends from 6 to 20 miles above the Earth's surface, is formed by the sun's action on oxygen (O_2) converting it to ozone (O_3). Ozone occurs in a concentration of 1 molecule in a 100,000 and absorbs most of the sun's harmful ultraviolet B light (UVB). The ozone layer

therefore protects life from the UVB light which has a wavelength frequency which can dismantle organic molecules including DNA. Consequently, it can cause skin cancers, inhibits the immune system's ability to fight disease and can also permanently damage the eyes. UVB light is also dangerous to many other organisms particularly very small and single celled organisms because of its ability to penetrate only a few layers of cells (hence the danger of skin cancers for humans). UBV light also penetrates the surface of the seas to a depth of several meters where most marine micro-organisms live and which, it has been found, are sensitive to UBV. In itself this might not appear to be important until we remember that planktonic organisms form the basis of marine food chains. Plants are also detrimentally affected by UBV and for 60% of crop plants studied yields drop as UBV light increases. In conclusion damage to or loss of the Earth's ozone layer would have serious effects on all ecosystems.

Chloroflourocarbons (CFCs) were first synthesized in 1928 and are chemically stable, non-corrosive and apparently benign. CFCs are excellent insulators and coolants and when released into the atmosphere they were thought to be harmless. However, this apparently wonderful compound was being produced in millions of tons by the mid-1980s and 100s of millions of refrigerators, freezers, air conditioners, and coolers were produced with CFC coolants.

The bad news for this apparently synthetic dream molecule came in 1974 in two scientific papers from which it was clear that CFCs were reaching the stratosphere and breaking up and releasing chlorine atoms. The independently published second paper said that chlorine atoms can destroy ozone molecules. Furthermore, the chlorine atom can repeat the ozone destroying process many times. Clearly, the loss of the ozone layer could have very serious consequences for life on Earth. CFCs caused two ozone holes; one over each pole.

Banning CFCs, which were central to the white goods industry and grossing millions of dollars would clearly be difficult. However, the environmentalist lobby in the USA reacted strongly once the link between CFCs and the ozone layer became known. Their action focussed on aerosol cans, many of which used CFCs as a propellant (despite other agents also being used). In 1978 legislation was finally passed in the USA banning CFCs in aerosol cans which resulted in a substantial drop in CFC production around the world. However, world production rose back to earlier levels and went onto peak in the late -80s at more than 1,200,000 tons per annum (Meadows, Randers & Meadows, 2004). The effects of the CFCs are still very much with us as it will take more years for the ozone layer to completely recover.

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25.85 Paradigm shift

(q.v. Phase Transition, Tipping Points, Chapter 2)

A paradigm shift is occurring in design education. "*A paradigm is an accepted model or pattern*" (Thomas Kuhn, 1971, p.23) identifying an approach and also the underlying assumptions about a large field of activity. A paradigm shift is therefore a fundamental change as for example took place in physics with the shift from Newtonian to Einsteinian mechanics. Unfortunately, the term paradigm has become overused and probably zeitgeist, as suggested in Wikipedia, might be more appropriate in art and design. However, we adhere to the concept of a paradigm, as described by Kuhn, because the concept of zeitgeist is deliberately vague and defined as *"spirit of the times, trend of thought and feeling in a period"* (Sykes, 1984). Thomas Kuhn (1971), the science philosopher and historian, proposed and made famous the idea of paradigms, or patterns, to describe the established consensus of thought and procedures which for long periods support stepwise progress in a (natural) science. However, when increasing anomalies begin to become recognized which are incompatible and cannot be explained within the existing paradigm a "revolution" occurs and the … *"Failure of the existing rules is a prelude to a search for new ones"* (Kuhn, 1971). A crisis starts to develop and opposing schools of thought may argue the issues (hence "scientific revolution") to determine "*… which paradigm should in the future guide research on problems many of which neither competitor can yet claim to resolve completely.*" but which can account for the anomalies. However, *"To be accepted as a paradigm, a theory must seem better than its competitors, but it need not, and in fact never does, explain all the facts with which it is confronted."* Kuhn proposed that such revolutions could only occur in the sciences where there is a concensus and consistent practice and a cohesive body of knowledge enabling a pattern or paradigm to be clearly recognized and consequently distinguishable from any successor. Kuhn considered that outside the natural sciences, for example in the arts and design there was insufficient concensus to identify a paradigm. Nonetheless, when one considers some of Kuhn's statements it can be seen that they do throw light on the changes occurring in design practice vis a vis sustainability and there can be no doubt that globally design education is in a paradigm shift. (see Chapter 2)

Kuhn's own writings are enlightening, for example:

› *"Paradigms gain their status because they are more successful than their competitors in solving a few problems that the group of practitioners has come to recognize as acute."* (p. 23)
› *"The existence of the paradigm sets the problem to be solved; often the paradigm theory is implicated directly in the design of the apparatus able to solve the problem."* (p. 27)
› *"In the process of being assimilated, the second [paradigm] must displace the first."* p. 97)
› *"... the reception of a new paradigm often necessitates a redefinition of the corresponding science."* (p. 103)
› *"Led by a new paradigm, scientists adopt new instruments and look in new places. Even more important, during revolutions scientists see new and different things when looking with familiar instruments in places they have looked before."* (p.111)
› *"paradigms determine large areas of experience at the same time."* (p. 129)
› *"Probably the single most prevalent claim advanced by proponents of a new paradigm is that they can solve the problems that have led the old on to a crisis. When it can be legitimately made, this claim is often the most effective one possible"* (p.153)
› *"All the arguments for a new paradigm discussed so far have been based upon the competitor's comparative ability to solve problems."* (p.155)
› *"the fundamental tenets of a field are once more the issue, doubts are repeatedly expressed about the very possibility of continued progress if one or another of the opposed paradigms is adopted."* (p.163)

Max Planck sadly remarked that *"a new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents die, and a new generation grows up that is familiar with it."* (p.151). As a footnote to Planck we might add that the changes which we must now bring about in design must occur within the lifespan of a generation!

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25.86 Peak Resources

(q.v. Ecosystem Services, Gross Domestic Product

The economic model to which the 'western consumer society,' and much of the rest of the world, adheres is based on the false concept that the world's resources are inexhaustible. Consequently, the majority of economists and politicians continue to believe in the viability of continual economic growth, despite the reality that resources are finite. The concern is now twofold, first, resources are finite and secondly, we have now come so far down the road of economic growth that it is now almost impossible to conceive of another model with a different set of (sustainable) infrastructures.

A peak resource is defined as one for which consumption is greater than supply.

Since 1964 there have been fewer world oil discoveries (Heinberg, a. 2007). Furthermore, the prediction of peak oil was first made by M. King Hubbert who controversially predicted that oil supply would peak around 1970. Today, however, it now appears that world oil production peaked around 2005 - 2006 (Heinberg, 2007). Fossil fuels, minerals, and soil on which to grow food and biofuels and many other resources; all exist in limited amounts. Heinberg (2007) considers that the human demand for resources in the twenty first century will cause many to peak and prices to rise as the numbers of the world's consumers or middle class is expected to increase by about 3 billion from 2 billion to about 5 billion by 2030.

The problem today however, is not that our reserves of fossil fuels will peak or run out but that they are 'stranded assets' and have to remain substantially unused since burning them for energy will add to greenhouse gas emissions and take global warming beyond 2°C. More precisely, McGlade & Ekins (2015) write that *"Our results suggest that, globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 °C."*

Water is a special case because it is essentially a cycling, renewable resource (hydrological cycle) but *"by* *some estimates, humans already appropriate almost 50% of all renewable and accessible freshwater flows (Postal et al. 1996), leading to significant ecological disruptions"* (Palaniappan & Gleick, 2009) so that ecosystem services on which we depend are now failing. Consequently, peak water should really be known as 'peak ecological water' because water is required to support both ecological and economic need and sociological requirements. In other words there must be enough water to sustain nature as well as ourselves. However, since both ecological disruptions are occurring and more than a billion people are without drinking water and altogether 2.6 billion are without water for sanitation (http://www.peakresources.org/) we may already consider that we have gone beyond *'peak ecological water.'*

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25.87 Permaculture

(q.v. Ecosystems, Satoyama)

The wonderful productivity of nature's ecosystems exist because of the complex network of relationships between diverse plants and animals and their environment. In contrast, industrialized food production barely considers relationships beyond a simple 'do this for that to happen,' e.g. plough the field to prepare it for sowing. Spread fertilizer for a productive harvest, etc. Permaculture produces food by simulating nature's ecosystems by identifying and emphasizing the interconnections between the organisms and the environment and saving the enormous and unsustainable input of energy by mechanized agriculture. As Patrick Whitfield (2010) writes in his introductory book "*... the basic idea of permaculture: create edible ecosystems.*"

Permaculture aims to create a holistic system of self-sustaining organic relationships. For example, a forest ecosystem provides permaculture with a model for creating a forest garden where a mix of interdependent species are grown together for food and wood. This is in stark contrast to industrial mono-culture agriculture, growing one species over enormous fields and requiring enormous inputs of chemicals and fuel. However, the permaculture strategy is characterized by a forest garden of different but a compatible crop community of plant species of different sizes 'stacked' at different levels.

Permaculture and its variants are not new. Cultures in different parts of the world have learnt to manage gardens modeled on the natural forest. The Japanese call it *'satoyama'*, a natural environment that is managed, typically a coppiced woodland, with adjacent and small cultivated plots etc. In other words satoyama is characterized by the same concept as permaculture and achieves a co-existence with nature by the holistic recognition and care for the interrelationships.

In southern China farmers have been farming fish and rice together in the same fields for over a 1,000 years. Scientists discovered that as a consequence 68% less pesticide and 24% less chemical fertilizer was required to achieve the same yields. The fish helped to reduce the pests by a quarter whilst nitrogen from unconsumed fish feed and their excreta was taken up by the rice and boosted yields (Anon, 2011).

Other cultures which have developed forest garden type strategies are to be found in Tanzania amongst the Chagga people and in Kerala, south east India. Archaeologists (2008) have also reported evidence of urban management and garden cities in the Amazonian rain forest prior to the Spanish conquests and European settlement.

The term permaculture was first coined by two Australians Bill Mollinson and David Holmgren in 1978 when they published a book called *Permaculture One* (Whitfield, 2010). Mollinsen recognized that industrialized agriculture is not the way forward to a sustainable future. The peaking of oil production and the fact that fossil fuels will have to remain substantially un-used to keep climate change below 2°C (Steffen, et al. 2015) pose serious questions for western style agricultural as it has so far developed and obviously cannot continue.

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25.88 Planetary Boundaries

(q.v. Chapter 4, Anthropocene, Tipping points)

In September 2009 a team of scientists led by Prof Dr Johan Rockström published a 'milestone' paper in the journal Nature in which they described the identification of nine parameters or 'planetary boundaries' which they believe are essential for our species not to overstep. The Earth's environment has been surprisingly stable during the last 10,000 years – the geological age known as the Holocene. However, since the Industrial Revolution mankind has wrought such substantial changes that geologists now propose that we have entered a new geological age which they call the Anthropocene (q.v.). What are these Boundaries and why is it dangerous for us to exceed them?

The nine planetary boundaries are:

1. Climate change.
2. Rate of biodiversity loss.
3. Nitrogen and phosphorus cycles.
4. Stratospheric ozone depletion.
5. Ocean acidification.
6. Global freshwater use.
7. Change in land use.
8. Atmospheric aerosol loading.
9. Chemical pollution.

The scientists identified quantifiable limits for all except the last two boundaries on the list. They propose that mankind should keep within these boundaries, the *"safe operating space,"* so as to maintain the stable environment of the Holocene which has been enjoyed by mankind throughout the period of cultural evolution. However, the exponential increase of mankind's population, consumption and activities has already resulted in our going beyond the safe boundaries of pollution through the overuse of nitrogen fertilizers, biodiversity loss, and climate change. The disturbance of the Earth's subsystems by transgressing these boundaries could have severe results since many of the subsystems behave non-linearly and could abruptly change on reaching a tipping point. Furthermore, since many systems are interconnected, abrupt change in one subsystem could have unforeseen consequences in other systems.

The authors of the paper warn that their analysis *"suggests that three of the Earth-system processes – climate change, rate of biodiversity loss and interference with the nitrogen cycle – have already transgressed their boundaries."* Furthermore, that *"humanity may soon be approaching the boundaries for global freshwater use, change in land use, ocean acidification and interference with the global phosphorous cycle"* (Rockström, et al. 2009).

The significance of this pioneering paper was confirmed by its message being republished within months both in the New Scientist (Pearce, 2010) and the Scientific American (Foley, 2010) in 2010.

One tipping point may have been reached in 2007 when an enormous extent of the Arctic Ice cap had melted. The melting is now thought to be in a positive feedback mode as the exposed Arctic Ocean absorbs more of the sun's warmth which was previously reflected by the extensive ice cap. A record low for the extent of the Arctic sea ice was recorded again in 2011, undoubtedly caused by human-induced global warming. In 2007 the floating ice minimum melted to only cover 4.27 million square km but in September 2011 covered 4.24 million square km. *"Ice volume is now plunging faster than it did at the same time last year when the record was set, … if current trends continue, a largely ice-free Arctic in the summer* *months is likely within 30 years – up to 40 years earlier than was anticipated in the last Intergovernmental Panel on Climate Change (IPCC) assessment report."* (Vidal, 2011).

One tipping point which has been reached and scientists now believe is unstoppable is the meltdown of the West Antarctic Ice Sheet (WAIS) and this will add an estimated 3.3 metres to the world's sea level (Le Page, 2015).

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25.89 Planned obsolescence or "designed for the dump"

(q.v. WEEE, Re-Strategies, Peak Resources)

Planned obsolescence is a commercial strategy aimed at maintaining and increasing profits by the sales of products. The aim is to deliberately shorten the 'lifetime' of a manufactured product. Products with planned obsolescence break down and can no longer function after a limited period determined by the manufacturer despite the technological capability to produce products to function well beyond the limited period. In today's world which recognises finite resources this unethical practice unfortunately continues. The consequence is *"designed for the dump"* (Leonard, 2010) or throw away products which are a waste of resources and create pollution. The situation is further exacerbated by the deliberate design and manufacture of products so that they cannot be easily dismantled or repaired. Alternatively, the repair costs are so expensive that the favoured and usually cheaper option is to buy a new and upto-date model. Exactly what the manufacturer wants.

Since the 1920s manufacturers have been deliberately shortening their products' lifespans in order to keep consumers buying. Planned obsolescence is at the heart of the consumer society. In 1881 Thomas Edison had already been able to create lightbulbs which would burn for 1,500 hours and further developments extended the life-time of bulbs to 2,500 hours. A now rare and celebrated lightbulb at the Livermoore Firestation in the USA has been burning continuously for more than 100 years with a filament designed by Mr Challait. However, lightbulbs with a long life were bad for business because customers rarely needed to replace them. In 1924 Philips, Osram and the French company Delon formed the *Phoebus cartel* and mutually committed themselves to manufacturung lightbulbs which would burn for a much shorter time span than was technically possible. The Phoebus cartel agreed to produce bulbs which would burn for less than 1000 hours. The lightbulb became the first product victim of an industrial cartel to reduce its lifespan!

An online video film exposes the extent of obsolescence (1). The introductory text to the Community video asks ...

"Did you know that the lifetime of light bulbs once used to last for more than 2500 hours and was reduced on purpose to just 1000 hours? Did you know that nylon stockings once used to be that stable that you could even use them as tow rope for cars and its quality was reduced just to make sure that you will soon need a new one? Did you know that you might have a tiny little chip inside your printer that was just placed there so that your device will break after a predefined number of printed pages thereby assuring that you buy a new one? Did you know that Apple originally did not intend to offer any battery exchange service for their iPods/iPhones/iPads just to enable you to continuously contribute to the growth of this corporation? This strategy was maybe first thought through already in the 19th century and later on for example motivated by Bernhard London in 1932 in his paper Ending the Depression Through Planned Obsolescence. The intentional design and manufacturing of products with a limited lifespan to assure repeated purchases is denoted as planned/programmed obsolescence and we are all or at least most of us upright and thoroughly participating in this doubtful endeavor. Or did you not recently think about buying a new mobile phone / computer / car / clothes / because your old one unexpectedly died or just because of this very cool new feature that you oh so badly need?"

The American social commentator and critic, Vance Packard describes the different kinds of obsolescence developed by companies in his classic *The waste makers*. Obsolescence was a deliberate strategy to create economic growth at a time during the -50s when the American home market was materialistically satiated with consumer goods. Business colluded with the banks who introduced credit cards to finance consumer spending. Packard recounts how consumers were dissatisfied because they had bought products on credit but by the time the instalments were paid off and the product finally belonged to the owner it had already broken down. Perceptively, in 1960 Packard criticises and warns of the squandering of vanishing resources.

Packard (1967, p 58-59) identified three kinds of obsolescence:

"Obsolescence of function
In this situation an existing product becomes outmoded when a product is introduced that performs the function better.

Obsolescence of quality
Here, when it is planned, a product breaks down or wears out at a given time, usually not too distant.

Obsolescence of desirability
In this situation a product that is still around in terms of quality or performance becomes 'worn out' in our minds because a styling or other change makes it seem less desirable."

The third obsolescence brings the whole issue of fashion into question which ultimately is based on *conspicuous consumption* (Veblen, 1899) and the ability to display status and wealth, a display which is incompatible with sustainability. Is fashion design an unsustainable design oxymoron or paradox?

Today, obsolescence remains with us; we are compelled to update computers to remain compatible only to find that the redesign of sockets for connecting the wires no longer makes it possible to use the old printer or scanner forcing further purchases etc., etc.

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25.90 Politics

(q.v. economics, deep ecology & attitudes)

Politics is defined as *"the activities associated with the governance of a country or area, especially the debate or conflict between individuals or parties having or hoping to achieve power."* This is the definition provided by the New Oxford Dictionary of English (Pearsall, ed. 1998). That debate is concerned with different sets of priorities and aims to be achieved through different courses of action for governing a country.

Design and art students might think that politics is a subject about which they need not bother much. Unfortunately, with today's level of political competence (not to mention deception) we must all possess a far more holistic perception of the world and develop a viewpoint which certainly embraces some knowledge of politics especially the contemporary political scene. This is essential for our participation in democracy and achieving a sustainable world because politicians are our representatives and make decisions which are supposed to concern everyone's interests and future. This means that we need to be aware of what is happening concerning the politics of, for example; climate change and energy, agriculture, resources and recycling and the legislation to control the powers of corporations and so on. Consider, for example, the following action by 3 political leaders.

In 1998 the European Union began to develop a policy known as REACH (which stands for the Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals) to protect human health and the welfare of the environment. The aim of the REACH policy was to identify and phase out very hazardous chemicals which should be replaced by more benign chemicals. Furthermore, the REACH regulations would require that all new chemicals should be rigorously tested before entering the markets to ensure their safety (Goldsmith, 2009).

Once the first drafts of the proposed REACH regulations were circulated to members of the European Parliament, the powerful European Chemical Industry Council claimed that REACH was unnecessary and wrote to all MEPS in 2001 claiming that *"There is little direct evidence of widespread ill health or ecosystem damage being caused by the use of man-made chemicals"* (Neonicotinoids?). Meanwhile, in the interests of the chemical industry the three political leaders, *"Tony Blair, Gerhard Schröder and Jacques Chirac issued a joint letter to the EU commission, claiming that REACH would undermine the international competitiveness of the European chemical industry"* (Goldsmith, 2009). In addition, the US government aggressively joined in on behalf of its chemical industries against the REACH proposal. The result was that REACH was significantly watered down to the extent that *"The German chemical industry meanwhile, in its 2005 annual report, boasted that 'Many members of the European Parliament have taken up our proposals"* and that *"the EU Parliament Committee for the Internal Market and Consumer Protection has largely accepted our proposals and presented them in the debate as a practicable alternative to the commission's proposed regulation"* (Goldsmith, 2009). This is another example of *"corruption of the regulatory system that has allowed the rise of reckless and unsound science"* (Goldsmith, 2009). The politically inadequate control of the chemical industries both in Europe and the US means that *"Our food arrives contaminated with pesticides and wastes, wrapped in plastic made of hormone disrupting chemicals ... Man-made chemicals are creating a silent epidemic. Our children are sicker; cancer, obesity, allergies and mental health issues are on the rise in adults; and frighteningly, we may be less intelligent than previous generations"* (Cribb, 2014).

REACH came into force on 1st June 2007. This example illustrates that politicians do not always make decisions to protect the welfare of the electorate or the environment but for the benefit of powerful corporations. One reason for this is the extensive lobbying pressure politicians experience. In Brussels there are at least 30,000 lobbyists and it is estimated that they influence 75% of legislation. *"Lobbying is a billion-euro industry in Brussels"* (Traynor, 2014).

The American climate expert, James Hansen, one time head of the NASA Goddard Institute for Space Studies in New York, participated in a protest against the power firm E.ON building a new coal power station at Kingsnorth, Kent, England. Hansen said that *"The democratic process doesn't quite seem to be working ... The first action that people should take is to use the democratic process. What is frustrating people, me included, is that democratic action affects elections but what we get then from political leaders is greenwash ... The democratic process is supposed to be one person one vote, but it turns out that money is talking louder than the votes. So, I'm not surprised that people are getting frustrated. I think that peaceful demonstration is not out of order, because we're running out of time." Hansen commented that a scientific meeting in Copenhagen the previous week had clarified the "urgency of the science and the inaction taken by governments"* (Adam, 2009).

If politicians cannot stand up to the chemical industry then our concern now is how will they will stand up to the energy industries? *"Policy makers have generally agreed that the average global temperature rise caused by greenhouse gas emissions should not exceed 2°C above the average global temperature of pre-industrial times ... the unabated use of all current fossil fuel reserves is incompatible with a warming limit of 2°C"* (McGlade & Ekins, 2015). In their paper McGlade and Ekins suggest that, *"globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2°C."* Furthermore, *"policy makers' instincts to exploit rapidly and completely their territorial fossil fuels are, in aggregate, inconsistent with their commitments to this temperature limit. Implementation of this policy commitment would also render unnecessary continued substantial expenditure on fossil fuel exploration, because any new discoveries could not lead to increased aggregate production"* (McGlade & Ekins, 2015).

In *Awakening from the American dream*, Miles (1976) was primarily writing about energy but we can see that his propositions which begin with energy ramify and apply equally to politics and economics. His propositions were that:

""*(1) The more energy a society uses, the more interdependent it tends to become, both within itself and in relation to other societies.*

(2) The more interdependent a society becomes, the more complex it becomes, and the more man-designed and man-controlled its economic, ecologic, and political systems and sub-systems become.

(3) The more complex and interdependent the systems and subsystems, the more vulnerable they become to design failures, since:

(a) No human designers, and this applies especially to the politicians who are responsible for designing the largest systems, can know or comprehend all the factors that need to be taken into account, and their interrelation, sufficiently to make the current set of systems work well. If complexity and interdependence increase further, the problems will be further compounded and the stability of the systems further jeopardized.

(b) Those responsible for selecting the designers – the voting public in a society like the United States – are even less informed about the intricacies of the systems than the politicians who represent them. They cannot judge, therefore, which programs or social designers (politicians) to support, and in consequence they are highly likely to vote for the representatives who promise to support programs that benefit them directly and immediately – a fatal flaw in designing workable complex systems for interrelating enormous numbers of human beings with each other and their environments.

(4) The United States is probably nearing the point (it could even be beyond it) where the complexity of the systems of interdependence exceeds the human capacity to manage them, causing system breakdowns to occur as fast or faster than any combination of problem-solvers can solve them.

(5) World systems of interdependence are more remote, inefficient, and precarious than national systems, and may have exceeded their sustainable level of complexity" (Miles, 1976). In popular parlance, as was recently observed we have reached the point where *"Everyone is totally just winging it, …"* (Burkeman, 2014) as was demonstrated in political satires produced by the BBC in series called *"Yes Minister"* and *"The thick of it."* (BBC Worldwide Ltd, 2012).

The incompetence of those in power is particularly well illustrated by the 2008 economic crash. Lets use the UK to illustrate the situation. One would imagine that the Bank of England is a competent and able organization with experienced experts. However, secret documents from the time show how the Bank's court or board of directors, *"ill-prepared it was for the worst financial collapse in modern history, with senior officials changing their minds about the effectiveness of the regulatory system in place as the crisis unfolded"* (Elliott & Treanor, 2015). The economics correspondent of both the Guardian and Observer Phillip Inman (2014) writes that: *"One of the difficulties in describing the UK's current situation and the issues facing policymakers is the way elements of the economy are interconnected. The UK's links with other countries and major shifts in the way economies are organized has also complicated the story."*

This illustrates the profound problem of specialization and the fragmentation of knowledge disabling anyone from having a holistic perception so that decisions are made without the necessary information. In the UK, three bodies were supposed to be in charge of its fiscal management. This tripartite system of regulation was composed of HM Treasury, the Bank of England and the Financial Services Authority (FSA). The papers reveal that at one point the Bank congratulated itself on how well this tripartite system worked. However, subsequently the tripartite system was broken up and the FSA disbanded because *"the governor was telling the court that the tripartite arrangements were 'not sufficiently workable or relevant to managing a crisis'"* because *"The roles, in a crisis, of the Bank, the Treasury and the FSA were ill-defined,"* (Elliott & Treanor, 2015). Furthermore, the papers also reveal that *"the court of the Bank as a meek body, unwilling or incapable of challenging Bank officials"* (Pratley, 2015). The Bank of England's powers have now been increased and it has taken over the regulation of the banking system in the UK (Elliott & Treanor, 2015).

In conclusion, we need to be as fully informed as possible in order to both participate in- and protect democracy and ensure that it is driven towards and contributes to achieving a sustainable future; something which not all politicians are so concerned about!

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25.91 The Post Carbon Institute (PCI)

(www.postcarbon.org/)

(q.v. Transition initiatives, resilience)

The following text is slightly adapted from the Post Carbon Institute's web page:

The Post Carbon Institute was founded in 2003, with the *"mission to lead the transition to a more resilient, equitable, and sustainable world by providing individuals and communities with the resources needed to understand and respond to the interrelated economic, energy, and ecological crises of the 21st century … . We envision a world of resilient communities and re-localized economies that thrive within ecological bounds."*

The Issues addressed by the Post Carbon Institute are in response to their belief "that the world is experiencing the confluence of crisis in four interrelated systems – energy, ecology, economy, and equity – which we call E4. These crises can be summarized as:

› The age of extreme energy. Declines in the amount of affordable energy available to society mean far higher environmental, economic, and social costs.
› Overshoot abounds. Across the board – food, population, water, biodiversity, climate change, etc. – we are hitting biophysical limits.
› The end of growth. As a result of the limits within and outside the economic system, we are experiencing the end of economic growth as we've known it.
› Increasing inequality. Rising domestic and global inequality could lead to tremendous socio-political unrest (and ultimately economic and environmental disaster), as a growing population struggles to share diminishing economic and natural resources.

Our Strategy

Post Carbon Institute provides individuals and communities with the resources needed to understand and respond to the interrelated economic, energy, and ecological crises of the 21st century. We help build resilience to withstand these crises, and support social and cultural change to make society more ready to take decisive and appropriate action. Specifically, we:

› Grow collective understanding of our energy reality, and the need for both conservation and appropriate, community-centric renewable energy.
› Promote community resilience as the best way to build thriving, re-localized neighborhoods, towns, and cities capable of withstanding coming disruptions.

Support a growing movement of innovators and early adopters who can develop best practices and provide leadership both now and during future crises."

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25.92 Rare Earths and energy critical elements (ECEs)

(q.v. WEEE)

The rare earths belong to two groups of elements in the periodic table of elements known as the lanthanides and the actinides (Gray & Mann, 2009) and some of them are not rare at all. They include elements such as scandium, yttrium and the lanthanides which are essential for the information and communication technologies (ICT), and also for the developing green technologies and batteries. Rare earths possess a range of special qualities (electronic, magnetic, optical and catalytic properties) which profoundly enhance the performance of complex technological systems (Hatch, 2011).

Tungsten, tin and tantalum are required for capacitors and circuitry in the ICT and where as many as 65 different metals may be required for telephone circuits. Furthermore, these technologies are developing very rapidly (fulfilling Moore's law which predicts that the number of transistors which can be packed onto an integrated circuit board doubles every 18 months and the associated industries are aiming to maintain Moore's predicted rate of progress) (Williams, 2011). Rare earths also include the "energy critical elements" or ECEs which are elements able to transform the ways in which energy is captured, transmitted, stored and conserved.

These elements are unevenly distributed around the world with China possessing 50% (Anon. b, 2011) of the world's deposits and until recently China met 97% (Jones, 2011) of the world's demand. However, China caused international concern in 2010 after recognizing the significance of the rare earths it was exporting and so it proposed to raise taxes and reduce exports (Anon. a, 2011) in order to retain more of its rare earths for its own industries.

The news caused a flurry of concern worldwide because of the threats to both continuing technological development and economic growth especially in the west. In addition to the digital technologies, rare earths and ECEs are crucial for the energy and military technologies.

The supply of rare-earths has posed ethical problems for the ICT industries since some supplies entered the world market from terrorists committing genocide etc. in the Democratic Republic of the Congo. They market the elements to fund the purchase of arms. The US introduced the Dodd-Frank bill requiring companies to ensure that they are not sourced with "blood minerals" (Reardon, 2012).

An enormous problem is the recovery of the minerals from the colossal quantity of 'e-waste' now being produced in the West. New developments mean that consumers want the latest apps etc. on their I-phones for example. The development and increase of apps and functions has become possible as technologists understand how the properties of rare earth minerals provide the capabilities required for apps. In the 1980s about 12 elements were required for the manufacture of telephone circuitry. In the following decade the technological developments required about 16 elements but after the millenium the number of elements for a mobile phone or I-Phone had jumped to more than 60 elements.

Another big economic problem of rare earths is not only their finite supply but their recovery and recycling. *"Hazardous materials are liberated or generated after disposal in three ways:*

- *leaching from landfills,*
- *incineration and*
- *recycling … A great deal of ICT equipment is not recycled in proper facilities, however, but is processed by an informal (or backyard) industry in the developing world … There is mounting evidence that informal recycling in the developing world is causing serious environmental pollution"* (Williams, 2011).

It is estimated that the *"Millions of mobile phones, laptops, tablets, toys, digital cameras and other electronic devices bought this Christmas* [Vidal, 2013] *are destined to create a flood of dangerous 'e-waste' that is being dumped illegally in developing countries. The global volume of electronic waste is expected to grow by 33% in the next four years, … Last year nearly 50m tonnes of e-waste was generated worldwide – … These are electronic goods made up of hundreds of different materials containing toxic substances such as lead, mercury, cadmium, arsenic and flame retardants"* along with many rare earths. *"Once in a landfill, these toxic materials seep out into the environment, contaminating land, water and the air … An indication of the level of e-waste being shipped to the developing world was revealed by Interpol last week. It said almost one in three containers leaving the EU that was checked by its agents contained illegal e-waste"* (Vidal, 2013).

The rare earth elements play a key role in today's technological consumer society and demand for them has increased from 30,000 tonnes in the 1980s to around 120,000 tonnes in 2010 (Jones, 2011).

"Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU, with some 9 million tonnes generated in 2005, and expected to grow to more than 12 million tonnes by 2020." The European Commission has revised its WEEE directive *"To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential."* The new WEEE Directive (Directive 2012/19/EU) came into force in 2012 and was effective from 14 February 2014 (ec.europa.eu, 2014).

Our wasteful use of rare earths is an unethical squandermania. These are just some of the issues concerned with rare earths which are essential but finite resources. The question is: how can design help to solve the problems created by "e-consumerism"?

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25.93 Re-Strategies: Reduce, Recycle, Repair, Reuse & Remanufacture

(q.v. Circular economy, WEEE)

It is well known that during WWII recycling made a significant contribution to the war effort on every side of the conflict. Campaigns were made to collect aluminium pots and pans for manufacturing aircraft and many other materials were collected and recycled. During the 1970s when the oil crisis occurred recycling began to become established again and provided a spur for the recycling of glass and paper to save energy.

Reduce

The big message of *Factor Four* and *Factor Five* is the reduction by half in our use of resources with 50 case studies illustrating examples of best practice from all areas of daily life by using fewer resources or generating more productivity. In other words achieving more with less. In the sequel, Factor Five, provides further specific examples. von Weizsäcker et al (2009) quote Hawken, Lovins & Lovins (2004) the authors of Natural Capitalism: *"At the heart of this chapter, and, … the entire book, is the thesis that 90-95 per cent reductions in material and energy are possible in developed nations without diminishing the quantity or quality of the services that people want. Sometimes such a large saving can come from a single conceptual or technological leap … More often, however, it comes from systematically combining a series of successive savings."*

One of the strategies for reducing resources and energy was developed by Ohno-sensai (1912-1990), the father of the Toyota Production System. *"Ohno opposed every form of waste"* (Hawken, Lovins & Lovins (2004). Whether it was remaindered goods or workers hanging around waiting to make their contribution to the production line *"Ohno called these muda, which is Japanese for "waste," "futility," or "purposelessness.""* Hawken et al (2004) provide many examples of waste during production and identify one antidote as 'lean thinking' which is concerned with simplification (Womack & Jones, 1997) and saving waste. Ohno achieved continuous flow in low volume production thereby optimizing his workforce, his production equipment (neither too large nor too small for the job) and resources since his production process did not result in 1000s of articles stockpiled waiting to be sold. His manufacturing strategies have been very influential and widely adopted. *"Lean* *thinking fundamentally reduces waste at the level not only of the firm but of the whole of society, because, as the Financial Times put it, "only what is needed will actually be made"* (Hawken, Lovins & Lovins, 2004).

Recycle

When most people think of sustainability they probably think of re-cycling tins, bottles and paper. However, sites and buildings can also by recycled, with new functions; Stewart Brand said that *"Every building is a forecast. Every forecast is wrong."* In other words buildings could be made to be recycled. If not as a whole, then many of its components, which so often find their way to landfill, could be re-used and their virtual energy costs saved. *"Dismantling buildings and selling their materials can also be profitable"* (Hawken, Lovins & Lovins, 2004). There is enormous employment potential in creating circular economies and it has been done successfully and profitably as Hawken et al describe. However, examining many rubbish bins in western countries (and in many design schools) confirms that we have much progress to make to ensuring that our waste is a resource 'food' for manufacturing. We must create new infrastructures. *"The smaller the loop, the more profitable it is!"* (Stahel, 2006).

Repair

Probably most people reading this are familiar with the problem of a component failing on a computer-printer or a stereo-music centre only to have to buy a whole new product because the component to be replaced cannot be bought separately. Alternatively, the repair would cost as much as a new machine. Stronger legislation is needed to bring back a culture of repair to make manufacturers responsible for products to be repairable.

Reuse

Reuse is a traditional strategy for the further use of goods facilitated by exchanges, car-boot or garage sales, charity shops and flea markets etc. Since the beginning of this century e-bay, etc., has enabled the reuse of goods to become worldwide with dealers buying at flea markets in one country and selling them on e-bay to clients in distant lands. *"Reuse and remarketing saves about 75 per cent of the energy embodied in a product. Rising energy prices thus increase the economic advantage of product reuse versus new goods"* (Stahel, 2006).

Remanufacture

Remanufacturing started during WWII in both the USA and the UK and has continued for at least 60 years. It *"… has created hundreds of thousands of jobs in tax-paying businesses that restore old products to like-new performance; save energy, natural resources and landfill space; and reduce air pollution by less re-smelting … The US remanufacturing industry has a number of professional organizations promoting its advantages in specific sectors"* (Stahel, 2006). Remanufacturing can also provide not only opportunities for employment but also social innovation, rehabilitation and welfare as illustrated by the Out of the Dark charitable social enterprise which *"… recycles, restores and revamps salvaged furniture as a means to train, educate and employ young people from disadvantaged backgrounds. At the heart of Out of The Dark lies the premise of creating an extended family. Not only is the enterprise run as a family business, all young people involved are welcomed into the fold and become part of the family"* (Lonsdale, 2014).

A new ethic

We need to adhere to the ethic of not merely recycling materials but rather that designers *borrow* the world's resources to create temporary arrangements of resources known as 'designs.' The concept of *borrowing* has the moral obligation (lacking in the term 'recycling) of *returning* materials for further use. This is a real responsibility of design, designers *borrow* the world's resources and are morally obliged to ensure their *return* for re-use.

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http://www.product-life.org/en/cradle-to-cradle
http://www.product-life.org/en/the-30th-anniversary-of-walter-r-stahel-prize-winning-paper-the-product-life-factor
The emergence of the modern circular economy: http://product-life.org/en/circular-economy

25.94 Resilience

(q.v. DESIS, Ecometrics, Transition Initiatives. Planetary boundaries, Schesiology)

Resilience is defined as "*... the capacity of a system, be it an individual, a forest, a city or an economy, to deal with change and continue to develop. It is about the capacity to use shocks and disturbances like a financial crisis or climate change to spur renewal and innovative thinking. Resilience thinking embraces learning, diversity and above all the belief that humans and nature are strongly coupled to the point that they should be conceived of as one social-ecological system*" (Moberg & Simonsen, n.d.).

Furthermore, *"Resilience thinking is about generating increased knowledge of how we can strengthen the capacity to deal with the stresses caused by climate change and other aspects of global change. It is about finding ways to deal with unexpected events and crises and identifying sustainable ways for humans to live within the Earth's boundaries"* (Moberg & Simonsen, n.d.).

Moberg & Simonsen both work at the Stockholm Resilience Centre, based within Stockholm University and the Centre is concerned with *"Sustainability Science for Biosphere Stewardship"* (Source 1.). The Centre's emphasis is one of reconnecting people and society with the environment so that they can understand how humans depend on ecosystems and the ecosystem services that they provide. This means understanding how everything is interconnected. Moberg & Simonsen write that the core "*... problem is that many of the serious, recurring problems in natural resource management stem from a lack or recognition that ecosystems and social systems are dynamic and inextricably linked.*" Therefore a new social – nature contract is needed which recognizes and cares for the interdependence of social-ecological systems and their sustainability. This requires effective global stewardship to ensure we sustainably remain within the operating space defined the planetary boundaries or parameters. In other words that we cannot indefinitely emit green house gases, consume natural resources beyond what is replenishable etc. They also promote the concept of a broad holistic systems approach which is concerned with the wider (interconnectedness) effect of proposed solutions to problems which currently are too linear and consequently cause further problems (q.v. schesiology). The Stockholm Resilience Centre sends out an e-newsletter which is a rich resource for design students and design educators, for example their video explaining the 7 principles for building and applying resilience in social-ecological systems:

1. Maintain diversity and redundancy to increase resilience.
2. Manage connectivity and well connected systems.
3. Manage slow variables and feedbacks.
4. Foster complex adaptive systems thinking.
5. Encourage learning and collaboration.
6. Broad partiicipation.
7. Polycentric Governance supporting the interaction of multiple bodies. (Source 2)

There are other resilience centers, for example the Resilience Research Centre RRC (Source 3) based in Nova Scotia has a different orientation and is concerned with the resilience of young people within the community, schools and other adversities across different cultures. Dr. Michael Ungar, Co-Director of the RRC, proposes that resilience is better understood as: *"In the context of exposure to significant adversity, resilience is both the capacity of individuals to navigate their way to the psychological, social, cultural, and physical resources that sustain their well-being, and their capacity individually and collectively to negotiate for these resources to be provided in culturally meaningful ways."*

Despite the different orientations of resilience it is clearly an area with which design will become increasingly and closely associated. In March 2013 the AIGA held its conference entitled "Compostmodern: resilience" in San Francisco and posed the question: *"If our present systems are struggling to adapt to change, how can we create more resilient systems that bend, but don't break?"* It is noteworthy that America's Institute of Graphic Arts is addressing the subject of resilience.

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25.95 Satoyama

(q.v. permaculture, indigenous strategies)

Satoyama was the traditional landscape of Japan. Today the meaning has evolved to what might be described as an agricultural woodland; somewhat similar to coppiced woodland that also used to be traditionally maintained in the UK. Satoyama woodlands occurred on hillsides interspersed with carefully managed terraced paddy fields. The woodlands protected the soil from the heavy rains that occur in Japan. At the bottom of the hills were habitations and vegetable gardens and paddy fields. The whole was composed of a patchwork of coppices, rice paddies, habitations, vegetable gardens and irrigation ponds which Japanese people regard as their idyllic landscape.

Idyllic though the satoyama landscape appears, it is also rich in biodiversity and the provision of ecosystem services including:

› provision of food,
› provision of wood,
› provision of mulch and fertilizer,
› rainwater and flood control,
› water table replenishment,
› treatment of wastewater,
› pest control,
› etc.

Today, there is increasing interest re-establishing the satoyama practices as well as adopting satoyama in other regions. It is the antithesis of the western style industrialized agriculture growing monocultures in enormous fields. If satoyama localities were scattered and integrated into the western style industrial agriculture it would have a number of benefits, not least stimulating biodiversity for pest control.

Satoyama is a self sustaining system which has much to compare it with permaculture (qv).

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25.96 Schesiology: connections and consequences

(q.v. Ecology)

Schesiology is defined as the study of relationships, connections and their consequences. The word is derived from the Greek word for relationship *"schese"* or "*∑ XE∑ H*" and the familiar *"logos"* to give schesiology. Stebbing (2011) felt that a new word was required to encourage design students to more rigorously consider the relationships and the consequences of their design decisions beyond the typical design brief 'box' of the client's and user's needs. The author felt that words such as 'systems theory,' 'networks,' or 'interactivity,' etc. are inadequate due to the meanings and preconceptions already associated with them.

As a design force, nature always works with endless time and complete 'information.' In contrast, human design activity is always limited by both finite knowledge and the skills of the designer, deadlines and the design brief and the knowledge acquired within these parameters. Although, design is quite good for solving problems in their immediacy, nonetheless, further problems subsequently arise due to working with incomplete information.

Schesiology was initially coined to encourage a fuller exploration of the interactions between the components of visual composition such as contrast, rhythm, balance and proportion.

However, schesiology can equally be applied to design so as to encourage designers to consider their design solution more as an intersection point within a multidisciplinary web of relationships transversing other fields of knowledge and materials and ultimately linked to the biosphere.

For example, a well known pharma company requires wood for its paper packaging and has established fast growing eucalyptus plantations in South

America. However eucalyptus (a native Australian species which is well adapted to drought) is reknown for its aggressive water requirement and lowering water tables and thereby threatens indigenous ecosystems. Furthermore, the water requirements of nearby local farmers are also challenged. Applying a schesiological perception of the relationships and their consequences could have led to a more sustainable choice and a search for a suitable indigenous South American species for paper production.

Another example illustrates a more serious ethical issue which is the rare earths supplied to the manufacturers of I-technologies. Some of these rare earths emanate from the Congo Democratic Republic where warlords trade minerals for money to buy arms and commit mass rape and genocide.

Globalisation means that the chains of supply and waste become anonymous. Schesiology is a simple strategy to help us design ethically and more sustainably by focussing on the connections of our choices to areas well beyond the immediate design problem. A schesiological enquiry is therefore not limited within one field or system but crosses any disciplines in the persuit of the web of connections and consequences.

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25.97 SIPS

(q.v. MIPS, ecological footprint, Gaia theory)

SIPS is the acronym for Surface input per Service Unit and is "*a measure of land use. SIPS "is necessary to define ecological indicators in such a way that economic activity and ecological necessity can be linked*"" (Schmidt-Bleek, 1993). The two strategies, MIPS and SIPS, proposed by Schmidt-Bleek are attempts to address the problem of the finiteness of both the Earth's resources and its surface area.

When the Earth's surface provides for human needs; "*This means that through such human appropriation the biosphere loses evolutionary balance and stability. This loss can be partially compensated through planting such areas with grass, shrubs or trees*" (Schmidt-Bleek, 1993).

Schmidt-Bleek writes that: "*Our task is to find simple, scientifically defensible and easily measurable indicators that are able to reflect the complex ecological changes (losses) due to this appropriation of surface area …*

1. *Although these indicators should be simple, they should reflect significant influences on the environment.*
2. *They should be based on characteristics that are common to all processes, goods and services.*
3. *The chosen characteristics must be easily measurable and subject to quantification.*
4. *Their application should be cost-effective.*
5. *The measures should permit the transparent and reproducible estimation of environmental stress potentials of all conceivable plans, processes, goods and services from the cradle to the cradle.*
6. *Their use should always lead to directionally stable results.*
7. *The measures should form a bridge to market activities.*
8. *They should be usable on all levels: locally, regionally and globally."*

Schmidt-Bleek's (1993) colleague, Sascha Kranendonk, made some SIPS calculations and determined that to supply the Germans with the orange drink that is consumed requires a land surface about the size of the German state of Saarland (150,000 hectares) or an area of 24 m² per capita. Since oranges do not grow in Germany the juice is imported from Brazil and then transported 12,000 km to Europe.

The ecological rucksack for the orange juice requires 25kg of "environment" and the virtual water used just for the processing of the juice requires 22 glasses of water per glass of orange juice. There are more ecological costs such as the fuel used by agricultural machinery and also for the transport to Europe, etc.

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25.98 Sixth Extinction or the Holocene extinction

(q.v. Anthrpocene, Ecosystem Services, Planetary Boundaries)

Throughout the history of the Earth there have been five massive extinction events. Today mankind has brought about the sixth. The previous five extinction events which geologists have identified occurred:

1. 440 million years ago (mya) at the end of the Ordovician epoch when about 85% of marine species disappeared. At that time all life lived in the sea.
2. 375 -359 mya was the late Devonian extinction which was rather slow and caused the demise of fish groups and stopped any new coral reefs from forming for 100 million years.
3. 252 mya at the end of the Permian when as much as 97% species disappeared.
4. 201 mya at the end of the Triassic when a massive and rapid extinction occurred.
5. 66 mya when an asteroid caused the extinction of the dinosaurs and marked the end of the Cretaceous epoch. (Natural History Museum)

The sixth extinction, which is occurring now, began slowly thousands of years ago with the demise of the megafauna by early hunters. Biologists describe the current world ecological situation with the dying off of so many species as "the sixth extinction." The normal rate of extinction is about 1 species per million, per year and the evolution of new species is estimated to occur at about the same rate (Wilson, 2011). The current rate however, is now 1000 times the normal rate (Pimm, et al. 2014). Edward *"Wilson famously used the species – area relationship to estimate an annual extinction rate of 27,000 species – one species every twenty minutes. This and similar estimates have attracted criticism but recent work has shown that levels of species endangerment are rising in line with species – area predictions."* (Purvis & Hector, 2000)

In 2014 the World Wildlife Fund reported a 52% reduction in the populations of vertebrate animals worldwide (McLellan, et al. 2014).

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25.99 Soft Path Solutions

(q.v. Third industrial revolution)

The "Soft Path" strategy was first proposed by Amory Lovins in his pioneering and perceptive work 'Soft Energy Paths' (1977). Lovins's fundamental idea is to reconsider energy policy and make a transition from centralized, gigantic power plant systems with enormous infrastructures to a decentralized renewable family of "soft technologies:" *"direct solar energy, wind, and biomass conversion – the use of crop, wood, and other organic wastes and, where suitable … an ecologically balanced growth of trees and shrubs for conversion to liquid and gaseous fuels."*

Lovins identifies that the problem of centralized systems is their costly infrastructures and calculated that *"At least half your electricity bill is fixed distribution costs to pay the overheads of a sprawling energy system: transmission lines, transformers, cables, meters and people to read them, planners, headquarters, billing computers, interoffice memos, advertising agencies … Local or domestic energy systems can reduce or eliminate these infrastructure costs. The resulting savings can far outweigh the extra costs of the dispersed maintenance infrastructure that the small systems require …"*

Soft technologies are diverse, resilient, sustainable, benign and come from local sources. They also use relatively low technology, are flexible and easy to understand so that a householder or plumber might fix a solar panel or house wind turbine. The domestically distributed turbines and solar panels would mean that every household could become a contributor to the national energy grid rather than a consumer. Furthermore, local ‘soft systems’ are cheaper to maintain and repair as is currently being discovered in the maintenance of water systems in London.

Such a decentralized system would be incredibly resilient to disaster since centralized power grids are susceptible to various risks including solar storms, terrorism, storm damage etc. Furthermore, a power failure of a centralized system can spread to cause a blackout over a large area as happened in 2003 during the Northeast Blackout in the USA.

Soft path solutions were also proposed for freshwater resources by Peter Gleick (2003). Gleick observes that although the “hard path” management strategies for water provision have brought many benefits with the construction of massive dams and reservoirs to support irrigation etc. they have also brought many problems. For example, the water flows of many rivers no longer reach the deltas with detrimental effects on biodiversity. Furthermore, over 25 % of all North American freshwater fish species are faced with extinction.

Gleick recommends that a “soft path” strategy is required for water management. He proposes that small-scale decentralized facilities are now required as well as improving the existing productivity rather than seeking new sources of supply. Similarly to Lovins, Gleick proposes water provision more closely matched to users’ needs. *“… society’s goal should be not the use of water, but improved social and individual well-being per unit water used.”* Gleick notes that the amount of water for sanitation and waste disposal has dropped by 75% over the last two decades and greater savings are possible although waste disposal can be achieved without any water at all.

Decentralized “soft path” solutions for water provoke a range of ideas such as the creation of small regional reservoirs which would also encourage biodiversity. Management and channeling of water from flash floods due to localized heavy rainfall to sink fields for infiltration to refill aquifers. Rainwater collection from roofs etc.

Jeremy Rifkin (2011) in his book of *“The third industrial revolution”* (qv) follows Lovins’s thesis of decentralized renewable energy and *“asks us to imagine hundreds of millions of people producing their own green energy in their homes, offices, and factories and sharing it with each other in an “energy Internet.”*

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25.100 Stahel, R. Walter

(q.v. Circular Economy, Re-Strategies)

Walter Stahel (1946) studied at the Swiss Federal Institute of Technology in Zurich. He is a pioneer in developing and advocating sustainable concepts for industrial economies such as *‘service-life extension of goods – reuse, repair, remanufacture, upgrade technologically’* (Wikipedia, 2014). In 1982, he wrote a prize winning paper entitled *‘The Product Life Factor’* following which he co-founded a consultancy specializing in sustainable strategies called the *Product Life Institute* based in Geneva. He is a major developer of ideas concerning the circular economy and promoting resource efficiency by enhancing the life of products and thereby reducing resource consumption and contributing to dematerialization. He published his ideas in 2006 and (revised in 2010) in a book entitled) *‘The performance economy’*. Stahel published an earlier book in 1981 entitled, *‘Jobs for tomorrow’*.

The abstract to his important prizewinning 1982 essay *Product-Life Factor* reveals his visionary perception, and we quote the abstract in full, he wrote: *“This paper attempts to show that the extension of the use-life of goods is, first, a sensible point at which to start a gradual transition towards a sustainable society in which progress is made consistent with the world’s finite resource base and, second, a strategy consistent with an active and independent role for the private sector. Product life, or the period over which products and goods are used, governs their replacement speed and thus the consumption of natural resources required for their manufacture and the amount of waste they create. Shortening product-life increases demand for replacement goods where these can be afforded. Extending product-life optimizes the total lifespan of goods and reduces depletion of natural resources and consequently waste; it builds on and increases wealth. Longer use of products will thus contribute to the transition towards a sustainable society. Compared to fast-replacement, product-life extension is a substitution of service activities for extractive and manufacturing Industries, and a* *replacement of large-scale capital-intensive companies by smaller, labour-intensive, locally integrated work units. The private sector, whether R&D, manufacturing or finance, will find innumerable business opportunities in product-life extension activities - REUSE, REPAIR, RECONDITIONING and RECYCLING. Indeed, while increasing the number of skilled jobs available and reducing our dependence on strategic materials, such activities will provide the private sector with fresh impetus to make cheaper goods available as part of a self-replenishing economy built on a spiral-loop pattern which allows a substitution of manpower for energy. In this way, unemployment and poverty which certainly aggravate the fundamental instability of the world economy might be substantially reduced. The private sector has, moreover, resources and skills that uniquely qualify it to initiate this transition towards a sustainable society where a balanced use of resources and other societal goals are achieved. Potential disincentives and obstacles ca, we believe, be overcome with appropriate education and fiscal and policy measures."*

Stahel was the originator of the phrase '*cradle back to cradle*' which in its derivative form 'cradle to cradle' was subsequently popularized by McDonough & Braungart, (2002).

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25.101 Stationarity

(q.v. climate change)

'Stationarity' is the concept that meteorological systems fluctuate within an unchanging envelope of variable but predictable parameters.

Meteorologists now claim that climate '*stationarity*' is obsolete due to climate change. *"Stationarity is dead because substantial anthropogenic change of the Earth's climate is altering the means and extremes of precipitation, evapo-transpiration ... Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system"* (Milly, et al. 2008).

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25.102 Sustainability Science

(q.v. Ecological Literacy, Gaia theory, Three Sustainabilities)

Sustainability Science is a relatively new science and will be highly relevant for the development of design for sustainability. Here we examine several descriptions of sustainability science. Crucial to the development of Sustainability Science is what it will investigate and what are its core questions? This was answered in a paper by a team of 24 scientists amongst whom were Kates, Schellnhuber and Jäger (Kates et al. 2001). *"A new field of sustainability science is emerging that seeks to understand the fundamental character of interactions, between nature and society. Such an understanding must encompass the interaction of global processes with the ecological and social characteristics of particular places and sectors. The regional character of much of what sustainability science is trying to explain means that relevant research will have to integrate the effects of key processes across the full range of scales from local to global. It will also require fundamental advances in our ability to address such issues as the behavior of complex self-organizing systems. Combining different ways of knowing and learning will permit different social actors to work in concert, even with much uncertainty and limited information.*

With a view toward promoting the research necessary to achieve such advances, we propose an initial set of core questions for sustainability science."

- *"How can the dynamic interactions between nature and society – including lags and inertia – be better incorporated into emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?*

- *How are long-term trends in environment and development, including consumption and population, reshaping nature-society interactions in ways relevant to sustainability?*
- *What determines the vulnerability or resilience of the nature-society system, in particular kinds of places and for particular types of ecosystems and human livelihoods?*
- *Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warning of conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?*
- *What systems of incentive structures – including markets, rules, norms, and scientific information – can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?*
- *How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition toward sustainability?*
- *How can today's relatively independent activities of research planning, monitoring, assessment, and decision support be better integrated into systems for adaptive management and societal learning?"* (Kates, et al, 2001)

More recently, the Proceedings of the National Academy of Sciences (PNAS) website defines sustainability science as "*... an emerging field of research dealing with the interactions between natural and social systems, and with how these interactions affect the challenge of sustainability: meeting the needs of present and future generations while substantially reducing poverty and conserving the planets life support system." Furthermore, sustainability science is "extraordinarily multidisciplinary, spanning the natural, social, and technological sciences"* (Kates, 2011). According to the researchers Bettencourt & Kaur and their bibliometric research, sustainability science coalesces into an identifiable field around 2000. They investigated a large database of 20,000 papers published between 1974 and 2010 in which the words *"sustainability"* or *"sustainable development"* occurred in the title, abstract or keywords (Kates, 2011).

Jill Jäger was the author invited to write the first book in the planned series *"Forum for Responsibility,"* entitled *Our planet, how much can Earth take?* and which she completed as part of her work at the Sustainable Europe Research Institute (SERI) in Vienna. *"The Institute examines the ecological, economic, social and institutional conditions for sustainable development; analyzes and disseminates information on ecological limits; elucidates possible steps towards overcoming these ecological limitations; and creates scientifically accurate and practical policy proposals for sustainable development in Europe."*

Dr Jäger writes that: *"Sustainability sciences can be characterized and differentiated from traditional sciences as follows:*

- *The principles of sustainable development define new roles for sustainability scientists. Scientists become the initiators, facilitators, and coordinators of change, so to speak. They should act as facilitators of decision-making processes, as communicators, as teachers, students, and disseminators of knowledge. This kind of science must be very action-orientated.*
- *Science and research oriented towards sustainable development must be an integral part of social development processes. This requires that research goals are coherent with sustainable development goals.*
- *Sustainability research is very complex and extensive, its results are therefore also broader than conventional research results (example of conventional research results are "new theories," data, models, information, and publications). In addition to these results, sustainability sciences also reach other, novel results meant to further the creation of human, social, and institutional capital.*

Taken together, this adds up to new kinds of communication, decision making processes, and risk analyses; a new management of uncertainty factors: and a new quality control procedure in developing decision-making processes" (Jäger, 2008).

The Associate Editor of PNAS, William Clark (2007) in a paper entitled *"Sustainability science: a room of its own"* has suggested that the core questions for sustainability science are:

1. *"How can those dynamic interactions be better incorporated into emerging models and conceptualizations that integrate the Earth system, social development, and sustainability?"*

2. *"How are long term trends in environment and development reshaping nature-society interactions?"*
3. *"What factors determine the limits of resilience and sources of vulnerability for such interactive systems?"*
4. *"What systems of incentive structures can most effectively improve social capacity to guide interactions between nature and society toward more sustainable trajectories?"*
5. *"How can science and technology be more effectively harnessed to address sustainability goals?"*

These perceptions and concepts about sustainability science greatly contribute to the discussion and development of design for sustainability as a field of study and its curriculum.

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25.103 Syndromes

(q.v. wicked problems, schesiology)

A key aspect of understanding sustainability is the underlying connectivity of our planet. Consequently, the knowledge of any one discipline is inadequate to understand and solve human-environment interaction problems. Consequently, the German Advisory Council on Global Change (WBGU) developed an integrated tool for multi- and interdisciplinary research, integrated thinking and education. The WBGU proposed the '*syndrome*' concept to refer to "*functional patterns of human-nature interactions, or more precisely, negatively valued constellations relating human activities and environmental changes.*" The approach is based upon the concept of the World as two systems, the natural system (ecosphere) and the socio-economic human system (anthroposphere) and the study of their interrelationships which can contribute to either the aggravation or amelioration of certain states (Kruse, 2006).

"Traditional disciplinary approaches analysing individual facts or processes are no longer sufficient. Two particular challenges emerge:

i. *the need for integrating knowledge from various scientific disciplines and*
ii. *the necessity for producing action-oriented knowledge to cope with, mitigate, or counteract global change and its negative effects ...*

The syndrome approach aims at a broader view of the most relevant processes of global change and seeks to preserve the local context by integrating local and regional case studies. In order to allow a global view on local and regional dynamics of environmental degradation, the approach seeks to identify functional patterns of human-nature interaction – patterns of processes relating human activities and environmental changes" (Lüdeke, Petschel-Held, & Schellnhuber (2004).

Altogether 16 syndromes have been identified and classified according to three principal groups:

› Utilization syndromes concerned with the inappropriate use of natural resources.
  › Sahel Syndrome
  › Overexploitation Syndrome
  › Rural exodus Syndrome
  › Dust Bowel Syndrome
  › Katanga Syndrome
  › Mass Tourism Syndrome
  › Scorched Earth Syndrome
› Developmental syndromes concerned with non-sustainable development.
  › Aral Sea Syndrome
  › Green Revolution Syndrome
  › Asian Tiger Syndrome
  › Favela Syndrome
  › Urban Sprawl Syndrome
  › Disaster Syndrome
› Sink syndromes resulting from non-adapted waste disposal.
  › High Stack Syndrome
  › Waste Dumping Syndrome

› Contaminated Land Syndrome

Each of these 16 syndromes is a different environmental burden which is further exacerbated by 10 factors which they are then matrixed against:

1. Climate change
2. Loss of biodiversity
3. Soil degradation
4. Scarcity and pollution of freshwater
5. Threats to world health
6. Threats to food security
7. Population growth and distribution
8. Man-made disasters
9. Overexploitation and pollution of the world's oceans
10. Global disparities of development

The resulting matrix produces what is known as the global network of interrelationships. Identifying the constellation of interacting components "is an important prerequisite for approaches that allow for integrated and interdisciplinary research programmes, as well as teaching" (Kruse, 2006).

Kruse points out that the traditional "mono-disciplinary" teaching and learning practices are inadequate for finding solutions to these complex problems and Kruse recommends that curricula be redefined and redesigned to meet these complex ('wicked') problems.

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25.104 Teaching yourself sustainability; the MOOCs phenomenon

(q.v. Top 50 Sustainability Books, Timeline for sustainability)

Never before in the history of mankind has access to information and the potential for self development been easier; assuming that one possesses the technology. A developing phenomenon on the world wide web is the availability of free, online university level study courses known as Massive Open Online Courses (MOOCs) (Bartholet, 2013). Many MOOCs are offered by web-based platforms supported by reputable universities, colleges and organizations and are designed for large scale participation. A MOOC web site (http://www.mooc-list.com/) enables one to choose a course according to different criteria including the language, subject, and time requirement etc. They tend not to offer academic certification etc. although there are some exceptions. A number of courses are offered on sustainability (http://www.mooc-list.com/tags/sustainability), some are general introductions, whilst others are concerned with specific aspects such as water, soil, food production, energy, etc.

Here we list two further web page platforms as examples which offer help concerned with learning about sustainable design: the Autodesk Sustainability Workshop and the Canvas Network.

Autodesk Sustainability Workshop

Autodesk provides good online resources and videos dealing with a wide range of subjects demonstrating sustainable design. For example, the video on design for disassembly and recycling and the accompanying downloads provide an excellent introduction for disassembly strategies. The web site deserves a rigorous investigation by design students.

"*Autodesk® Sustainability Workshop offers free online resources that teach the principles and practice of sustainability in engineering and design. This site was created to help educators teach and students learn the broader context and importance of sustainability in the engineering and architecture profession. The videos and tutorials aim to make it easy for anyone, anywhere to learn sustainability strategies that can be incorporated into the design process. Our goal – develop sophisticated, yet easy-to-use learning tools that will be used, for free, by educators and students alike to create a more sustainable world.*" Homepage: http://sustainabilityworkshop.autodesk.com/about-us

See more at: http://sustainabilityworkshop.autodesk.com/about-us

http://sustainabilityworkshop.autodesk.com/sites/default/files/core-page-files/autodesk-sustworkshp_designfordisassemblyandrecycling.pdf

The Canvas Network

The Canvas Network is another platform promoting itself to "*instructors and institutions an open platform to share their expertise and institutional experience with the world. Put courses, knowledge and insight into the hands and minds of more people than ever before. Reach new students and collaborate with other instructors and peers that have similar interests.*"

The Canvas Network also offers courses on sustainability. For example, one "*... course provides an introduction to the environmental aspects of sustainability, including renewable energy techniques, the impact of non-renewable sources, air quality, storm water management, land use, and the built environment. Topics include climate change and greenhouse gases; wind, solar, water, and geothermal energy; bio-fuels; conservation techniques; global demand; legal and regulatory aspects; and job creation.*"

Homepage: https://www.canvas.net/courses/intro-to-sustainability-1

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See more at: http://sustainabilityworkshop.autodesk.com/about-us
http://sustainabilityworkshop.autodesk.com/sites/default/files/core-page-files/autodesk-sustworkshp_designfordisassemblyandrecycling.pdf
The Canvas Network:
https://www.canvas.net/courses/intro-to-sustainability-1

25.105 TEEB: The Economics of Ecosystems and Biodiversity

(q.v. Tragedy of the Commons; Ecosystem Services)

The Economics of Ecosystems and Biodiversity (TEEB) is a field which has relatively recently become established. It is an interdisciplinary field whereby ecosystems are assessed in terms of their economic value. Ecosystems have been regarded as a commons and consequently, perceived as simultaneously belonging to everybody and nobody and so their value has not been recognized. "*The invisibility of biodiversity values has often encouraged inefficient use or even destruction of the natural capital that is the foundation of our economies*" (Sukhdev, et al., 2010).

Nature is a commons (Hardin, 1968). Consequently, it ends up being very badly exploited by our industrial, commercial, and consumer culture because what belongs to everyone and simultaneously no-one is readily abused be it the atmosphere (witness CFCs or CO_2), or the oceans and the world wide demise of fish stocks or the rain forests (20% of the which have been deforested since 1970 and 80% of that is now beef ranches).

Ecosystems perceived anthropocentrically provide ecosystem services (q.v) on which human survival depends. These services provide provisioning services (e.g. food, water etc.). Regulating services (e.g. cleaning air and purifying water, etc.) Cultural services (spiritual values, intellectual stimulation, etc.) and Supporting services essential for the previous three service groups (soil formation, nutrient cycling, pollination etc.). Clearly, all these ecosystem services, essential for human existence can be translated into fiscal values: which is the economics of ecosystems and biodiversity. This has now been done so that the ecosystem services per hectare for mangroves have been calculated at $18,000, for rainforest at $23,000 and for coral reefs at $1,195,000 (Pearce, 2012). Although these figures may be debatable, the point is that, for example, a mangrove provides a defense against storms, rain forests provide wood, purify the air and circulate water, and coral reefs provide nurseries for fish as illustrations of some ecosystem services. No-one can argue that Nature does not have monetary value.

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25.106 Third Industrial Revolution (TIR)

(q.v. Soft Paths)

The optimistic and fundamental concept behind the Third Industrial Revolution is the lateralization of energy. Jeremy Rifkin's (2011) hypothesis is that we can bring about a third industrial revolution and he proposes that it will be based on 5 pillars which are:

1. The complete shift from fossil fuels to a world economy based on renewable energy in the form of: solar, wind, hydro, geothermal, ocean waves and biomass.
2. Buildings will need to become their own powerplants collecting and generating their own energy and linked into a grid so that businesses and homeowners become both producers, consumers and contributors to their own and the energy requirements of others. This will be possible through the interconnectedness of a smart energy grid.
3. Distributed hydrogen storage technologies will buffer intermittent supplies to balance needs when required.
4. Internet technology provides the model to reconfigure the distribution of electrical energy to an energy internet enabling supply to meet demand in different regions with the development of a smart energy grid.
5. The transition of automation from fossil fuel to renewable electricity will mean that vehicles can also plug in to the same power system and also serve as portable power plants.

The third industrial revolution therefore has a common energy currency: renewable electricity from locally distributed generative sources. The concept of local resourcing as opposed to centralized supply is a concept first proposed by Amory Lovins (1977) which he called '*soft energy paths*'. Soft structures are laterally distributed and local and not the 'hard' centralization of resources managed by expensive and large utilities. The problem with large centralized utilities is the danger of overdemand and of a centralized collapse as for example with power failures that can occur across a whole region. Decentralized local facilities are also more resilient since a failure would only affect a relatively small region. Peter Gleick (2003) also wrote about Lovins' 'soft path' strategies for the management of water with local capture, storage and supply as opposed to the 'hard' strategy of centralized structures of enormous dams and reservoirs. The centralization of utilities such as reservoirs and dams substantially endangers the geology creating the risk of earthquakes as well as causing ecosystem and biodiversity loss and altering the local climate as is happening in China.

Another component of Rifkin's third industrial revolution is 3-D printing which he believes will change how we consume because it will provide the capability to produce many products locally further contributing to the lateralization of society.

The key character of the third industrial revolution will be the decentralization and localization of essential utilities made possible by employing management by digital technology.

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25.107 Three Sustainabilities: Ecological, Social/Cultural, Economic

(q.v. Chapter 1.1, Sustainability Science, Net Primary Producers)

The three sustainabilities have been referred to by various names including: **the triple bottom line (TBL)** was coined by John Elkington, the founder of SustainAbility, in 1994 who recommended that companies should identify three separate bottom lines. The first being the corporate profit, the second is the company's "people account" and the third is the company's "planet account" or how environmentally responsible the company has been. This simplifies to 3 Ps: profit, people and planet. Hindle (2012) writes that *"Only when companies measure their social and environmental impact will we have socially and environmentally responsible organizations."* All three areas must be behaving sustainably, but they are deeply interconnected.

The concept is often represented diagrammatically in a Venn diagram as three overlapping circles. In other representations the 3 Ps are represented as three columns which ultimately support the 'tabletop' of human welfare. However, these representation give the wrong idea; rather, the three accounts or sustainabilities exist as a nested trophic pyramid. The fact is that there can be ecosystems without economies but not economies without ecosystems. A fact which still today many economists are unable to comprehend. However, a group of scientists (Griggs et al, 2013; see Chapter 1.1) have proposed the correct model with the three entities as interdependent, nested entities (as some others have also proposed) with economic sustainability nested within and dependent on social sustainability which is nested within and dependent on environmental/ecological sustainability. Indeed, this concept is closely similar to the pyramid of trophic levels that exist in nature with energy passing up through the layers of the system. In nature's trophic pyramid the base layer is composed of the primary producers, plants (net primary producers: NPP (q.v.)), turning sunlight into biomass and on which we are all ultimately dependent. The next layer are the herbivores and the next the carnivores and finally the top predator carnivores. Each layer towards the top becoming fewer in number being dependent on the layer below for its energy and which in the top 2 layers might be equated with money (although, not always!).

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25.108 Timeline for Sustainability

(q.v. 1970-the Turning Point)

In the early preparation of *Changing Paradigms*, we thought that it would be useful to include a Sustainability Timeline, however, an excellent book already exists for those wanting to look into the history of sustainability – a new field.

The book we recommend is the *"Landmarks for Sustainability"* published by Wayne Visser, the same author as *"The Top 50 Sustainability Books."* In fact both titles provide an excellent starting point since "The Top 50 ..." lists the books chronologically. Both titles are a must for anyone starting in this gigantic field!

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25.109 Tipping point or phase transition

(q.v. Planetary boundaries, Phase Transition, Overshoot)

Tipping points occur when forces acting on a system cause it to change from one regime, organization or state of self-organization into another. Examples occur across many fields and a simple example is provided by water, which possesses two tipping points, one at 0°C when it suddenly freezes and the other at 100°C when it boils and forms steam. The Earth is a far more complicated system but, nevertheless, we are recognizing that we may have passed two tipping points. In climatic systems *"For a system to possess a tipping point, there must be a strong positive feedback in its internal dynamics, i.e. strong 'self-amplification' of external forcing"* (Lenton, 2012).

1. The Arctic Ice cap

One of the consequences of global warming has been the melting of the Arctic ice cap by 3.2% per decade relative to the average ice cover from 1981 to 2012. This is equivalent to an annual decline of the ice cover by 47,800 square kilometers (18,500 square miles). The January ice cover in 1979 was about 15,500,000 square kilometers and in January 2014 13,750,000 according to the graph showing the 3.2% decline. (Source 1.)

During the summer of 2007 from June to September there occurred a record sea ice melt of the Arctic ice cap reducing the ice cover to 4.13 million square kilometers (or 1.59 million square miles) (Source 2.). This is *"roughly 40% below the average from 1979 to 2000"* (Smol, 2012).

The 2007 record minimum ice cover was broken in 2012 when the sea ice melted to 4.10 million square kilometers (1.58 million square miles) (Source 3.)

One might expect that with continuing CO_2 emissions causing further global warming that the Arctic ice cap will steadily melt. However, the record extent of the 2007 melt was a great surprise to scientists because it posed the question as to whether a tipping point had been reached. How could this happen?

Tim Lenton explains that *"there must be a strong positive feedback in its internal dynamics"* and this exists in the Arctic ice cap system due to the albedo effects. The degree of reflectivity of a surface is known as the albedo effect and scaled so that a matt black surface reflecting no light has a value of 0 and white a value of 1. Therefore darker surfaces become warmer in direct sunlight while *"Snow and ice have high albedos and reflect 60% to 90% of the Sun's energy"* (Smol, 2012). The snow and ice cover of the Arctic ice cap normally reflects the suns rays but with less and less ice cover the sun's rays now warm the exposed seas which, being darker absorb rather than reflect the sun's energy.

The melting of the polar ice cap could, if not already, become a positive feed back whereby the increased surface area of the sea absorbing more of the sun's energy becomes warmer thereby accelerating the continuing melting of the ice cap. Now that the extent of the summer melt continues to break records it appears that the tipping point may have been passed and we can anticipate that Arctic will be free of summer sea ice by about 2035 (Smol, 2012). Lenton (2012) writes that the *"The Arctic may already be committed to a qualitative change in which the ocean becomes largely ice-free in summer, with projections for when this will happen starting at 2016 ± 3 … but most models estimates starting around 2050 … when global warming is around 2°C."*

2. Antarctica

In 2014 two papers were published reporting that two massive glaciers in the West Antarctic Ice sheet have now passed tipping points and have started to meltdown. This will probably cause the rest of the West Antarctic ice sheet also to meltdown raising sea-levels an estimated 3.3 metres (Le Page, 2015)

3. Methane emissions

Another tipping point which may now have been reached is the destabilization of methane hydrates on the sea bed. Methane hydrates or clathrates are formed by the association of methane and water molecules and frozen together into a solid resembling ice. When the conditions are right the water molecules create cages in which the methane molecules get trapped forming the methane hydrates. These conditions are found in the deep sea-beds where there are sufficient pressures and very cold conditions which stabilize the hydrates. However, if the hydrates are exposed to warmer temperatures the methane becomes liberated.

In recent years (New Scientist, 2009) methane has been bubbling up from the Arctic Ocean west of the Svalbard Archipeligo where over 250 plumes of gas have been reported. The cause maybe due to the warming of the west Spitzbergen current which during the past 30 years has become 1°C warmer.

More recently, Phrampus and Hornbach (2012) report the active destabilization of gas hydrates covering an area of at least 10,000 square kilometers off the east coast of North America along the Carolina Rise. The scientists write in their abstract that *"Our analysis suggests that changes in the Gulf Stream flow or temperature within the past 5,000 years or so are warming the western North Atlantic margin by up to eight degrees Celsius and are now triggering the destabilization of 2.5 gigatonnes of methane hydrate … This destabilization extends along hundreds of kilometers of the margin and may continue for centuries. It is unlikely that the western North Atlantic margin is the only area experiencing changing ocean currents; our estimate of 2.5 gigatonnes of destabilizing methane hydrate may therefore represent only a fraction of the methane hydrate currently destabilizing globally."* (1 gigatonne = 1,000,000,000 tonnes) Methane gas has also been found bubbling up from the thawing lakes in North Siberia. Walter and colleagues (2006) calculate that as much as 3,800,000 tonnes of methane gas may be emitted from these lakes each year. Furthermore, carbon stocks that were previously stored in the permafrost are now also being released (Walter et al, 2006).

The problem with methane gas is that it is a more potent green house gas than CO_2. However, recent work by Schindell and colleagues (2009) shows that due to the aerosols already present in the atmosphere the gas-aerosol interactions change the impact of green house gases. Methane has a substantially stronger global warming potential (GWP) which was previously thought to be about 20 times more potent than CO_2, however, Shindell and colleagues calculate it to be upto 105 times that of CO_2. The GWP of CO_2 is 1 and so the GWP of methane when it interacts with aerosols is 105 times that of CO_2.

Since the beginning of the new century it appeared that there was no global warming over the surface of the planet for over a decade. Scientists were concerned as to where the heat was going. The hiatus in the apparent slowdown in global warming is explained by the recent discovery that the Atlantic Ocean has been a heat sink and taking up the 'missing' heat so that it is becoming warmer. This is a very dangerous situation because of the risk to melting more of the methane hydrates on the seabed (Chen & Tung, 2014). This could drive us toward the tipping point for the hydrates in which as more methane is released it causes further warming of the world in a positive feedback. It appears that a tipping point may have been reached which will contribute to further global warming,

The geological record reveals that early in the Eocene the Earth warmed due to the atmosphere becoming flooded with an estimated two teratonnes (two million million tonnes) of carbon compounds. Apparently, the release of the carbon compounds occurred over a period of 10,000 years and it took about 200,000 years for Gaia (the whole earth system) to recover. The scientist who researched the event, Prof Elderfield at the Department of Earth Sciences, Cambridge University (Gribbin & Gribbin, 2009) estimates that the atmospheric CO_2 content probably never went much above 440ppm. However, temperatures around the equator rose by about 5°C and by 8°C in the higher latitudes! Today, the great concern is firstly, we are emitting enormous quantities of greenhouse gases over a very short period and we have already reached 400ppm of CO_2. Secondly, scientists fear that tipping points may cause abrupt climate change (Pearce, 2007).

These two examples suffice to illustrate the concept of a tipping point. Unfortunately, they are not the only tipping points and others include the Greenland ice sheet meltdown, Atlantic thermohaline circulation, Yedoma permafrost and the Arctic winter sea ice. Meanwhile, (Lenton et al, 2008) there is also the potential of climatic tipping points beyond the Arctic in other regions of the world including:

› drying and dieback of the Amazon rainforest due to deforestation.
› melting of the West Antarctic Icesheet (which has apparently started).
› boreal forest dieback.
› destabilization of the Indian summer monsoon.

Tipping points have been also described in terms of planetary boundaries which should not be exceeded. These were described in a paper by Johan Rockström and colleagues (2009) published in *Nature*. Please refer to Chapter 4 and to Planetary boundaries in the Glossary.

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25.110 Top 50 Sustainability Books

(q.v. Teaching Oneself, Timeline for Sustainability)

The literature on Sustainability is now very extensive and for design students who want to become familiar with the subject, the problem of knowing which authors to read is itself a difficult problem. However, one book which is highly recommended meets this need and is entitled:

The Top 50 Sustainability Books by Wayne Visser (2009) and published jointly by Greenleaf Publishing and the Cambridge University Press.

It has been compiled by the Cambridge Programme for Sustainability Leaderhship which set out in 2008 *to identify the most influential books on sustainability*. This project also entailed interviewing all the living authors so that many entries have an *'in their own words'* section where many authors have amplified their aims. The Top 50 offers an excellent opportunity for evaluating any of the listed books so as to ascertain whether it should be purchased and read in depth. Each entry includes:

› the bulleted key ideas
› a synopsis
› excerpts from each book itself
› biographical summary of the author
› in his own words
› additional bibliography

Unquestionably, this book provides a good starting point for getting into the sustainability literature.

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25.111 Toxicity for Design

(q.v. WEEE, End-of-Pipe Treatment)

Materials' studies for design students can no longer merely be limited to the suitability of materials for specific structures, functions and their appropriate strengths and stresses. The ubiquitous use of synthetic materials (i.e. not naturally occurring) in the world's consumer culture makes it mandatory for design students to study toxicity. There are an enormous number of chemical compounds marketed in materials, the large majority of which are inadequately tested for their safety: *"The number of new chemicals is increasing exponentially, with approximately 12,000 new substances added daily to the American Chemical Society's CAS registry. Although only a portion of these chemicals are introduced into the environment, data on the hazard posed by even high-production volume (HPV) chemicals (those with a production volume exceeding 1000 tons/year) are available for only a fraction of the HPV chemicals produced or imported into the United States."* (The American Society of Human Genetics, et al., 2011).

Furthermore: *"In 2009 about 1.5 million American men, women and children had cancer diagnosed, and 562,000 people died from the disease. The panel found that the country needs to overhaul existing chemical laws ..." In America the burden is "on the Government to prove beyond a doubt that a chemical is unsafe before it can be removed from the market. The standards are so high that the Government has been unable to ban such chemicals as asbestos, a widely recognized carcinogen. About 80,000 chemicals are in commercial use in the US, but federal regulators have assessed only about 200 for safety"* (Layton, L., 2010).

At the time of writing (Dec, 2013) the CAS registry is the world's largest inventory of substances and contains details on 77 million substances. The CAS website states that "approximately 15,000 new substances are added each day." it has details on 72,914,493 commercially available chemicals and an inventory of 308,790 regulated substances. The CAS registry includes:

› Organic compounds
› Inorganic compounds
› Metals
› Alloys
› Minerals
› Coordination compounds
› Organometallics
› Elements
› Isotopes
› Nuclear particles
› Proteins and nucleic acids
› Polymers
› Nonstructurable materials (UVCBs
› http://www.cas.org/content/chemical-substances/faqs#q1

Some of the reasons why design students should study toxicity are:

› offgassing: offgassing occurs when chemical compounds from a material disperse into the surrounding air. For example, a chemical smell can often be detected when the lid of a plastic box is opened; the smell is/are the 'offgassed' chemicals.
› 'cocktails' of mixed chemicals. The domestic environment contains many synthetic chemicals ranging from cosmetics, deodorants, adhesives, plastics, digital and electrical gadgets, fire retardants, etc. Chemicals from diverse products offgas into, for example, a

centrally heated domestic environment and can combine to form unknown compounds.

- depending on the toxin, some chemicals can cause physiological and /or psychological changes at low concentration doses.
- In 2005 a study by the University Hospital in Groningen, Holland, was commissioned by the World Wildlife Fund and Greenpeace to analyze the blood of pregnant women. Their research revealed that *"More chemicals from everyday household products cross the placenta from mother to baby than we ever imagined"* (Anon. Up Front, 2005) and contained hazardous chemicals from 8 chemical groups: artificial musks, alkyphenols, bisphenol-A, brominated flame retardants, perflourinated compounds, phthalates (found in ink, paint and cosmetics), organochlorine pesticides and triclosan (Schuiling, van der Naald, 2005). A spokesman for the investigating team, Pieter Sauer concluded that *"Apparently, every chemical that is introduced into the environment can enter the unborn child. What we don't know is what the long-term effects of these substances are."*

As designers this is knowledge we need to know as we can all too easily endanger consumers with the materials we choose for products.

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25.112 Tragedy of the Commons

(q.v. Planetary Boundaries, Ostrom)

The 'tragedy of the commons' refers to the common land that was typically in the centre of the medieval village. Today the 'common' or village green can still be found in many villages in rural England and, where they still exist, are large enough for the village fair or cricket match. However, in medieval times the common was a piece of land which belonged to the entire village and where any of the villagers were entitled to put there livestock. This was fine so long as not everybody wanted to put all their animals out onto the common at once. However, the 'tragedy of the commons' occurs when everybody does exactly that. Each villager seeks to gain the most from what is free. Therefore, he may well place an extra animal to graze on the common from which he will get the entire benefit.

The tragedy is however, that the extra animal contributes to the overgrazing which disadvantages all the livestock and villagers by only a fraction. This being so other villagers seek to maximise their gain by putting more animals to graze on the common as well. As each villager adds more animals to the common it is clear what will happen. The common is grazed bear and becomes a useless quagmire as every individual follows their own interest. As Garrett Hardin concluded, *"Freedom in a commons brings ruin to all."*

In what has become a classic paper, Garrett Hardin (1968) described this principle and how it applies to the world's commons today. *"As the human population has increased, the commons has had to be abandoned in one aspect after another.* [in other words privatized] *First we abandoned the commons in food gathering, enclosing farm land and restricting pastures and hunting and fishing areas. These restrictions are still not complete throughout the world. Somewhat later we saw that the commons as a place for waste disposal would have to be abandoned. Restrictions on the disposal of domestic sewage are widely accepted in the Western world."*

Some of the problems due to the commons not being owned include atmospheric pollution. He wrote *"… we are still struggling to close the commons to pollution by automobiles, factories, insecticide sprayers, fertilizing operations, and atomic power installations."* Finally, in his paper, he decries the 'commons' for parents to have as many children as they want because every newborn places an additional ecological burden on the Earth. Therefore the *"Freedom to breed will bring ruin to all."*

Meanwhile, the Nobel Prizewinner for economics in 2009, Elinor Ostrom, refutes Hardin's thesis. Ostrom has conducted much research into how different stakeholders use a commons. She finds that communities with an intimate knowledge of a commons are perfectly capable of managing it sustainably. Other communities however, can destroy their common. Each case depends on its own situation and the extent to which communities can implement their own rules to ensure the sustainability of a commons. The administration of a commons (e.g. forests or fisheries) by a government is also not a guarantee for the sustainable management of a commons. This has been well illustrated by the EU fisheries policies which has seen the populations of many fish species crash. Ostrom's research, based on detailed observations, provides valuable information on the sustainable management of resources.

References and further reading

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Ostrom, E. (2012) The future of the commons, London, Institute for Economic Affairs.

Source

Hardin, G. (1998) Extensions of "The Tragedy of the Commons," Science, vol 280, no 5364, pp 682-683. (Available online at:
http://www.pelagicos.net/MARS6910_spring2013/readings/Hardin1998.pdf

25.113 Transition Initiatives

(q.v. Peak Resources, Incredible-Edible, Resilience)

A Transition Initiative is a collective local community action in response to anticipating the end of (cheap) oil and aims to prepare and reorientate a community from oil dependence to an oil-free lifestyle. The concept of the Transition Initiative's founder, Rob Hopkins, is to help wean communities off fossil fuel energy sources through a holistic strategy of social innovation, and reorientation to a sustainable and self-resilient culture. Most governments appear to have no plans for either peak oil or divestment in fossil fuels for alternative strategies as to how nations will exist without fossil fuels. It was with this awareness, especially in the UK, that stimulated Hopkins to develop his concepts and describe them in his *The Transition Handbook* (2008).

The perception amongst some local communities and others is that governments are too slow to either perceive or prepare for anticipating future perturbations due to energy shortages, resource peaks, food and water shortages etc. Transition communities are now preparing themselves for an uncertain future by developing and adopting strategies which will make them resilient to these anticipated problems.

Ashley Seager (2009) writing in the Guardian Weakly reported that the International Energy Authority "*... had previously asserted that oil production would not peak before 2030 at the earliest. Now it thinks we might be very close.*

The IEA figures showed there could be a gap of 7m barrels a day between supply and demand by 2015." Seager continued that the British government "*... has no plan and barely acknowledges the problem, despite years of campaigning about peak oil.*" This viewpoint was supported six months later in the same paper when it reported on its front page that "*US military sees serious oil shortages by 2015.*" Clearly, there must be cause for concern when the world's biggest consumer of fuels publicly revealed its vulnerability. This concern is also reflected by the fact that there are now over 35 Transition Initiatives of various kinds in towns and communities in the UK and over 500 globally.

More recently, the news has emerged that the shortage of fossil fuels will not be due to the peaking of these resources but to the fact that in order not to exceed 2°C global warming a very substantial proportion of the known reserves will have to remain in the ground. The results of the researcher by McGlade and Ekins "*suggest that, globally, a third of oil reserves, half of gas reserves and over 80 per cent of current coal reserves should remain unused from 2010 to 2050 in order to meet the target of 2 °C.*" Furthermore, "*policy makers' instincts to exploit rapidly and completely their territorial fossil fuels are, in aggregate, inconsistent with their commitments to this temperature limit.*"

References and further reading

Hopkins, R. (2008) The Transition Handbook, Vermont, Chelsea Green Publishing.

Hopkins, R. (2011) The Transition Companion, Making Your Community More Resilient in Uncertain Times (Transition Guides), Cambridge, Transition Books. Green Books.

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McGlade, C. & Ekins, P. (2015) The geographical distribution of fossil fuels unused when limiting global warming to 2 °C, Nature, vol 517, pp 187- 190, (doi:10.1038/nature14016).

Pinkerton, T. & Hopkins, R. (2009) Local Food, how to make it happen in your community, Totnes, Transition Books/ Green Books.

Seager, A. (2009) Governments have no Plan B to replace dwindling oil supply, The Guardian Weekly (30.10-5.11.2009) p. 17.

Macalister, T., & Webb, T. (2010) US military sees serious oil shortages by 2015, The Guardian Weekly, 16-22.04.2010, p. 1.

25.114 The United Nations Environmental Program

(q.v. Millenium Development Goals)

The following text is largely from the UNEP web page.

The United Nations Environmental Program for environment and development was established in 1972 and “*is the voice for the environment within the United Nations system. UNEP acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment.*

UNEP work encompasses:

- *Assessing global, regional and national environmental conditions and trends*
- *Developing international and national environmental instruments*
- *Strengthening institutions for the wise management of the environment.”*

The Mission of UNEP is: *“To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.”*

The Mandate of UNEP is: *“To be the leading global environmental authority that sets the global environmental agenda, that promotes the coherent implementation of the environmental dimensions of sustainable development within the United Nations system and that serves as an authoritative advocate for the global environment”* (http://www.unep.org/About/)

The subsites of the UNEP home page offer many updates and informative downloads on topics which include:

- Climate Change
- Disasters & Conflicts
- Ecosystem Management
- Environmental Governance
- Chemicals & Waste
- Resource efficiency
- Environment under review

UNEP produces an immensely useful range of publications (mostly available as pdf.s from the UNEP web page), notably the Year Book Series of which for example, the 2014 Yearbook deals with serious problems including:

1. Excess nitrogen in the environment
2. Combating (re)emerging infectious diseases
3. Marine fish and shellfish farming
4. Illegal wildlife trade
5. Methane hydrates
6. Realizing the potential of citizen science
7. Air pollution
8. Plastic debris in the ocean
9. Securing soil carbon benefits
10. Rapid changes in the Arctic

In conclusion UNEP provides an invaluable resource of information in its Knowledge Repository (http://www.unep.org/publications/) all of which is oriented towards securing a sustainable future.

References and further reading

UNEP YEAR BOOK 2014: emerging issues in our global environment, Nairobi, UNEP

Sources

http://www.unep.org/About/
http://www.unep.org/publications/

25.115 Union of Concerned Scientists

(q.v. 1970- the turning point)

The prominent organization, the Union of Concerned Scientists, began as a group of students and faculty members at the renown Massachusetts Institute of Technology in 1969 and which has now become an alliance of 400,000 scientists and citizens. The Union is an organization independent of political and commercial interests but concerned that *“people have the right to know the best-available science behind the issues that affect their lives, and the right to expect their leaders to use that scientific information to inform the choices they make”* to secure a sustainable future.

The home page provides a comprehensive coverage of the world’s unsustainable problems and also presents strategies for the way forward to a sustainable future. For example, UCS is highly critical of the US agro-industry which is strongly supported by the government and which provides $5.08 billion in subsidies for growing corn and soya beans compared with providing only a $90 million for proposed local food investment. The issues addressed together with strategies for their resolution include:

- Global warming,
- Clean vehicles,
- Clean Energy,
- Nuclear Power,

› Nuclear weapons & global security,
› Food & Agriculture.

Source
http://www.ucsusa.org/

25.116 Videographic Sources

(q.v. 1970- the turning point)

Videos and the internet Media, like books and printed media, are valuable sources of reference. The listing below is very incomplete but hopefully a useful start to providing insights into sustainability: The films and videos are organized according to the following categories: **ENVIRONMENTALISM, ECONOMICS, RESOURCES, FOOD, CONSUMERISM, POLLUTION & CLIMATE CHANGE** with often cited summaries of each normally under the headings:

› released
› presented b
› produced by
› availability
› theme

ENVIRONMENTALISM:

"Home"
released: 5 June 2009.
presented by: Elzevir Films / Europa Films
produced by: Yann Arthus-Bertrand (Yann Arthus-Bertrand has said that the movie has no copyright and that everyone can download the movie from the Internet.)
availability: www.youtube.com/watch?v=jqxENMKaeCU
theme: Presents our impact on the world and how we are threatening the ecological balance. The film takes a long perspective of humankind's impact on the Earth upto the present day. There is stunning aerial photography showing contrasting ecological regions from over fifty countries accompanied by a sobering commentary.

"The Sixties - Years that shaped a generation"
released: 2005
produced by: PBS TV
availability: www.youtube.com/watch?v=mUc2eLe-rul
theme: Presents an excellent history of the decade which had spawned many movements by its end including the movements for equal human rights, peace and ban-the-bomb, anti-war, gay rights, feminism, and environmentalism etc. "Its important for the youth of the world to feel that they can change the world" and proclaims that *"it was a time when a generation rebelled and lost its innocence."*

Earth Days
released: 2009
presented by: Stewart Udall, Stewart Brand, Hunter Lovins, Dennis Hayes, Rusty Schweickart and Dennis Meadows.
produced by: Robert Stone
availability: https://www.youtube.com/watch?v=cBVGzf-fFIo
theme: Introduces the beginnings and development of the environmental movement during the 60s and 70s and *"The history of our environmental undoing through the eyes of nine Americans whose work and actions launched the modern environmental movement."* (http://www.rottentomatoes.com/m/1215791-earth_days/).

ECONOMICS:

Dr Ha-Joon Chang on Neoclassical Economics
released: 2013
presented by: Dr Ha-Joon Chang
produced by: the Renegade Economist
availability: https://www.youtube.com/watch?v=RuVrbYIZq7c
theme: Dr Ha-Joon Chang explains how we have developed a system of neo-classical economics and the power play which brought it about.

Dr Ha-Joon Chang - 23 things they don't tell you about Capitalism
released: 2010
presented by: Dr Ha-Joon Chang
produced by: Tomorrows Ideas Today: the Royal Society of Arts - Vision
availability: https://www.youtube.com/
theme: In a lecture at the RSA the development economics expert, Ha-Joon Chang, dispels the myths and prejudices that have come to dominate our understanding of how the world works.

The Corporation
released: 2006

presented by: Mikela Jay
produced by: Bart Simpson & Carl Green,
availability: DVD and at https://www.youtube.com/watch?v=xHrhqtY2khc
theme: *"Thought-provoking political documentary by Canadian filmmakers Jennifer Abbott and Mark Achbar. In the mid-19th century, American corporations began to be legally recognised as individuals, a move that has given them unprecedented rights. In collaboration with novelist Joel Bakan, the filmmakers pose the question: if a corporation was a person, what sort of person would it be? Applying psychiatric principles and social research, they come to the conclusion that this 'person' would be a power-hungry, egocentric and highly destructive psychopath. The film won Best Documentary World Cinema Audience Award at the 2004 Sundance Film Festival."* (Review, Amazon, UK: http://www.amazon.co.uk/Corporation-DVD-Mikela-Jay/dp/B000P1KTEQ/ref=sr_1_1?s=dvd&ie=UTF8&qid=1421226391&sr=1-1&keywords=the+corporation))

Four Horsemen - Feature Documentary - Official Version
released: 2013
presented by: Ross Ashcroft
produced by: Megan Ashcroft, Jason Whitmore & Ross Ashcroft and Motherlode, a Renegade Economist Film
availability: https://www.youtube.com/watch?v=5fbv-quHSPJU&feature=em-subs_digest-vrecs
theme: FOUR HORSEMEN is an award winning independent feature documentary which lifts the lid on how the world really works. It questions the systems we have created and suggests how they might be reformed.
Inside Job
released: 2010
presented by: Matt Damon
produced by: Charles Ferguson and Sony Pictures Classics
availability: DVD
theme: The film is presented in five parts. Part 1 How we got here. Part 2 The 2001-2007 Bubble. Part 3 The Crisis. Part 4 Accountability and Part 5 Where are we now. It starts in Iceland where the deregulation and privatization of the banks took place in 2000. This is followed by the bankruptcy of Lehman Brothers and the collapse of AIG. Then Iceland followed by the rest of the world went into recession. (http://en.wikipedia.org/wiki/Inside_Job_(2010_film))

Capitalism: a love story
released: 2009
produced by: A dog eat dog films
availability: DVD and at: https://www.youtube.com/watch?v=rgcdtOcfqfc
theme: *"With both humor and outrage, Michael Moore's Capitalism: A Love Story explores a taboo question: What is the price that America pays for its love of capitalism? Years ago, that love seemed so innocent. Today, however, the American dream is looking more like a nightmare as families pay the price with their jobs, their homes and their savings. Moore takes us into the homes of ordinary people who see lives have been turned upside down; and he goes looking for explanations in Washington, DC and elsewhere. What he finds are the all-too-familiar symptoms of a love affair gone astray: lies, abuse, betrayal ... and 14,000 jobs being lost every day."* (Review at: http://www.amazon.co.uk/Capitalism-A-Love-Story-DVD/dp/B0036QV860/ref=pd_bxgy_d_h__img_y)

Teaching economics after the crash
a BBC 4 Radio broadcast
broadcast: Sunday, 4 January, 2015
presented by: Aditya Chakrabortty
produced by: BBC Radio 4
availability: http://www.bbc.co.uk/programmes/b04svjbj
theme: *"At universities from Glasgow to Kolkata, economics students are fighting their tutors over how to teach the subject in the wake of the crash. The Guardian's senior economics commentator, Aditya Chakraborrty ..."* provides an excellent introduction to both the problem of the economics curriculum and includes insights into the financial crash as well.

RESOURCES:

The Oil Crash
released: 2007
presented by: Basil Gelpke and Ray McCormack
produced by: Lava Productions & Telepool
availability: DVD
theme: The journalist Basil Gelpke and the film maker Ray McCormack present the history of oil and its future and clearly connect the American obsession with the Middle East.

Blue Gold, World Water Wars
released: 2010
presented by: Malcolm McDowell
produced by: Sam Bozzo,Tony Clarke and Maud Barlowe and Purple Turtle Films
availability: (Region 1 DVD) and on web at: https://www.youtube.com/watch?v=B1a3tjqQiBI
theme: All life depends on water. Those who have the ability to pay will have water while those who don't will not. In the final analysis it is about profit. *"Wars of the future will be fought over water, as they are today over oil, as the source of all life enters the global marketplace and the political arena. Corporate giants, private investors, and corrupt governments vie for control of our dwindling fresh water supply, prompting protests, lawsuits, and revolutions from citizens fighting for the right to survive past civilizations have collapsed from poor water management. Will ours too?"* (DVD box cover text). The film is based on the book "Barlow, M. & Clarke, T. (2004) Blue Gold, the fight to stop the corporate theft of the World's water, New York & London, The New Press.

FOOD:

Food Fight
released: 2008
presented by: Chris Taylor
produced by: Positively 25th St Productions & November Films
availability: DVD
theme: Most foods that we buy in supermarkets today contain more fat, salt, sugar and artificial additives than a couple of decades ago. This film provides an insight into today's food industry.

Food Inc
released: 2009
presented by: Robert Kenner
produced by: Participüant Media & River Road Entertainment & dogwoof
availability: DVD, official trailer is at https://www.youtube.com/watch?v=5eKYyD14d_o
theme: *"In Food, Inc. film maker lifts the veil on the food industry, exposing the highly mechanized underbelly that's been hidden from the consumer with the consent of government regulatory agencies. Food supply is now controlled by a handful of corporations that often put profit ahead of consumer health, the livelihood of farmers, the safety of workers and our own environment …"*

The End of the Line
released: 2009
presented by: Charles Clover & Roberto Mielgo
produced by: Arcane Pictures, Calm Productions, Dartmouth Films
availability: DVD, trailer at http://endoftheline.com/
theme: The film documents how the populations of the ocean's fishes are being fished to virtual extinction. *"Filmed over two years, The End of the Line follows the investigative reporter Charles Clover as he confronts politicians and celebrity restauranteurs who exhibit little regard for the damage they are doing to the oceans … Filmed across the world – … featuring top scientists, indigenous fishermen and fisheries enforcement officials, The End of the Line is a wake-up call to the world."*

The End of the Line - Collapsed State
released: 2009
presented by: Prof Palumbi
Trailer for the End of the Line
availability: www.endoftheline.com https://www.youtube.com/watch?v=D47QsvvGILY&feature=em-subs_digest-vrecs
theme: *"The End of the Line is a powerful film about one of the world's most disturbing problems - over-fishing. Advances in fishing technology mean whole species of wild fish are under threat and the most important stocks we eat are predicted to be in a state of collapse by 2050."* (https://www.youtube.com/watch?v=D47QsvvGILY&feature=em-subs_digest-vrecs).

We feed the World - Essen Global
released: 2005
language: German
presented by: Jean Ziegler, Erwin Wagenhofer
produced by: Allegro Film & Universum Film GmbH
availability: DVD, trailer at: http://www.we-feed-the-world.at/trailer_quicktime.htm
theme: *"WE FEED THE WORLD is a film about food and globalisation, fishermen and farmers, long-distance lorry drivers and high-powered corporate executives, the flow of goods and cash flow – a film about scarcity amid plenty. With its unforgettable images, the film provides insight into the production of our food and answers the question what*

world hunger has to do with us." (http://www.we-feed-the-world.at/en/film.htm)

CONSUMERISM:

THE STORY OF STUFF - Consumerism, Capitalism, & Environment in America
released: 2007
presented by: Annie Leonard
produced by: Erica Priggen, Free Range Studios
availability: available at https://www.youtube.com/watch?v=3eWBg80jn04
http://storyofstuff.org/
theme: *"We have a problem with Stuff. We use too much, too much of it is toxic and we don't share it very well. But that's not the way things have to be. Together, we can build a society based on better not more, sharing not selfishness, community not division. The Story of Stuff Project's journey began with a 20-minute online movie about the way we make, use and throw away all the Stuff in our lives. Five years and 40 million views later, we're a Community of 750,000 changemakers worldwide, working to build a more healthy and just planet. We invite you to watch and share our movies, participate in our study programs and join our campaigns. Come on, let's go!"* (http://storyofstuff.org/)

CENTURY OF THE SELF
released: 2013
presented by: Adam Curtis
produced by: BBC
availability: as a DVD but can also be watched on line at: http://freedocumentaries.org/documentary/bbc-the-century-of-the-self-happiness-machines-season-1-episode-1#watch-film
theme: A four part documentary. "*In this revealing documentary, Curtis unearths how capitalists and governments use Freudian psychology to influence and manipulate public opinion and consumption. Are we truly free agents or are we the unknowing puppets of the powers above? From the director of "The power of Nightmares."* Cited from DVD cover. Curtis also reveals the work of Edward Bernays, the father of "spin" and public relations.

CONSUMED - Is Our Consumer Culture Leading to Disaster?
released: Aug 9, 2013
presented by: Geoffrey Miller & Jonathan Chapman
produced by: Journeyman Pictures
availability: https://www.youtube.com/watch?v=bOKlo4TWVsU
theme: Presents how the secrets of the human mind are destroying our world through consumerism.

THE LIGHTBULB CONSPIRACY | planned obsolescence
released: 2010
writer: Cosima Dannoritzer
produced by: Arte France, Television Espanola, Televisio de Catalunya
availability: https://www.youtube.com/watch?v=vfbbF30xf-E
theme: *"Once upon a time ... products were made to last. Then, at the beginning of the 1920s, a group of businessmen were struck by the following insight: 'A product that refuses to wear out is a tragedy of business' (1928). Thus Planned Obsolescence was born. Shortly after, the first worldwide cartel was set up expressly to reduce the life span of the incandescent light bulb, a symbol for innovation and bright new ideas, and the first official victim of Planned Obsolescence. During the 1950s, with the birth of the consumer society, the concept took on a whole new meaning, as explained by flamboyant designer Brooks Stevens: 'Planned Obsolescence, the desire to own something a little newer, a little better, a little sooner than is necessary ...'. The growth society flourished, everybody had everything, the waste was piling up (preferably far away in illegal dumps in the Third World) - until consumers started rebelling ... Can the modern growth society survive without Planned Obsolescence?"* (http://www.imdb.com/title/tt1825163/)

SURPLUS: Terrorized Into Being Consumers
released: 2003
written by: Erik Gandini
produced by: Erik Gandini ATMO
availability: DVD and available at: https://www.youtube.com/watch?v=bXmuWecIQ0s
theme: *"Surplus: Terrorized Into Being Consumers is an award winning Swedish documentary film on consumerism and globalization, created by director Erik Gandini and editor Johan Söderberg."* (https://www.youtube.com/watch?v=bXmuWecIQ0s)

POLLUTION & CLIMATE CHANGE:

An Inconvenient Truth
released: 2006
presented by: Al Gore

produced by: Sangster 1Paramount Pictures & Participant Productions
availability: DVD and at: https://www.youtube.com/watch?v=OcLG-tcMvyg
theme: United States Vice President Al Gore's - LONG DOCUMENTARY: *"From director Davis Guggenheim, An Inconvenient Truth is a passionate and inspirational look at former Vice President Al Gore's fervent crusade to halt global warming's deadly progress by exposing the myths and misconceptions that surround it. In this intimate portrait of Gore and his "travelling global warming show," Gore comes across as never before in the media - funny, engaging, open and intent on alerting citizens to this "planetary emergency" before it's too late."* (http://www.takepart.com/an-inconvenient-truth/film)

The Age of Stupid
released: 2009
presented by: Pete Postlethwaite
produced by: Lizzie Gillett & Spanner Films
availability: DVD
theme: *"The Age of Stupid stars Pete Postlethwaite as a man living alone in the devastated world of 2055, looking at old footage of seven real people from now and asking: why didn't we stop climate change when we had the chance"* (Pickles, http://www.imdb.com/title/tt1300563/)

Plastic Planet
released: 2009
presented by: Werner Boote
produced by: Farbfilm*Verleih, Neue Sentimental Film /Brandstorm Entertainment
availability: DVD. Trailer at http://www.plastic-planet.de/
theme: *"Werner Boote presents an up-close and personal view of the controversial and fascinating material that has found its way into every facet of our daily lives: plastic. He takes us on a journey around the globe, showing that plastics have become a threat for both environment and human health."* (Werner Boote: http://www.imdb.com/title/tt1292648/)

25.117 Vision

(q.v. deep ecology, Kogi people)

> *"We are still reaching for the sky. In the developed countries people are coming back down, saying, 'It's empty up there.'"*
> Gyelong Paldan, 1990, quoted by Helena Norberg-Hodge (1991)

> *"James Brent, chair of Plymouth Argyle FC and newly appointed chair of governors at Plymouth University, says it is vital the board and executive share the same vision."*
> Fazackerley, A. (2014)

The famous biologist, C.H.Waddington, recounts the dilemma of the US Defence Department when it wanted to design a robot and thinking that they did not need to fuss about a philosophy. However, after millions of dollars had been wasted *"this is just what they are finding they have to fuss about. The only way to make a robot anything more than an adding machine is to provide him with a philosophy. He cannot even see to any purpose, let alone use language, unless there is built into his system some sort of model of the kinds of things or processes that he may expect to encounter. It's only when someone endows him with a philosophy that a robot begins to get within sight of even the simplest human capabilities. It's no good saying 'Okay, but I've got beyond that stage. I can do without one.' You can't, any more than you can do without your DNA genes, ... Some sort of philosophy is a prerequisite for humanity ...*

Philosophies do not need to be detailed. In fact if they are too detailed they become counter-productive. The essential function of a philosophy is to provide mental machinery for dealing with a large variety of things [we might also here interject: 'situations'] and interpreting them into something which has 'meaning', i.e. something to which we respond or react" (Conrad H. Waddington, 1977).

It is very hard for young people, during their personal development, to find their vision. Furthermore, it is not something generally attended to in western education which in any case is oriented towards finding employment. Not only is finding one's own vision early in life inherently difficult but it has been made more so by our globalized and materialistic world with the commercial pressure to find satisfaction in consumption. A vision might be defined as a set of guiding principles or light for one's life. It is perhaps worth observing that the technology and complexity of the unsustainable consumer does not automatically lead to a happy and fulfilled life.

Unfortunately, pessimism about the future being brought to us by the western consumer culture is not difficult to find (Emmott, 2013) nor is it either helpful nor sustainable. Where can we look for help? Many indigenous peoples provide answers including the Kogi people (q.v.) of the Sierra Nevada de Santa Marta in Colombia (Ereira, 1990); the Ladakh people who live in the foothills of the Himalayas in northern India (Norberg-Hodge, 1991) (q.v. Consumerism & Ladakh); or the nation state of Bhutan (q.v.) (Kelly, 2012).

The concept of vision is important to the Awajún people who live in the Peruvian Amazon (Brown, 2014). The Awajún culture has traditionally used visions produced by the use of plant drugs, however, Gil Inoach, "*an outspoken federation leader and environmentalist*" together with some others want *"to revitalize the traditional vision quest"* because *"the Awajún have long believed in tajímat (prosperity) visions. "The ancient version of tajímat signified abundance: to be a visionary, to have well behaved children, to have gardens, to be a hunter and a fisherman, to be respected for one's reputation, to have wives and a large house," Inoach said. A modern tajímat is different. "What we're looking for is to become a people with our own system of education, developing our own technologies, a people who express their understandings to persuade the world of the value of protection and conservation, of the values of development and reciprocity.""*

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Kelly, A. (2012) Gross National Happiness: a tiny state's big idea that could change the world, The Guardian Weekly, 07-13.12.2012, vol 187, no 26, p 9.

Norberg-Hodge, H. (1991) Ancient Futures, learning from the Ladakh, San Francisco, Sierra Club Books.

Waddington, C.H. (1977) Tools for thought, St Albans, Paladin Books.

25.118 Water, Green, Blue, Brown, Grey

(q.v. deep ecology, Kogi people)

Green Water

In the early 1990s, the hydrologist, Malin Falkenmark of the Stockholm International Water Institute, Sweden, coined the terms 'green-' and 'blue water' to distinguish the different courses water follows in the hydrological cycle (Shiermeier, 2008) as a means to help managing our water resources. For example, 'green water' is lost to human management since it is the water taken up by plants, whereas 'blue water' may become 'green water' when extracted from an aquifer, lake or river and then used for irrigating crops.

'Green water' is water that enters the atmosphere through evaporation and transpiration or evapotranspiration from plants. Initially water, falling as rain, enters the top soil and may remain in the root zone of plants. Plants take up the water through their root systems along with nutrients and the green water is drawn up into the roots and then by transpiration into their stems or trunks and finally into the leaves from where it eventually evapotranspirates from the leaves' stomata (pores) into the atmosphere.

The stomata can open and close and optimally control the quantity of water evapotranspirating from the leaves depending on the ambient conditions of light, temperature and soil moisture. The 'green water' which evaporates into the atmosphere through evapotranspiration is treble the amount that would evaporate from the same surface area of ground devoid of vegetation. Consequently, plants, be they crops, forests or meadows, make an essential contribution to the Earth's hydrological system (Mauser, 2007).

'Green water' is crucial for the land based production of biomass by photosynthesis (also referred to as Net Primary Production – NPP) on which terrestrial life depends. Photosynthesis is the process by which the chlorophyll in the leaves combines 'Green water' and carbon dioxide to create glucose and oxygen.

$6CO_2 + 6H_2O$ > interaction of sunlight on chlorophyll > $C_6H_{12}O_6 + 6O_2$

In regarding this wonderful formula we can see how photosynthesis is a win/win reaction because it not only sequesters the green house gas, carbon dioxide, but also, by using the sun's energy, creates the oxygen we need along with the sugar-glucose!

Blue Water

In contrast to 'green water,' 'blue' water runs off the ground's surface into lakes and rivers or seeps, or infiltrates, into the earth where it becomes groundwater or collects in and recharges aquifers. The greater the run-off then the more 'blue' water is potentially available for human use. Eventually, the water reaches a river's estuary and joins the oceans where evaporation from the sea's surface and formation into clouds enables the cycling water to fall again as rain. *"In the commonly used terminology, water 'withdrawal' refers to the direct human extraction of blue water flow for societal use in irrigated agriculture, industry and municipal use"* (Falkenmark & Rockström, 2007).

However, true water 'use' is always somewhat less than the water 'withdrawal.' For example, when irrigating crops the water 'consumed' by the plants becomes part of the green water flow and evaporates from their leaves. However, some of the water percolates into the soil and rejoins the groundwater. *"Green water flow from vegetation is by far the largest 'consumptive' use of water … Consumptive water use refers to water withdrawn from a source and made unsuitable for reuse in the same basin" so also "When use results in contamination of water it then has to be considered as consumed water."* (Falkenmark & Rockström, 2007).

Brown water

Brown water is the blue water that is contaminated by human use and then returned to the surface water system.

Grey water and Blackwater

Greywater or "used" water might be said to get its name from its colour due to relatively limited domestic use in the kitchen, and for personal hygiene washing and laundery, in other words it contains soaps, detergents and other residues but it is relatively clean. Therefore it can be reused without treatment, for example, for irrigation and for flushing lavatories. It does not contain industrial chemicals or hazardous wastes or human sewage (Pedersen, Woelfe-Erskine, & Hill-Hart 1, 2007). Blackwater is water containing human faecal material or sewage.

Virtual Water

The concept of 'green water' enables us to better understand another concept – 'virtual water' (qv). Virtual water is not the water within a vegetable, fruit or grain but the 'green water' required to grow the plants throughout their lifetime and from which the produce can be harvested.

A plant needs a continual supply of water to live (green water) so that it can finally bear fruit or be harvested. The sum total required is the 'virtual water' and the quantities are staggering; for example, the water required to grow a kilogram of wheat is about 1,000 liters and to grow and to produce a kilogram of coffee requires an estimated 20,000 liters of water (Pearce, 2006).

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25.119 Water, Virtual

(q.v. Green, Blue, Brown, Grey water)

Virtual water is not simply the water within a vegetable, fruit, or grain but the 'green water' required to grow the plants from seed to when the produce can be harvested. A plant needs a continual supply of water to live (green water) so that it can finally bear fruit for harvesting. This is the 'virtual water' and the quantities of water required by a plant throughout its life time are staggering; for example, the water required to grow a kilogram of wheat is about 1,000 liters and to grow a kilogram of coffee requires an estimated 20,000 liters of water (Pearce, 2006).

The concept of virtual water was developed by the water expert, Prof Tony Allen. He powerfully makes the point how little we understand water and how grossly we waste it. He describes the quantity of water required to produce a typical breakfast in the UK or USA consisting of bacon and eggs, toast, an expresso coffee, a glass of milk and an apple. Allen explains that the expresso might appear to be only 3-400 milliliters of water, however the water required to grow, produce, package and ship the beans is about 140 liters! The breakfast Allan described requires a total of 1,100 liters of water to produce or the equivalent of 3 bath tubs filled with water! The principle applies not only to organic products but also to inorganic products since most require water for their manufacture.

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25.120 WEEE Waste Electrical & Electronic Equipment

(q.v. Rare Earths, Circular Economy)

"Waste of electrical and electronic equipment (WEEE) such as computers, TV-sets, fridges and cell phones is one the fastest growing waste streams in the EU, with some 9 million tonnes generated in 2005, and expected to grow to more than 12 million tonnes by 2020.

WEEE is a complex mixture of materials and components that because of their hazardous content, and if not properly managed, can cause major environmental and health problems. Moreover, the production of modern electronics requires the use of scarce and expensive resources (e.g. around 10% of total gold worldwide is used for their production). To improve the environmental management of WEEE and to contribute to a circular economy and enhance resource efficiency the improvement of collection, treatment and recycling of electronics at the end of their life is essential" (ec.europa.eu, 2014).

To address these problems two pieces of legislation have been put in place by the European Commission:

a. The Directive on waste electrical and electronic equipment (WEEE Directive) supports the return free of charge of EEE and provides for the implementation of collection schemes with the aim of increasing re-use and re-cycling and the circular economy (Directive 2002/96/EC).
b. Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive). A new Directive was proposed in order to confront the rapidly increasing waste stream (Directive 2012/19/EU) and became effective on 14 February, 2014.

In 2003 EU legislation came into force restricting the use of hazardous substances in electrical and electronic equipment. This law requires the substitution of "*... heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants such as polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE)*" (ec.europa.eu, 2014) with safer alternatives. The legislation on hazardous substances became effective in 2013 (RoHS recast Directive 2011/65/EU).

Despite the good intentions of some legislators the enormous quantities of EEE waste from first world countries are being illegally dumped in West Africa, under the guise of technological aid. *"Defunct computers end up in landfill sites in Ghana and Nigeria"* (Wray, 2008) where they poison the ground water with heavy metals and other toxic residues.

Meanwhile, many people in developing countries seriously endanger their own health by making a living by scavenging the EEE dumps for the metals they are able to extract. The UK company *Learning Light* has created learning materials for illiterate waste workers to guide them to safely dismantle inkjet printers and other equipment, etc. The course modules are designed to meet the EU requirements regarding its WEEE Directive but a number of difficulties still have to be overcome for a successful circular economy to be created.

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25.121 'Wicked' Problems

(q.v. Syndromes)

'Wicked problem' is a term that was coined by Horst Rittel who applied it to a class of complex problems which are difficult to define because of their social context. Due to the pluralism of society, a public good cannot be definitively agreed on or defined and so there can be no objective definition of public good or equity. Therefore, an 'optimal solution' to a social problem is impossible to achieve without initially imposing very strict definitions and consequently, *"there are no "solutions" in the sense of definitive and objective answers"* (Rittel & Webber, 1973). 'Wicked problems' are termed so, not because of any hidden evil within, but simply due to the trickiness of trying to find a solution and one which will satisfy all stakeholders.

Rittel & Webber distinguished wicked problems by the following characteristics:

1. There is no definitive exhaustive formulation of a wicked problem due to endless causal chains linked to interacting open systems. Therefore, there is always incomplete information. On the contrary, 'tame' problems can be definitively defined.
2. Wicked problems have no stopping rule but rather the solution is that which is reached when the financial budget is exhausted or time runs out.
3. Solutions to wicked problems are not true-or-false, only good-or-bad.
4. Answers to "tame" problems can be assessed whereas the response to a wicked problem, after being implemented creates waves of consequences, some perhaps unanticipated, while others are perhaps anticipated. The consequences themselves generate further repercussions which are impossible to trace.
5. Solutions to wicked problems can only be implemented once since there is no opportunity for learning by trial-and-error. The solution's implementation will have changed the situation making correction impossible and create a new wicked problem. As the great Greek philosopher, Heraclitus of Ephesus, said *"You cannot swim twice in the same river."*
6. A solution to a wicked problem raises a *"host"* of possible answers which in the end leads to the decision *"OK, let's try that."* which ignores the possibility of another "host" of possible answers being considered.
7. Every wicked problem is fundamentally unique because despite their similarities to other wicked problems there might be another characteristic of tantamount importance. Wicked problems cannot be classified according to any taxonomy.
8. Every wicked problem can be considered to be a symptom of another problem.
9. The choice of the explanation determines the nature of the problem's solution because people choose explanations which they find most plausible.
10. The planner has no right to be wrong. Science progresses by a cycle of a scientist testing a hypothesis and the results lead to a formulation requiring further verification or testing. Therefore science builds on continual verification which means that scientists are sometimes found to be wrong in determining the truth. A planner must not make a mistake although he works in a field of intangibilities. Whatever is planned must work.

(This is a summary of the ten points fully described in Rittel, & Webber, 1973)

In order to identify as many components to a wicked problem as possible Rittel developed a computer program called IBIS (which stands for Issue-Based Information System) which was further developed by Conklin. The aim of this program was to identify as many of the interactions and relationships embedded within and extending beyond wicked problems.

Conklin (2005) provides "… *a few examples of wicked problems*

› *Whether to route the highway through our city or around it?*
› *How to deal with crime and violence in our schools?*
› *What to do when oil resources run out?*
› *What should our mission statement be?*
› *What features should be in our new product?*"

We can see from this list of examples that these societal problems are distinct from scientific problems because wicked problems are characterized by the plurality of society, diverse stakeholders and their differing perceptions of a problem.

Conklin's examples make it clear that design is largely concerned with "wicked problems." Furthermore, a group of severe wicked problems are called 'syndromes,' (q.v.) many of which involve the interactions of societies with environments.

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Part 5

Appendices

Yrjö Sotamaa

26 Kyoto Design Declaration

(from the Cumulus Association web page: http://www.cumulusassociation.org/component/content/1-current-affairs/217-kyoto-design-declaration-signed-on-march-28-2008/225)

The highlight of the Kyoto Design Conference, Japan, the first Cumulus conference held outside Europe. (28-31.03.2008).

The Kyoto Design Declaration was signed in Kyoto on the 28th of March 2008 by the Executive Board of Cumulus, President Christian Guellerin, Past President and Author of the Declaration Yrjö Sotamaa, Rector Kan Shimamoto, Kyoto Seika University, and Industrial Designer Takuo Hirano from Japan, representing the 124 global members of Cumulus. The Declaration received support ao. from ICSID, BEDA, AIGA and EIDD. By signing the Kyoto Design Declaration, the members of Cumulus Association are committed to sharing global responsibility for building sustainable, human-centred and creative societies.

TEXT OF THE DECLARATION:

The statement of commitment by the members of Cumulus to sharing the global responsibility for building sustainable, human-centered, creative societies.

PROPOSING NEW VALUES AND NEW WAYS OF THINKING

All the people of the world now live in global and interdependent systems for living. We continue to enhance the quality of our lives by creating environments, products and services utilizing design. Design is a means of creating social, cultural, industrial and economic values by merging humanities, science, technology and the arts. It is a human-centered process of innovation that contributes to our development by proposing new values, new ways of thinking, of living and adapting to change.

AN ERA OF HUMAN CENTERED DEVELOPMENT

A paradigm shift from technology driven development to human centered development is underway. The focus is shifting from materialistic and visible values to those which are mental, intellectual and, possibly, less material. An era of "cultural productivity" has commenced where the importance attributed to modes of life, values and symbols may be greater than that attributed to physical products. Design thinking stands steadfastly at the centre of this continuum. Simultaneously, this development highlights the importance of cultural traditions and the need to extend and revitalize them.

THE IMPERATIVE FOR DESIGNERS TO ASSUME NEW ROLES

Global development and an awareness of the growth of related ecological and social problems are posing new demands and offering new opportunities for design, design education and design research. Design is challenged to redefine itself and designers must assume new roles and commit themselves to developing solutions leading to a sustainable future.

SEEKING COLLABORATION IN FORWARDING THE IDEALS OF SUSTAINABLE DEVELOPMENT

The members of Cumulus, representing a global community of design educators and researchers, undertake the initiative outlined in this, 'THE KYOTO DESIGN DECLARATION', to commit themselves to the ideals of sustainable development. Furthermore, the members of Cumulus have agreed to seek collaboration with educational and cultural institutions, companies, governments and government agencies, design and other professional associations and NGOs to promote the ideals of, and share their knowledge about, sustainable development.

FROM EDUCATION TO GLOBAL RESPONSIBILITY

In order to fulfil its declared mission to contribute to sustainable social, environmental, cultural and economic development for current and future generations, and to contribute to an environment and culture that makes harmonious and healthy life possible, the Cumulus members make this declaration. Members will commit themselves to accepting their part in the further education of our youth within a value system where each of us recognizes our global responsibility to build sustainable, human-centered, creative societies.

THE POWER TO MAKE FUNDAMENTAL IMPROVEMENTS TO OUR WORLD
Human-centered design thinking, when rooted in universal and sustainable principles, has the power to fundamentally improve our world. It can deliver economic, ecological, social and cultural benefits to all people, improve our quality of life and create optimism about the future and individual and shared happiness.

Peter Stebbing

27 Greening the Campus

(q.v. Glossary: AASHE)

Introduction
Greening the campus refers here not to the curriculum, but how the campus functions. Probably everyone would agree that educational institutions cannot ethically teach sustainability if the institution is itself not an example of its own curriculum. It is clearly ridiculous for students to learn about re-cycling in a lecture but then afterwards to go into the cafeteria where coffee is served in styrofoam cups (which are possibly carcinogenic) which are disposed of in bins mixed with unsorted rubbish including: paper serviettes, plastic spoons, glass and plastic drink bottles and empty drink cans. This however, remains the situation in many colleges and universities all over the world. It is unsustainable and must be stopped because it nullifies what the students have learnt and greening the campus is the solution.

Greening the campus should permeate every aspect of a campus's organization and requires a change in the corporate culture of an educational institution. Greening the campus is concerned with the full gamut of an institution's organization and administration, including: energy management, waste, lighting, air quality, water and its conservation, purchasing, catering services, paper and other waste materials, building materials and maintenance, office equipment and supplies, events, transportation, supplies for laboratories and studios, and so on.

It is not the aim to describe a specific modus operandi here but rather to advocate the necessity of higher education institutions to implement sustainability throughout the campus. Different countries have different procedures such as the STARS procedure in the USA organized by the Association for the Advancement of Sustainability in Higher Education. In Europe several procedures are available including the voluntary EMAS and the European standard ISO14001 which are referred to below.

We must recognize that all "*… universities and colleges have a unique opportunity, in the classroom and by example of their physical plant, to provide students with a basic understanding of the interactions between business decisions and the natural systems on which our health and well being depend … Universities can both teach and demonstrate environmental principles and stewardship by taking action to understand and reduce the environmental impacts that result from their own activities*" (Creighton, 1998). It begins with the personnel:

1.0 Personnel
Greening a campus is not an activity that can be delegated to a small committee composed of a couple of teaching staff, someone representing the administration and some students. Rather, it has to be policy authorized from the top down and actively promoted throughout the organization of the entire school in which every level is involved: the dean, the teaching staff, the departments, the entire administration and the students, but especially the students. Why? This is because sustainability permeates every aspect of our lives and therefore every decision offers a more or less sustainable opportunity.

1.1 The Leadership
Top-level commitment and visible action from the head of the institution is critical as it is also from the heads of the departments for reasons which include:

- it protects the environment and for future generations,
- reduces waste,
- benefits health, safety, and the community,
- reduces liability,
- it saves resources, materials, and energy,
- and consequently saves money.

It is to be hoped that education is not following the world of commerce where "*... in most cases business leaders are burying their heads in the sand when it comes to addressing issues ranging from climate change to the collapse of biodiversity*" (Confino, 2014). Good leadership is crucial for achieving corporate change across a campus. Furthermore, many institutions have made the move to becoming sustainable and it can also be a promotional factor in recruiting student applicants.

1.2 Departments

Each department should have its own departmental working group composed of several lecturers/professors and students (perhaps from each semester/year group).

1.3 Administration

The administration needs to be deeply involved and schooled in revising past unsustainable practices so as to move towards sustainability and saving money. This requires encouragement and support for example, to identify new eco-friendly providers of resources made from recycled materials or which are locally manufactured to reduce transport costs. The organization of waste collection so that as much waste as possible can be recycled may initially require additional administration. The recognition of the importance of sustainability by the administration is crucial since they often do not traditionally recognize their actions as being educational. However, they can set many examples which illustrate sustainability and which also reduce running costs.

1.4 Students

The student body should have its own working group and in some universities it has been students who have resulted in a university's adoption of sustainable management. For example students at Tübingen University in Germany were the driving force behind the introduction of the environmental management of the University and its successful registration under the Eco-Management and Audit Scheme (EMAS). The Tübingen Student Initiative published its own book: Greening the University Perspektiven für eine nachhaltige Hochschule only a year after they began their initiative.

In 2009 they started to prepare for the rigorous EMAS audit and organized campus wide actions resulting in reductions in the use of resources (energy, water, paper. etc.). In October 2011 the University was the first to be registered with EMAS in Baden-Württemberg, Germany. Another university with a strong commitment to sustainability and creating a sustainable community is Leuphana University in Lüneberg, Germany (http://www.leuphana.de/ueber-uns/organisation/fakultaet-nachhaltigkeit.html).

2.0 Areas for sustainable action

Institutions of higher education are communities and provide educational illustrations of everyday aspects of life which can be conducted less or more sustainably. Therefore areas for action might be grouped as described below, however, this list will vary according to the character of the campus:

- Commuting to and from the university and transportation
  - Car-sharing etc.
- Buildings and grounds
  - Energy consumption
  - Water consumption
  - Waste management
  - Maintenance
  - Construction and renovation
  - etc.
- Laboratories, Studios & Workshops
  - Sustainable resourcing (e.g. print supplies
  - Energy consumption etc.)
- Catering Services
  - Regional provisions of food & selecting food for low impact
  - Food Waste
  - Kitchen equipment
  - Water usage & conservation
  - etc.
- Purchasing of materials
  - Environmentally friendly materials
  - Purchasing for energy efficiency
  - Waste reduction
  - Energy efficient equipment
  - Recycled products

  - › Student shop
- › Administration
  - › Reducing paper
  - › Office supplies & equipment
- › University events and student social activities
  - › Sustainable resourcing (see Greening the Conference) etc.
- › Student Halls of residence
  - › Laundry
  - › Waste
  - › Energy
  - › etc.

This list is by no means complete but rather indicative of the breadth of organization that can be implemented for making the campus sustainable. The actual procedures are described by the sustainability auditing procedures such as STARS, ISO14001 and EMAS (all described below) etc.

Initial Audit

Metrics are needed to know the ecological footprint of the campus before introducing sustainability measures and to demonstrate and feedback the savings made in resource consumption, emissions, and energy consumption etc.

Eco-Management and Audit Scheme (EMAS)

EMAS is an environmental management scheme based on EU-Regulation 1221/2009 for the voluntary participation by organizations. The description of EMAS is extracted from the EMAS web page:

"The EU Eco-Management and Audit Scheme (EMAS) is a management instrument developed by the European Commission for companies and other organizations to evaluate, report, and improve their environmental performance. EMAS is open to every type of organization eager to improve its environmental performance. It spans all economic and service sectors and is applicable worldwide. Currently, more than 4,500 organizations and approximately 8,150 sites are EMAS registered worldwide. Among them are many multinational enterprises and smaller companies as well as public authorities …

EMAS is a voluntary tool available for any kind of organization aiming to:

- › *Improve its environmental and financial performance;*
- › *Communicate its environmental achievements to stakeholders and society in general.*

The third revision to the EMAS Regulation has improved the scheme's applicability and credibility and strengthened its visibility and outreach. This section provides an introduction to Environmental Management Systems (EMS) in general and in-depth information on EMAS, its key provisions, participation and registration procedures, case studies of registered organizations and frequently asked questions." (http://ec.europa.eu/environment/emas/index_en.htm)

ISO14001

This text is extracted from the ISO web page:

"ISO 14001:2004 specifies requirements for an environmental management system to enable an organization to develop and implement a policy and objectives which take into account legal requirements and other requirements to which the organization subscribes, and information about significant environmental aspects. It applies to those environmental aspects that the organization identifies as those which it can control and those which it can influence. It does not itself state specific environmental performance criteria.

ISO 14001:2004 is applicable to any organization that wishes to establish, implement, maintain and improve an environmental management system, to assure itself of conformity with its stated environmental policy, and to demonstrate conformity with ISO 14001:2004 by

a. *making a self-determination and self-declaration, or*
b. *seeking confirmation of its conformance by parties having an interest in the organization, such as customers, or*
c. *seeking confirmation of its self-declaration by a party external to the organization, or*
d. *seeking certification/registration of its environmental management system by an external organization.*

All the requirements in ISO 14001:2004 are intended to be incorporated into any environmental management system. The extent of the application will depend on factors such as the environmental policy of the organization, the nature of its activities, products and services and the location where and the conditions in which it functions.

ISO 14001:2004 also provides, in Annex A, informative guidance on its use." (accessed from: http://www.iso.org/iso/catalogue_detail?csnumber=31807)

STARS

"The Sustainability Tracking, Assessment & Rating System™ (STARS) is a transparent, self-reporting framework for colleges and universities to measure their sustainability performance." (https://stars.aashe.org/) STARS was launched in January 2010 by the Association for the Advancement of Sustainability in Higher Education (AASHE). Towards the end of 2013 the AASHE released an update of STARS (STARS 2.0) which "is meant to "facilitate more meaningful assessments of campus sustainability performance while remaining accessible and relevant to the diversity of higher education institutions."

"STARS is the most thoroughly vetted and extensively tested international sustainability framework for colleges and universities, it is by no means perfect. The current version of STARS is intended to stimulate, not end, the conversation about how to measure and benchmark sustainability in higher education. AASHE welcomes … feedback and participation in continuing to refine and shape the system …

STARS is designed to:

› *Provide a framework for understanding sustainability in all sectors of higher education.*
› *Enable meaningful comparisons over time and across institutions using a common set of measurements developed with broad participation from the international campus sustainability community.*
› *Create incentives for continual improvement toward sustainability.*
› *Facilitate information sharing about higher education sustainability practices and performance.*
› *Build a stronger, more diverse campus sustainability community."* (AASHE 2013)

A strategy for "greening the campus" could encompass a plan over several years beginning with an initial audit. In this way, by dividing the plan into stages on a year by year basis is more likely to contribute to overall and longterm success. As each step becomes successful and witnessed by the rest of the campus so it will contribute to a corporate attitude change which will make subsequent steps easier to implement.

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Peter Stebbing

28 Greening the Conference

Introduction

Conferences have a heavy eco-footprint. The Cumulus Association organises two conferences per year, and sometimes an ancillary conference or two also take place under its name. Cumulus is committed to its own Kyoto Design Declaration (see Appendix 1) which was signed in 2008. Furthermore, as an educational organization, it is also concerned with educating young people to be sustainable and therefore it is imperative that Cumulus conferences are exemplary in their sustainable organization. Students are also involved in the conference organization and therefore the conferences can provide valuable learning opportunities for organizing a sustainable event.

A sustainable conference is a design problem and luckily all Cumulus members are intimately familiar with design. Consequently, designing and organizing a sustainable conference should be no problem. Unfortunately, the temporary character of a conference encourages cost cutting and frequently the convenience of an instant throw-away unsustainable culture. Normally, between 200 to 300 delegates attend a Cumulus conference, a substantial number of whom fly from different continents to reach the venue clocking up air-miles and contributing to carbon emissions and an enormous carbon footprint. What is to be done?

Designing more sustainable conferences

Bejamin Lester (2007) proposes the following tips for conference delegates in a paper called "Greening the Meeting":

1. *"Skip meetings when you can.*
2. *When you can't, combine trips to get the most out of your air miles."*
   (Cumulus delegates could combine a conference with other activities such as visiting a partner institution (and not just the host) to give: a lecture, a seminar or workshop for students at a partner institution or participate in a teacher exchange so as to maximise the benefits for the cost of the air miles. The Society for Conservation Biology has estimated that *"95% of the society's entire emissions comes from jet fuel used in getting members to the annual meeting"* (Lester, 2007) One strategy is to contribute $20 to the registration fee for projects to offset carbon emissions.)

Other recommendations include:

3. *"Avoid conferences in far-flung lands.*
4. *For conferences close to home, carpool or take a train.*
5. *Choose a hotel close to the conference to avoid commuting.*
6. *Ask conference organizers to team with local hotels to reduce linen changes and other waste for conference attendees.*
7. *Avoid using disposables such as plastic tableware and Styrofoam (linked to cancer) cups.*
8. *Don't collect brochures that will only get thrown out"* (Lester, 2007).
9. The conference program together with associated information can be digitally circulated along with confirmation of a delegate's payment thereby saving printing costs and the associated materials. Dematerialisation should be a significant organising strategy.
10. The hosting university should not attempt to show off their different campuses, especially when they are spread across a big city so that delegates have to travel to different venues every day. Often public transport is not easy to use for delegates from different countries and so they frequently resort to taxies.
11. Every effort should be made to be sustainable since *"every little helps"* and every action can be viewed as either part of the solution or contributing to the problem!
12. Finally, sustainability saves money if correctly carried out.

It is generally agreed (the author, let it be said, is of the same opinion) that there is no substitute for meeting colleagues *"over a glass of wine"* because networking and brainstorming are the essence of conferences. However, two conferences a year is a big footprint and so what other strategies might be employed to reduce their footprint? One suggestion is simply to limit the numbers of delegates that can attend the conference which is not altogether a popular strategy. Another suggestion is to use a central venue rather than one at an outlying location. For example, a conference held at Port Elizabeth required nearly all the attending delegates to take a connecting flight from Johannesburg to reach Port Elizabeth. If the conference venue had been at Johannesburg it could have saved all the emissions of the connecting flights.

The second conference could be organised on a different basis to the first; so that while the first conference is to encourage intercontinental contact, the second conference could be to promote networking within the same continent. How might this function?

Continental Node conferences

The strategy to use major cities and saving air miles could be further developed by holding simultaneous conferences in several of the major continents which would require delegates to travel only to a nodal conference sub-venue (major city) within their own continent. The conference plenary sessions and key note presentations could be coordinated for simultaneous or delayed transmission linked together using Access Grid or similar application over the internet. Clearly careful planning is necessary for coordination with local times. However, the planning itself encourages closer contact with other Cumulus member institutions.

Several benefits of Nodal Conference sub-venues

Although the opportunities for personal networking are limited other benefits take their place:

1. Obviously, it is more sustainable to travel within one's own continent and thereby reduce air miles and carbon emissions.
2. The reduced travel costs would enable greater participation by the Cumulus membership itself (The current expense of travelling to a single venue already prohibits many potential delegates from participating in conferences).
3. The Conferences could reach a wider non-membership public and thereby further promote the aims of Cumulus.

There are more comprehensive guides to creating a sustainable conference but here we want to alert organisers to a range of possibilities. Conference organizers are urged to consult the Green Meetings Guide prepared by Peter Defranceschi and Emma Mitrotta at Local Governments for Sustainability at ICLEI, which although oriented towards organising a meeting in Brussels provides a strategy and a framework for organising a conference in any city. The Green Meeting Guide produced by UNEP and ICLEI is for medium sized conferences of up to 200 participants. The UNEP guide embraces a broad range of experience acquired from the large number of meetings convened by the UN. It is organised into two sections *"what to know"* and *"what to do."* The UNEP guide provides links to a variety of further sources.

References and further reading

Defranceschi, P., Mitrotta, E. (2011) How to organise sustainable meetings & events in Brussels A practical guide, Brussels, ICLEI - Local Governments for Sustainability (accessed at: http://www.iclei-europe.org/fileadmin/templates/iclei-europe/files/content/Brussels/bxl-greenmeetings-guide.PDF)

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Changing Paradigms: designing for a sustainable future is intended for designers, design students and design educators, who want to understand why and how to integrate Sustainability into design education and practice. It consists of five parts; Part One presents why we must design for a sustainable future, Part Two describes how to design for a sustainable future, Part Three presents student design projects exemplifying sustainable design, Part Four is a glossary of 120 terms and concepts about Sustainability and design, and finally, Part Five includes three appendices: The Cumulus Kyoto Design Declaration, and guidelines on how to green both school campuses and conferences. This book has been edited by Peter Stebbing and Ursula Tischner, who have invited internationally renown experts to contribute chapters. Changing Paradigms offers a comprehensive survey of essential knowledge for designers and other creative professions to shift their focus to the new design paradigm for sustainable production, consumption, and life styles.

CUMULUS THINK TANK

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