

# Opportunities for Global Sustainability

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## **Abstract**

In spite of our substantive knowledge about global un-sustainability, insufficient progress is being made to halt systematic socio-ecological decline. Much information is readily available on downstream impacts, with limited focus on upstream activities driving such effects. This thesis uses backcasting from socio-ecological principles for sustainability to identify major upstream human activities violating these principles, the underlying drivers reinforcing such activities, alternative practices already in use with potential for significant expansion, and emerging opportunities for action across different sectors of society. Results show emerging patterns of high magnitude violations across all four socio-ecological principles indicating nexus points in energy, transportation and agriculture. These activities are reinforced by our societal structure which is designed to meet human needs through a growth paradigm which in turn does not adequately consider the ongoing health of ecosystems or the sustainable functioning of society itself. Shifting to potential solutions, examples focus on themes such as renewable energy, green chemicals, organic agriculture, and self-organising network structures. Recognising that these actions may not be enough, the thesis explores elements of a global vision which could guide progress. Emerging nexus points for societal change include education, information flows (particularly the media), design (as a leverage point), self-organization, and governance.

**Keywords:** Global Sustainability, Systems Thinking, Backcasting, Sustainability Principles, Strategic Planning, Sustainable Development

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# Executive Summary

## *Introduction*

In spite of substantial knowledge about global un-sustainability, insufficient progress is being made to halt global systematic socio-ecological decline. Much information is readily available on downstream effects; however information on upstream activities driving such effects is much less readily available. This often results in problem-focused reactive management approaches such as extrapolating past and present trends into the future, and making trade-offs based on the urgency to deal with unwanted side-effects; instead of proactively managing uncertainty by attempting to create the desired future of a sustainable society in the biosphere.

## *Purpose*

The intention with this research project is to use systems thinking to provide a broad overview of the goal of sustainability, to understand current reality in relation to this goal, to illustrate opportunities for action through real-world examples, and to identify second-order principles to inform action. To this end, the research questions posed are as follows:

1. What current human activities, structural barriers and paradigms impede global society's progress towards sustainability and what potential enablers are there that we can build upon?
2. What are potential elements of a global vision of a sustainable future in terms of human activities, structures and paradigms?
3. What are some opportunities for moving toward this global vision?

## *Method*

Adopting a whole-systems perspective, this thesis uses backcasting from basic socio-ecological principles for sustainability in order to identify major upstream human activities violating these principles, the underlying drivers reinforcing these activities, and alternative practices already in use that we can potentially build on. These socio-ecological principles also known as

“the System Conditions” are specifically designed for backcasting and are stated as follows:

*“In a sustainable society, nature is not subject to systematically increasing...*

*(1) ... concentrations of substances extracted from the Earth’s crust,*

*(2) ... concentrations of substances produced by society,*

*(3) ... and degradation by physical means.*

*And, in that society,*

*(4) ... people are not subject to conditions that systematically undermine their capacity to meet their needs” [1].*

## ***Results: Barriers and Enablers***

With respect to sustainability barriers and enablers, findings are presented in relation to each of the System Conditions, highlighting current activities in violation and under-tapped potentials. Key findings are as follows:

*System Condition 1.* Approximately 99% of the mass of the Earth’s crust is made up of 8 elements, while the remaining 1% contains another 90 elements. Many of these scarcer elements are found in fossil fuels, and are dispersed during combustion processes. Emissions are also generated from the extraction and processing of mined materials, as well as industrial production of consumer end-products. Dispersal can also occur throughout the products useful life and following disposal, typically to landfill. In this context, the most significant human activities include fossil and nuclear based energy consumption (approximately 77% of world energy supply, with transportation as a significant end-user), the materials consumption by the automotive and electronics industries and agriculture in terms of fertiliser and pesticide production and mechanised activities.

Given their vast potential to meet global energy needs in a sustainable way, there is a need to scale up installed capacity for harnessing alternative renewable energy sources such as solar, wind and biomass. Diverting the \$145 billion subsidies currently spent on fossil fuel and nuclear energy would go a long way to making this happen. Additional gains can be made from energy conservation since up to 71% of primary energy is currently wasted, and global end-use efficiency is estimated at around 3.5%.

*System Condition 2.* The most problematic naturally existing substances that are increasing in concentration due to human activities include methane, carbon-, sulphur- and nitrogen-oxides, and radioactive nuclei. The major activities driving these effects include the use of fossil fuel and nuclear energy, transportation, and agricultural practices.

Systematically increasing concentrations of substances that are persistent and foreign to nature are primarily driven by the production of chemicals, the burning of fossil fuels, and the use of nuclear energy. The chemicals industry is responsible for creating over 100,000 chemicals, and relies heavily on petroleum as a feedstock. With basic toxicity data only available for as little as 14% of these chemicals, the burden of proof regarding their toxicity has been transferred to the customer (and therefore to society at large). Furthermore, the lack of a systems perspective means that problems are being dealt with on a chemical by chemical basis.

Shifting to renewable energy sources and optimizing energy efficiency represent major potentials to build on. Another key potential is the green chemical industry, which is growing worldwide. Finally, the shift to organic, local agriculture can go a long way to eliminating emissions and toxicity.

*System Condition 3.* Major human activities that result in physical degradation of ecosystems include agriculture, forestry, fisheries and the process of urbanisation. In the last 50 years, over 40% of agricultural land has been degraded, and agricultural practices account for approximately 70% of total global water use. Prior to human intervention, forests covered two-thirds of the planet; now forests cover only half of that, and continue to decrease on an annual basis. Approximately 75% of global fisheries are either over-fished or fished at their biological limit, and the effects of urbanisation in terms of physical encroachment are significant.

In spite of such significant challenges, there are some interesting potentials to build on. In 1989, the collapse of the Soviet Union cut Cuba off from its supply of agriculture inputs (such as fuel, chemical fertilizers, pesticides, herbicides etc.), forcing the country to develop what is proving to be a very successful organic agricultural system. In the commercial context, sustainable forestry practices like Collins Pine have been successful in economic terms, grossing approximately \$230 million per year, and in

ecological terms, their lands contain more wood today than they did 100 years ago.

*System Condition 4.* As a global society, we are currently focused on making the means (i.e. economic growth) into the end goal. For example, nearly \$2 trillion per year is spent on subsidising unsustainable activities in the economy, and money trading, unrelated to trade in physical goods and services, accounts for over 80% of the global money market. Power is concentrated in a few hands, the powerful create the rules, and the rules are self-reinforcing. A major side-effect of globalisation is the loss of culture and local stories of meaning. The absence of a shared global story of meaning is in turn a major driver of these side-effects. The global economy should serve the goal of meeting basic human needs within ecological constraints, rather than being treated as a goal in itself, indifferent to people and the environment it depends on.

Global potentials to build on in this context include the significant increase in awareness on sustainability over the past 40 years, resulting in initiatives such as the UN Global Compact, the Equator Principles, the UN Millennium Ecosystems Assessment and the World Commission on Social Dimension of Globalisation. In addition, many community level initiatives have sprung from local action, with many communities actively participating in networks such as Global Action Plan, a network of national and local organisations working towards sustainability.

### ***Results: Concrete Opportunities for Action***

Moving on to opportunities for action, real examples have been identified for a range of social actors across broad sectors of global society. These concrete opportunities for action toward sustainability typically address more than one System Condition and are therefore presented by major upstream human activity. The following examples illustrate the kinds of solutions and actions contained in the main body of this report.

- *Agriculture.* Direct science and technology resources towards sustainable agriculture, and establish recycling systems for plant nutrients.

- *Energy.* Allow private renewable energy systems to connect with local grids; Identify and designate areas appropriate for wind farms.
- *Forestry.* Shift subsidies towards sustainable forestry operations and encourage the establishment of community forests.
- *Fisheries.* Establish protected marine areas and focus on sustainable aquaculture practices, primarily with non-carnivorous fish species.
- *Metals.* Develop a common coding system for metals and investigate ways to separate metal alloys.
- *Chemicals.* Practice biomimicry and develop non-persistent plastic additives.
- *Built Environment.* Investigate fuel-celled carbon fibre monorail systems and compact neighbourhood commercial centres.
- *Societal Structures.* Standardize sustainability certification for all goods and services and tax speculative financial transactions. Explore double dividend taxation such as taxing carbon emissions and proportionately reducing employee taxes.
- *All Areas.* Develop awareness through visioning processes and fostering a clear understanding of the goal of a sustainable society in the biosphere. Leverage the media, the entertainment industry, schools and universities, focusing the latter specifically on trans-disciplinary approaches and disciplines such as biomimicry, green chemistry etc.

## ***Results: Vision for Sustainability***

Finally, recognising that identifying appropriate actions may not be sufficient to arrive at success, this thesis also explores potential components of a global vision which could guide progress towards success.

Abraham Lincoln's wise proverb that "*a house divided against itself will not stand*" points to the need for a universally shared story of meaning that reflects our collective responsibility to each other, and our collective stewardship of our common habitat. Such a vision of a sustainable global society flows logically from the System Conditions. Future oriented, it includes statements like "*fisheries and forests are harvested in a sustainable manner so that no more than their annual growth is taken*" and "*basic human subsistence needs such as food, water, shelter and clothing are a right and no longer merely a privilege.*"

While a principle-based vision frames our understanding of the end goal, further elements such as overarching principles for systems and activities inform and guide actions towards the end goal. Overarching guiding principles are second order principles focused on the key areas of human activities where solutions are needed. Examples of guiding principles for agriculture include *“the functions, biodiversity and integrity of soil ecosystems are maintained, enhanced and restored”* and *“agriculture relies on crop rotations and polyculture to avoid the need for unnatural substances such as pesticides and herbicides”*.

Finally, societal structures and paradigms serve to reinforce (or undermine) progress toward sustainability. In this thesis, societal structures identified provide a principle based framework for a sustainable society, and suggest things like *“global society is focused on enabling local self organization that is geared to satisfying fundamental human needs”* and *“our structures are flexible enough to change and adapt in alignment with our progress towards sustainability”*. Within societal structures, underlying paradigms should build awareness and understanding of sustainability and influence societal decision making. Examples of supporting paradigms include *“sustainable development can go on forever, physical growth cannot”* and *“poverty is both a cause and effect of environmental degradation”*.

## ***Summary***

When we step back and look at the whole system through the lens of all four System Conditions and at the activities that are currently unsustainable, three primary patterns emerge. The first pattern indicates that we have structured society to meet human needs based on a growth paradigm which does not adequately consider the ongoing health of ecosystems or the sustainable functioning of society itself. The second pattern is that Agriculture, Energy, and Transport are nexus points where high magnitude violations of all four System Conditions occur. The third pattern is the extent to which we rely on dominant power structures to meet needs, resulting in a system that reinforces gross inequity. These patterns are driven by the idea that the economy is an end in itself, by the worldview that separates human beings from nature, and by the illusion that we need to dominate nature and control resources to meet our needs.

Change needs to be addressed at all levels, and can be enhanced through the creation of networks and alliances of positive action amongst all types of players. Nexus points for building awareness and changing values include strengthening education, facilitating information flows, harnessing the power of the media, using design as a leverage point, stimulating self-organization, and evolving governance that supports community action and self-reliance.

A core strength of this research project is the identification of major human activities that are driving current violations of the System Conditions, as opposed to resulting effects arising from these violating activities. At the same time, a key insight that emerged from the process is how easy it is to get bogged down trying to understand the problem, and therefore how important it is to focus on the vision to find creative solutions. In terms of limitations to this research, time constraints prevented the prioritization of opportunities. Planning at the global scale is a difficult undertaking; however it is no less important to prioritize efforts at this scale. We therefore recommend this as a topic for future research.

## ***Conclusion***

In conclusion, there is no silver bullet, no single intervention that will make sustainability happen. Instead, there are many actions that will lead society towards sustainability that require participation from everyone at some level.

*“Problem solving belongs to the realm of knowledge and requires fragmented thinking. In the realm of understanding, problem posing and problem solving do not make sense since we deal with transformations that start with, and within, ourselves. It is no longer the “we are here, and the poor are there, and we have to do something about it, so let us devise a strategy that may solve the problem.” It is rather that “we are part of something that has to be transformed because it is wrong, and, since I share the responsibility for what is wrong, there is nothing that can stop me from starting the process by transforming myself.”*

*Manfred Max-Neef, Chilean Economist, 1991 [2]*

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# 1 INTRODUCTION

Global sustainability is an issue that is on the rise with a growing sense of urgency. While most of the world's leading scientists agree that we are not moving fast or far enough, there is a general misperception that global society is on the whole successful, with a few social and ecological issues that need to be addressed at some point. As we will show in this thesis, the problem is not that we have created some local environmental and social problems. The reality is that while there are a few successes that we can build on, we are effectively on a path of self-destruction, systematically degrading the habitat on which our lives depend, and the social cohesion on which our society is built.

## 1.1 Global Systematic Decline

The biosphere has evolved over 4.5 billion years to create the conditions that make human life possible. What began as a very hostile toxic environment has gradually been detoxified by each successive species, preparing the way for the next to evolve. Over time, the human species evolved, born into a habitable environment owing to the availability of the life-supporting services on which we depend such as clean air and water.

In contrast to this geological timeframe, the impact of human activities on Earth in the past 100 years has reached such a significant scale that we are systematically destroying the ecosystems on which we depend for these life-supporting services. For example, the human species has in a mere few decades extracted from the Earth's crust significant amounts of toxic elements that millions of species treated over billions of years. The scale of our destruction has exceeded nature's capacity to bounce back, reaching a stage of systematic decline. At the same time as we are destroying our habitat, our social fabric is also in systematic decline, further escalating our destructive behaviour towards nature. In spite of our efforts, basic human needs go largely unmet. Increasing numbers of people are already experiencing social and/or ecological collapse, as they struggle to access such basic items as food and safe drinking water.

Global sustainability is about the continuation of life as we know it and is not optional in the long run. As our social and environmental problems systematically escalate, our capacity and options to deal with them is systematically declining, along with a narrowing time frame for corrective action before system collapse. History teaches us through examples such as the fall of the Roman Empire and the collapse of civilisation on Easter Island that system collapse is no myth if society fails to heed the warning signs and take corrective action. Equally, system collapse is not inevitable. Prigogine maintains that systems in a state far from equilibrium enter into irreversible processes. At certain bifurcation points, the system either collapses from chaos or evolves to a higher level through self-organisation and order emerges [3]. In line with Prigogine's theory of bifurcation, global society can choose to evolve to a higher level, one of sophisticated societal organisation for sustainability, based on a universally shared story of meaning. Time is of the essence; the chances of being successful are far greater today while the social fabric is still largely in tact and robust enough to take on the challenge. According to social diffusion theory, it may take as little as 15% of the population to create a tipping point for societal transformation [4]. Now the question is: will we rise to the challenge in time?

## 1.2 Insufficient Global Progress

*“Overall the globe is less sustainable now (2004) than it was when we wrote our first book. Then, the global society used resources and generated pollution at levels that were beneath the carrying capacity of the planet. Now they are above. Decline was avoidable 33 years ago; now it is not.”<sup>1</sup>*

*Dennis Meadows, Co-Author,  
Limits to Growth: The 30-Year Update, 2005 [5]*

Since Rachel Carson's seminal publication, The Silent Spring, back in 1962 [6], public awareness of the need for sustainability has grown significantly. Several world summits have been held to discuss the issues, starting with the 1972 Stockholm Summit, followed by the Rio Earth Summit in 1992, and the recent Johannesburg World Summit on Sustainable Development in

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<sup>1</sup> Reflecting on progress since the 1972 Limits to Growth publication.

2002. International political processes have achieved some success, such as the phasing out of harmful CFC's, and similar attempts are underway to address climate change (through the Kyoto Protocol) and poverty (through the Millennium Development Goals). Organisations such as the World Resources Institute [7] and the World Watch Institute [8] publish annual reports on the state of the world. The UN has commissioned studies such as the 2-year \$20 million study of the state of global ecosystems resulting in the 2005 Millennium Eco-Assessment report [9], and the study of the social dimension of globalisation interviewing over 2000 experts resulting in the 2004 Fair Globalisation: Creating Opportunities For All report [10]. These and other initiatives have also translated into significant private sector awareness through the concept of Corporate Social Responsibility (CSR). New institutions have been formed to engage and mobilise the private sector, such as the World Business Council for Sustainable Development [11], the Global Reporting Initiative [12], and other member-driven initiatives. The result of all these efforts is that today, more people know more about the problems than ever before.

However, in spite of all these achievements over the past 43 years actual progress on halting *systematic* decline has not materialised. We appear to be drowning in information, yet starved of wisdom. As a society, we are failing to come to grips with the underlying systemic issues, and are instead reacting to each new problem with a new solution. Organizations working towards sustainability can only go so far before they are confronted with much larger structural barriers to change. Further, once aware of the unsustainable nature of our current systems, many people become overwhelmed with the magnitude of the matter, do not see viable alternatives or even the possibility that society can become sustainable, and either focus on incremental changes or essentially shut it out of their consciousness.

The challenge of global sustainability is a question of how we manage our collective human impact on the Earth system and with regards to each other [13]. Our collective failure to act is evidence of the crisis in leadership for global sustainability.

## 1.3 A “Whole-Systems” Perspective

For our global society to be sustainable there needs to be a general shift in human consciousness towards accepting collective responsibility for the good of the whole. Abraham Lincoln’s wise proverb that "*a house divided against itself will not stand*" points to the need for a universally shared story of meaning that reflects our collective responsibility to each other, and our collective stewardship of our common habitat.

*Sustainable Development* is defined as the ability “to meet the needs of the present without compromising the ability of future generations to meet their own needs [14]”. Human beings are probably biologically designed to handle interactions on a tribal scale, where we see the effects of our individual actions [15]. However, when our local interactions have global impacts, society needs to evolve to a more sophisticated level of organisation if we are to eliminate the unwanted side-effects of our global interactions.

Furthermore, there is a need for widespread appreciation of the "systemic" nature of un-sustainability, that is, an understanding of the patterns driving and reinforcing systematic degradation, as well as the structural barriers preventing change. Collective efforts can only be successful when the entire system allows for appropriate changes. Therefore, we need to actively design and foster sustainable global systems which enable rather than impede sustainability at the local level. This global whole-systems perspective should then inform appropriate, effective strategies and actions at the individual, organizational, national and international levels.

In order to achieve this transformation, there is a need for a clearly defined and commonly understood definition of what success looks like for sustainability, and against which opportunities, strategies and progress can be easily measured and tested. From this perspective we can start to recognise the real opportunities and benefits that arise from alignment among nature, society and individual interests, rather than be constrained by trade-offs based on current problems. Opportunities can then be prioritised into strategic action plans, the “Alexander Cuts”<sup>2</sup> or shortcuts through complexity, which can channel time, energy and resources into

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<sup>2</sup> The story of Alexander the Great cutting through a complex knot no-one could undo.

making sustainability happen, and in so doing, can accelerate the global transition to a sustainable society.

Finally, we need to learn to recognise real leadership for sustainability, “the Alexander” leading the way. Real progress and innovations towards sustainability are being made in many cases by smaller-scale businesses and initiatives, unconstrained by established processes and practices [16]. Innovation leads change, as smaller inventions get incorporated into the mainstream by those with large-scale capacity. However, there is a danger that as we mobilise action towards sustainability, we confuse power with leadership. It is not a question of whether we have enough power in the form of money, time, energy, know-how, or lack of selfish incentives. The question is whether there will be enough leaders in time, to lead the scale of transformation required, both in terms of innovation, and its translation into mainstream practice [17].

## **1.4 The Role of this Research**

The overall aim of this research project is to contribute to the identification of leverage points for systemic change in three key areas: shifting the underlying unsustainable paradigms of society that govern the structural system design, changing the structural system design flaws that create the problems and motivating rapid implementation of strategic solutions.

The Natural Step (TNS) is an international non-government organisation focused on promoting and disseminating genuine commitment to and competence in Sustainable Development. Together with its academic research partners, TNS has pioneered a strategy tool based on *Backcasting from Sustainability Principles* for use at the community and organisational levels which is based on a scientific, structured, whole systems approach. The methodology brings awareness of our current unsustainable ways (that is, the reality of systemic decline, it’s increasing pace, and the consequently decreasing options), articulates the fundamental, scientifically grounded principles upon which a sustainable society rests, and provides a framework for strategically moving there [18].

More specifically, working with The Natural Step International, this research project applies Backcasting from Sustainability Principles at the

global level in order to contribute to furthering knowledge in the following general areas:

- Global sustainability from a whole-systems perspective
- Patterns of the causes of global un-sustainability
- Opportunities for globally sustainable solutions
- Sectors to focus on based on the magnitude of and contribution to un-sustainable practices, and
- Sustainability leaders at the forefront of change.

The anticipation is that progress in these areas might reveal new ideas for strategies to open up political dialogue on the subject.

At this high level of whole systems analysis, the opportunities that are identified may not at first appear to be new or profound insights into the kinds of leverage points that would guide society towards a sustainable future. What will be novel, however, is a non-reductionist approach to see the problems in a whole systems perspective, analyse the potentials and opportunities to arrive at an attractive vision, and to identify some essential leverage points toward that vision. It can be likened to the difference between a doctor studying the details of a pustule on the skin, versus stepping back and identifying a number of pustules which together add up to blood poisoning, and taking yet another step back and discovering an epidemic which needs to be treated as a whole, rather than trying to treat individual spots one by one.

Rather than generate new information, this thesis uses readily available research to generate new insights and perspectives that can lead to better strategies for action. These insights identify what areas to target first and are focused on reducing systemic decline, on drawing resources into the process (e.g. money, time, people, and assets), and on building momentum through social and democratic processes.

While the project attempts to lay out a global overview of the current situation and how issues are interconnected, it is not intended to be comprehensive and complete. The objective is to illustrate major issues and activities we should be concerned with, in order to identify smart early moves which will stabilise rapid decline, and buy time to address issues of a smaller magnitude.

Furthermore, this report intends to demonstrate the value of this strategic approach to achieving global sustainability by generating insights on a highly complex and dynamic system without needing complete detailed information, by generating systemic interventions and actions that will make sustained progress towards the goal and by providing a global template that can be expanded or refined over time, drilling deeper, or adding and subtracting information, according to current priorities.

In this context, the key research questions are as follows:

- 1) What current human activities, structural barriers and paradigms impede global society's progress towards sustainability and what enabling potentials are there that we can build upon?
- 2) What are potential elements of a global vision of a sustainable future in terms of human activities, structures and paradigms?
- 3) What are some early opportunities for moving toward this global vision?

## 2 METHODS

The approach for this research project is to use the backcasting method for planning in complex systems encapsulated by the TNS framework, also known as the “ABCD process”. This process uses *backcasting from basic principles for success* to arrive at strategic guidelines for actions towards sustainability.

### 2.1 Research Methodology

*“If forecasts are made from a position in which trends are driving the problem profile and if planning tends to reduce solutions to realistic levels, then, by definition, problems will be maintained into the future.”*

*Karl-Henrik Robért, Founder, The Natural Step, 2004 [19]*

The dominant strategic planning methodology in use today, forecasting, can be described as planning based on projecting trends into the future, and subtracting anticipated or known problems. Forecasting is not enough when the system under analysis is highly complex, and more importantly as is the case with sustainability, when the trends are part of the problem [20].

#### 2.1.1 Backcasting from Scenarios

Backcasting is a strategic planning methodology which articulates a future goal, and then assuming that it has already been achieved, asks the question, “How did you get there?” [21]. In contrast with forecasting, backcasting is not limited by knowledge of past and present trends. There are three significant distinctions between backcasting and forecasting [22]. Firstly, backcasting is limited only by the creativity applied to the process, rather than by the ability to analyse and predict trends. Secondly, backcasting emphasises the goal, removing unnecessary constraints and recognising that there are many strategies to achieve the goal. Thirdly, backcasting embraces uncertainty in that its focus on direction and ability to adjust to changing conditions means that it doesn't require a static playing field.

Backcasting is particularly helpful for planning since it is not necessary to know everything about the problem at hand before effective action can be initiated. On the contrary, it enables initial actions to be identified and implemented, and then as conditions change, the plan is continually adapted, enabling continuous progress towards the goal, as the picture emerges. Furthermore, what is held to be “realistic” from a backcasting perspective is the pace of transition towards the goal, not the goal itself. With forecasting, the goal can be compromised if it is limited to what can “realistically” be achieved relative to current constraints.

The backcasting approach has been pioneered using scenarios to envision the goal and guide planning efforts. However backcasting from scenarios has limitations for decision-making. Firstly, it is difficult to get groups of people with diverse values and backgrounds to agree on the specific details of a vision. Furthermore, it is difficult to get agreement on core assumptions for a future scenario, given that complex situations are dynamic and therefore subject to significant change in relatively short timescales. Finally, scenarios could lock planning into specific strategies for achieving the scenario, instead of tapping into a range of possible solutions for reaching the goal.

### **2.1.2 Backcasting from Sustainability Principles**

Given the complex and systemic nature of the sustainability challenge, and the high degree of uncertainty involved, it is important to focus interventions on upstream causes, rather than get caught up in the numerous and significant downstream impacts and resulting issues. An alternative to using scenarios is to backcast from principles. Using a principled definition of the goal removes the need to agree on all the details, and enables problems to be designed out of the system, thereby providing an effective way to avoid unnecessary short-term tradeoffs.

Holmberg and Robért have arrived at basic socio-ecological principles for sustainability [23]. These principles are based on the laws of thermodynamics, and when violated, constitute mechanisms through which the system (society in the biosphere) can be destroyed. The principles (also known as the “System Conditions”) are constraints which determine whether society is sustainable or not. The principles are as follows:

*“In a sustainable society, nature is not subject to systematically increasing...*

*(1) ... concentrations of substances extracted from the Earth’s crust,*

*(2) ... concentrations of substances produced by society,*

*(3) ... and degradation by physical means.*

*And, in that society,*

*(4) ... people are not subject to conditions that systematically undermine their capacity to meet their needs.”*

The basic principles for sustainability are not designed to create utopia, they rather constitute minimum constraints for achieving a *sustainable* society. In addition to these success criteria, every social actor, from the community level to international groups, and across the public and private sector domain, will have societal goals and institutional aspirations. These success criteria are sustainable as long as they do not violate these basic constraints.

It is important to view current reality on a global scale through the lens of the sustainability principles, because they act as mechanisms through which to identify the upstream unsustainable activities, their underlying drivers, and therefore real opportunities for systemic change. The principles also act as a litmus test for whether proposed interventions or corrective actions are themselves sustainable.

In 2002, a study of the various sustainability tools and frameworks was undertaken by their pioneering founders. Robért et al conducted a study to understand the relationship between The Natural Step, Factor 10, Ecological Footprint, Sustainable Technology Development, Cleaner Production, Zero Emissions, and Natural Capitalism [24]. The outcome of this study was that while each of these tools are complementary in terms of application and second order principles for achieving sustainability, the Natural Step System Conditions lay out the end goal, acting as overarching principles or minimum constraints for sustainability. What makes these socio-ecological principles unique is that they are the only sustainability principles that have been specifically designed for backcasting.

## 2.2 Research Process

Based on the method of backcasting from basic principles, The Natural Step has pioneered a strategic planning manual for sustainability that uses the above-mentioned socio-ecological principles. This manual, commonly known as the ABCD process, consists of the following steps:

- (A) Develop awareness of the biosphere as a system and use the sustainability principles as constraints within which to create a vision of a sustainable society.
- (B) Understand the dominating sustainable and unsustainable practices and paradigms of the world via an assessment of physical flows and activities that are critical with reference to the principles for sustainability.
- (C) Brainstorm early opportunities for action towards the vision.
- (D) Prioritise actions that make progress in the right direction, serve as a flexible platform for further development (while avoiding blind alleys), and bring financial, social and democratic resources into the process, to reinforce continued efforts towards the goal.

This research project is framed by the scientific, structured, whole systems approach encapsulated by The Natural Step's ABCD process. The research process makes use of logical deductive reasoning from the fundamental rules defined in the framework to infer conclusions that are specific to the context of this thesis, which is the global challenge of sustainability.

The ABCD process was applied iteratively at the following levels:

- *Overview Level:* From a bird's eye view, this analysis looked at what is currently happening and what needs to happen on a global scale through the lens of the sustainability principles.
- *Paradigm and Structural Level:* This analysis identified the associated paradigms, resource flows and social structures underpinning unsustainability, in an attempt to inform and validate the overview perspective. It identified the major sectors at odds with the sustainability principles, informed the vision of a sustainable society and uncovered high leverage points for action toward that vision.

Within the context of the framework, research was carried out on secondary data sources which are publicly available and verifiable, in order to validate our analysis of the current reality. With a whole systems perspective of the current reality, a number of brainstorming exercises were conducted to envision a sustainable future. This exercise resulted in a compendium of possibilities and/or second level principles that portray a future where the System Conditions are being met. In addition, literature reviews were undertaken to identify principles and actions already proposed by organisations working at the global scale.

### **3 RESULTS**

This section provides an overview of the results arising from the research process in general and in response to the research questions in particular. These findings are presented in the order of the research process steps outlined above (Section 2 Methods).

## 3.1 Step A: Awareness

*ABCD Analysis* is a tool which develops strategies for sustainable development. Based on an understanding of current reality and success criteria for sustainability, these strategies identify actions and tools which will support real systemic progress towards a sustainable society in the biosphere.

The objective of Step A is to create a shared perspective on how to collectively ‘play the game’ of sustainable development by explaining basic rules for planning in complex systems. Firstly, this step focuses on understanding the system (society in the biosphere), in this case, the global reality of un-sustainability. Principled criteria for success, including the System Conditions as minimum constraints, are then shared and explained. When the framework is applied at the organisational or community level, this step is used to create a shared mental model amongst the participants involved in the process of building a sustainability plan. This is followed by an explanation of the subsequent process steps, B, C and D introduced under Section 2.2 Research Process).

### 3.1.1 Understanding the System

The fact that human activities are now putting Earth’s life support system at risk, signals the need to manage our collective impact to make our society sustainable. How should human society respond in order to manage this impact? This question goes beyond scientific and economic considerations to raise fundamental moral and ethical issues [25].

Society’s response will be driven by general human *perceptions* of global impacts and related risks, rather than actual societal knowledge thereof. Since human beings are biologically designed to handle interactions at the tribal level, we rely on visible and timely feedback. Many issues related to sustainability issues have impacts that are either slow to accumulate or invisible to the human eye, separated through time and/or space. The temporal disconnect between the slower pace of natural cycles and the rapid rate of increase of human impact, is one reason behind the systematic degradation of ecosystems. Furthermore, the spatial disconnect between

human activity and socio-ecological impact results in further ecosystem degradation as well as systematic degradation of social cohesion, which in turn further compounds the systematic degradation of ecosystems. Seen from the perspective of these tempo-spatial disconnects the general misperception that socio-ecological impacts are isolated, and an acceptable trade-off for economic success, is not surprising. Failure to understand reality often results in such misperceptions and related false paradigms.

The above constitutes an illusion of a cylinder world, in which human capacity to address sustainability issues remains constant, corresponding to society moving through a constant window of opportunity, like a cylinder. The Natural Step has adopted the metaphor of a “funnel” to describe the reality of systematically increasing issues (arising from un-sustainable activities), alongside systematically decreasing options (arising from degrading ecosystems and social fabric). A description of this global state of systematic decline is provided in the introduction to this thesis.

There is a fundamental need to create a shared understanding of this current “funnel” reality. In addition, and particularly amongst social agents working actively towards sustainability, there is a need to create a shared understanding of the basic principles of success for achieving sustainability, so that efforts are aligned and mutually reinforcing. This need for raising awareness amongst social actors across broader global society is also identified under Step C as an opportunity for action.

### **3.1.2 Planning Strategically for Success**

Many attempts at progress towards sustainability have failed to achieve significant progress. Progress is often limited by the use of tools which operate in isolation of any strategic guidelines, limiting progress to incremental improvements on the status quo; naïve actions based on poorly defined and poorly understood goals; and strategies, where they are in place, disconnected from the reality of the system they seek to influence.

Comprehensive planning for success in any complex system requires a clear distinction between the system under analysis and the criteria by which success is defined and measured in the system [26]. Strategies for achieving success should be explicitly connected with success criteria, as well as the current reality of the system as a starting point. This enables

actions arising from the strategic plan to be directly aligned with achieving success in the smartest possible way. Furthermore, tools used should support actions that are aligned with a strategy for achieving success in the overall system.

Having understood the system and the principles for achieving success (in this case, sustainability) in Step A, the remaining B, C, and D steps of the ABCD process inform a strategic plan for achieving success in the system which would include aligned actions and supporting tools.

## 3.2 Step B: Current Reality

This section provides an overview of our current global reality with respect to sustainability, presented according to each of the four System Conditions. Through research, we were able to identify some of the more significant human activities where the greatest urgency for change is necessary relative to each System Condition. This research also helped us to substantiate the magnitude of unsustainability and to identify some of the key players. By shifting their current activities, key players can play a significant role in leading society towards sustainability.

Paradigms and social structures can also play a significant role in guiding society's activities. As such, this section identifies the dominating paradigms and structures that underpin unsustainability.

There are tremendous potentials and opportunities for society to comply with each of the System Conditions. This section, therefore, identifies some of those potentials and opportunities as well as the key players who are behind such sustainable activities.

Specifically, this section answers our first thesis question which asks:

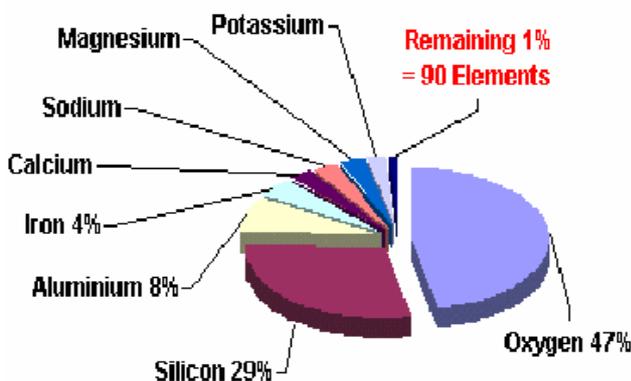
*“What current human activities, structural barriers and paradigms impede global society's progress towards sustainability and what potentials can we build upon?”*

### 3.2.1 System Condition 1

*“In a sustainable society, nature is not subject to systematically increasing concentrations of substances from the Earth’s Crust.”*

#### 3.2.1.1 Introduction

“Approximately 99% of the mass of Earth’s crust is made up of eight elements: oxygen (47%), silicon (29%), aluminium (8%), and iron (4%), followed by calcium, sodium, magnesium, and potassium. The remaining 1% contains about 90 elements of natural origin (see Figure 3.1. below) [27].”



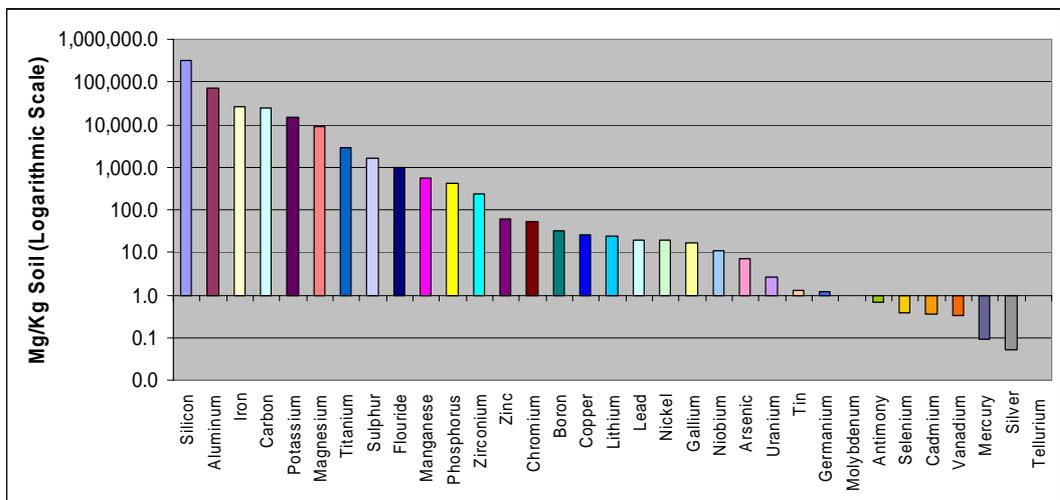
**Figure 3.1. Composition of Earth’s Crust**

These remaining 90 elements are found in relatively low concentrations in the biosphere. They have been slowly removed through natural weathering, deposition and sedimentation cycles over billions of years, aided by millions of species. Over this geological timeframe, and in tandem with this detoxification process, the evolution of life-forms occurred. Ecosystems and living organisms can therefore tolerate these naturally occurring low concentration levels.

Eco-toxicity refers to the systematic increase in concentrations of these substances. Ecosystems react to concentration levels of substances rather than to net volumes. Nature’s exact limits for handling eco-toxicity are unknown, however, once these limits are surpassed, biodiversity decreases

as organisms are killed off and the ecosystems which provide services such as clean air and water start to breakdown. The process by which these substances accumulate in water, soil, and living organisms is known as bioaccumulation. The key issue however is not the exact mechanisms by which these substances exert negative effects, but rather that they are allowed to increase in concentration until they eventually exceed eco-toxic thresholds [28].

Figure 3.1 above highlighted the relatively abundant elements such as oxygen, silicon, aluminium, etc. Figure 3.2 below shows the relative background soil concentration of a range of elements, compared to the more abundant elements (see also Table 3.1 below). In this context, whether an element is considered scarce or abundant refers to the background concentration level found in soils, which should not be confused with the availability of base ore for mining purposes.



**Figure 3.2. Soil Concentration of Elements<sup>3</sup>**

Systematic increases in concentrations in natural systems occur when human activities reintroduce substances into the biosphere at a faster rate than natural cycles such as sedimentation and bio-mineralization can redeposit them back into the lithosphere (Earth's crust). Concentration levels are finely balanced between natural cycles of weathering, final depositing and sedimentation.

<sup>3</sup> Based on logarithmic scale of Table 3.1: Concentrations in Soils

In order to maintain nature's balance, the average mining rate less the rate of final deposition must be less than or equal to the ecospheres capacity for sedimentation, or in other words, human induced concentrations must stay within corresponding natural limits [29]. It is important to note that the problem is not the net introduction of these substances into the biosphere, since they can be inert in different forms. The problem occurs when substances are allowed to break down into particulate form and disperse into living systems.

When substances deposited in the lithosphere are extracted and converted into materials used by society, they are temporarily controlled within the technosphere until they break down, either through natural cycles or as a result of human activities. The technosphere refers to societal infrastructure (e.g. copper pipes) and end products (e.g. lead in paint). Unless we can contain these elements in tight technical loops and not allow them to escape, any human induced net input into the natural cycle will cause a systematic increase in concentration. These technical loops are not fool-proof; therefore society should focus on using naturally abundant substances, and phase out use of scarcer substances. That way, if substances leak out, nature's buffers can handle it.

Human induced increasing concentrations are a result of the extraction, processing, end-use and disposal of mined materials. Since the Industrial Revolution, significant volumes of these substances have been used as raw materials for production, resulting in increasing concentrations way beyond natural levels. The top 17 elements of significant concern are shown in Table 3.1 below, in decreasing order of their ratio of human (anthropogenic) flows to natural flows. The table also shows concentration in soils, the future contamination factor and current production volumes. Future contamination factor (FCF), is defined as the stock of mined materials already in circulation in the technosphere divided by the natural flow rate and is a measure of how much of the element has already accumulated in the technosphere, and therefore the scale of contamination threat if these substances leak into natural systems. Current production volumes indicate continued levels of dependence on these substances and the rate at which the future leakage threat is increasing.

Element*	Sym -bol	Conc. In Soils mg/kg	Anthropo- genic Flows / Natural Flows (I)	Future Contamin- ation Factor (FCF) (II)	2000 Production Volumes (thousand tonnes) (III)
Copper	Cu	25.00	24	60	14,676
Silver	Ag	0.05	22		
Lead	Pb	19.00	12	70	3,038
Tin	Sn	1.30	11	2	
Molybdenum	Mo	0.97	8.5	4	543
Zinc	Zn	60.00	8.3	20	8,922
Mercury	Hg	0.09	6.5	90	
Nickel	Ni	19.00	4.8	2	1,107
Chromium	Cr	54.00	4.6	3	
Cadmium	Cd	0.35	3.9	10	
Iron	Fe	26000.00	1.4		
Uranium	U	2.70	1.2		36
Manganese	Mn	550.00	1.1		
Lithium	Li	24.00	0.64		
Vanadium	V	80.00	0.32		
Zirconium	Zr	230.00	0.3		
Niobium	Nb	11.00	0.17		
Potassium	K	15000.00	0.11		
Titanium	Ti	2900.00	0.096		6,580
Gallium	Ga	17.00	0.093		
Aluminium	Al	72000.00	0.048		24,461
Magnesium	Mg	9000.00	0.028		
Tellurium	Te			15	
Antimony	Sb	0.66	6	5	
Germanium	Ge	1.20	0.96		
Boron	B	33.00	0.52		
Arsenic	As	7.20	0.33		
Silicon	Si	310000.00	0.021		
Carbon	C	25000.00	6.4		
Sulphur	S	1600.00	3.7		
Phosphorus	P	430.00	3.5		141,589
Selenium	Se	0.39	2	1	
Fluoride	F	950.00	0.17		4,520

**Table 3.1. Top Elements of Significant Concern**

I Flows from mining and fossil fuels / Flows from weathering and volcanic processes

II Known volume accumulated in the technosphere divided by natural levels

\* Burning fossil fuels contributes to increasing concentrations of many of these elements, and in quantities greater than the contribution from mining.

II 2000 global production volume of mineral commodity

\* Fluoride expressed as Fluorspar and Phosphorus as Phosphate rock

Sources: Azar et al (1996) [30], TNS Consensus Document on Metals [31], MMSD Report (2002) [32], State of World 2005 [33] )

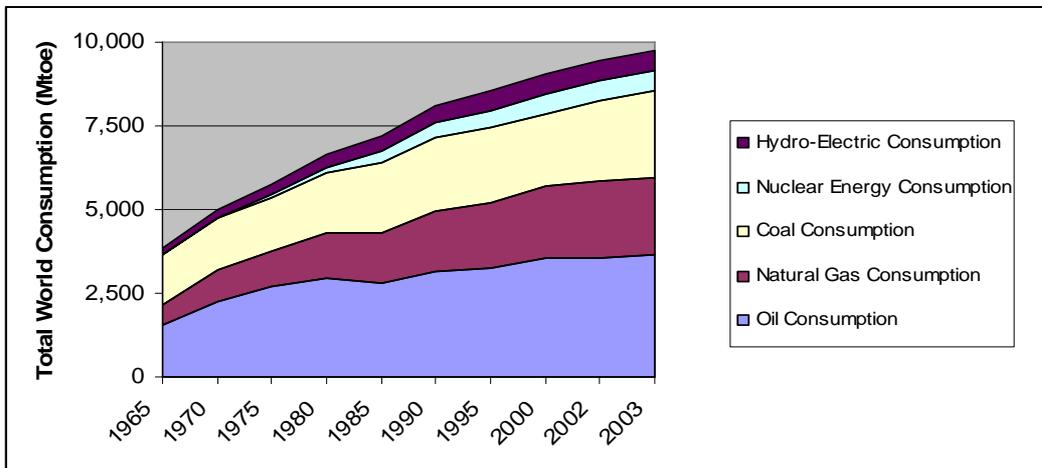
The combination of relative scarcity (measured by concentration in soils), the extent to which human flows already exceed natural flows, and the future threat of contamination (measured by accumulated stock in the technosphere) gives an indication of the relative urgency to phase out the use of certain scarce elements. For example, the concentration of mercury in soil is only 0.09mg/kg yet the accumulated stock in the technosphere is 90 times background levels, and current human flows exceed natural flows by 6.5 times. The concentration of copper in soil is higher at 25mg/kg, however human flows are 24 times the level of natural flows, and the accumulated stock is 60 times background levels. Lead has a similar soil concentration at 19 mg/kg, with human flows exceeding natural flows by 12 times and an accumulated stock 70 times background levels.

### **3.2.1.2 Overview of Major Human Activities**

Many of the elements listed in Table 3.1 are dispersed into the ecosphere when fossil fuels are burned. Emissions are also generated from the extraction and processing of minerals by the mining and oil & gas industries, as well as industrial production processes which use these minerals as raw material inputs. Dispersal can also occur throughout the useful life of the end-products as well as during the final disposal process, when products are typically sent to landfill. The most significant human activities that currently violate this System Condition through increasing concentrations of scarce elements are outlined below.

## Energy

Currently 77% of world energy use is based on fossil fuels (see Figure 3.3 below). Fossil fuel consumption in 2002 was roughly 7,900 million tons of oil equivalent (Mtoe), of which oil represents 44%, followed by natural gas and coal, each representing 28% [34]. A further 16% of world energy is derived from nuclear sources, while the remaining 7% is mostly hydro-electricity, and a small amount of alternative sources such as wind, solar, biomass, etc.



**Figure 3.3. World Energy Consumption (1965-2003) [35]**

**Fossil Fuels.** World energy demand is currently 77% dependent on the consumption of fossil fuels. Fossil fuels such as oil, natural gas and coal contain many of the scarce elements (see Table 3.1 above), which natural cycles had previously removed from the biosphere. Public awareness of the relationship between oil consumption, CO<sub>2</sub> emissions and climate change has grown significantly in recent years. At the same time however, appreciation of the fact that CO<sub>2</sub> is just one of several greenhouse gases released from fossil fuel combustion is limited. Carbon capture/sequestration is currently touted as a potential solution to rising CO<sub>2</sub> emissions; however it shouldn't be confused with being sufficient to justify the continued use of fossil fuels. In addition to carbon, *several* scarce elements are dispersed from combustion of oil and coal. Therefore, even if carbon sequestration becomes a viable reality, burning fossil fuel

will continue to violate this System Condition, unless these other problematic elements are prevented from dispersing in the biosphere.

***Nuclear Energy.*** Nuclear energy supplies another 16% of global electricity, through 438 commercial nuclear power plants operating in 30 countries. The fuel source for nuclear energy, uranium, is a scarce and highly toxic element which remains hazardous for hundreds of thousands of years. In 2002, 36,000 tonnes of uranium was extracted from the earth's crust, creating dust tailings that can spread radioactive contamination. For example, in Kyrgyzstan, 2 million tonnes of uranium waste sits in 23 tailing ponds, with the risk of dispersing into the local river system contaminating the water supply for 6,000 local inhabitants [36].

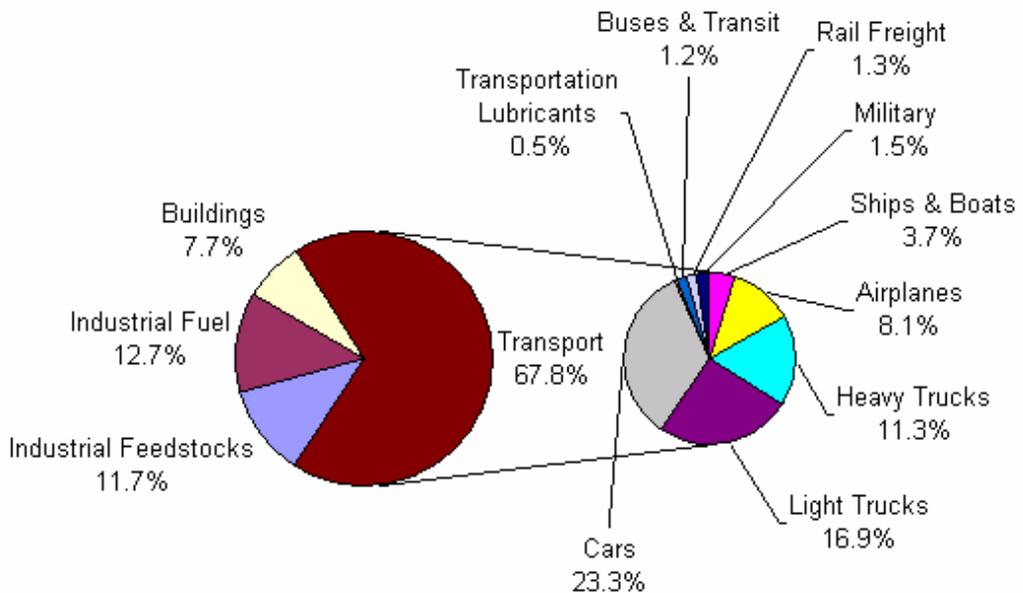
Nuclear energy is also highly controversial given its history of accidents and disasters such as Chernobyl in 1986. Even if these significant risks as well as the threat of reactor meltdown could be closely managed through sophisticated processes, nuclear energy is saddled with other problems. In addition to uranium, many other scarce heavy metals are used in the construction of nuclear reactors. Many of the reactors built to date are now entering the end of their useful life, without adequate long-term disposal strategies. Nuclear power plants also depend on fossil fuels for their operation, producing up to 3 times the CO<sub>2</sub> per kilowatt-hour that wind power does [37].

Given all of these substantive issues, which further compound the hidden costs, nuclear energy is highly unlikely to be an economically viable energy strategy in the long run, and is not a sustainable alternative to fossil fuel [38]. Although Belgium, Germany, Sweden and Spain are planning complete phase-out over the next 30 years, 28 new reactors are under construction worldwide with another 35 being planned [39].

***Energy Subsidies.*** Global subsidies for fossil fuel and nuclear energy currently amount to roughly \$100 billion per year, with another \$200 billion per year in quantifiable externalities (indirect subsidies) [40]. The expansion of nuclear energy capacity and the continued subsidisation of unsustainable energy sources demonstrates the current trade-offs being made between economic growth as the means, and the goal of socio-ecological sustainability, instead of planning for sustainable economic development.

## ***Transportation***

Another major human activity that depends on fossil fuels is the transportation of people and goods. Industrialised nations consume 59% of all world transportation energy. Being the largest industrialised nation and a major consumer of fossil fuel, the United States alone accounts for in excess of 33% of total world transportation energy [12]. Over 65% of United States oil consumption is related to transportation (see Figure 3.4 below).



**Figure 3.4. 2000 US Oil Consumption by End Use [41]**

Although transportation makes up such a large share, the sector is highly fragmented across a range of different modes of transport. Emissions from the many millions of different road, rail and aircraft carriers are therefore individually much harder to reduce than emissions from relatively fewer stationary sources such as buildings or industrial plants.

Road transportation dominates the global transportation system, with vehicle emissions acting as the single biggest contributor to air pollution, emitting fumes such as carbon monoxide, sulphur dioxide, nitrogen oxides and lead [42]. Global subsidies for road transportation amount to roughly \$400 billion per year, excluding quantifiable externalised costs to society,

estimated at another \$380 billion [43]. As affluence increases, vehicles are replacing bicycles for shorter journeys, resulting in trends such as the fact that global bicycle production fell by 25% in 1998 from peak of 107 million units in 1995. Although air transport is a relatively small contributor, since 1960, it is the fastest growing segment at 9% per year. According to the Inter-governmental Panel on Climate Change (IPCC), aircraft are responsible for releasing 3.5% of global emissions of greenhouse gases.

In addition to dependence on fossil fuel for operation, the manufacture of transport vehicles such as industrial and domestic road, rail and aircraft carriers consume vast quantities of various elements, including many scarce elements. For example, a modern jet engine contains 41% titanium, 34% nickel, 11% chromium, 7% cobalt, and smaller amounts of aluminium, vanadium, carbon, molybdenum, niobium and tantalum [44]. At the end of their useful life (typically 15-20 years), vehicles are typically disposed of via landfill.

## ***Agriculture***

*“Phosphorus is accumulating in ecosystems at a rate of 10.5–15.5 teragrams per year, compared with a pre-industrial rate of 1–6 teragrams per year, mainly as a result of the use of phosphorus (obtained through mining) in agriculture [45].”*

Modern agricultural practices include heavy use of fertilisers and pesticides. A large proportion of pesticides (85-90%) never reach their targets, instead dispersing through air, water and soil [46]. A significant raw material in the production of fertilisers and pesticides is phosphorus, which is found in low concentrations in the atmosphere [47]. In 2000, the production volume of phosphorus was 142,000 tonnes, further contributing to the human flows which are currently 3.5 times the rate of natural cycles (see Table 3.1 above). Phosphorus accumulation occurs mostly in soils, creating a future threat to ecosystems if these soils erode into freshwater systems. Since this process is slow and difficult to prevent, there is a likelihood that ecosystem services will deteriorate where they are affected.

## ***Building Materials***

Another major source of increasing concentrations is a result of the construction industry. The mining of aggregates for construction materials (such as sand and gravel) constitutes the largest material volumes mined, with world production estimated to exceed 15 billion tonnes per year [48]. According to the United States Green Building Council, 40% of the world's materials and energy are used by buildings. In the United States in particular, buildings account for 30% of greenhouse gas emissions, 30% of raw materials use, 12% of potable water consumption and 30% of waste output which equates to 136 million tons annually sent to the landfill [49].

Scarce elements which are widely used in the construction industry include copper and lead, whose anthropogenic flows are 24 and 12 times their natural flow rates respectively, compared with more abundant elements in use such as iron and aluminium, which are respectively 1.4 and 0.048 times their natural flow rates (see Table 3.1).

## ***Electronic Equipment***

The fastest growing manufacturing industry is the electronic equipment market. This is especially significant given the amount and range of scarce elements contained in electronic components, often referred to as “toxics traps”.

For example, a typical computer monitor with a cathode ray tube display contains up to 4 kilograms of lead, as well as chromium, phosphor, barium, cadmium and beryllium. A single 32-megabyte microchip weighing only 2 grams requires at least 72 grams of chemicals, 700 grams of elemental gases, 32,000 grams of water and 1,200 grams of fossil fuels for its production, and a further 440 grams of fossil fuels for its operation over a typical lifespan of 4 years, running for 3 hours per day. Furthermore, it is a myth that dematerialisation is automatically achieved through smaller and lighter products. The materials required to produce this tiny 2 gram microchip weigh up to 1.2 kilograms, 630 times the weight of the final product, compared to the materials required to manufacture a car, which weigh twice as much as the final product [50]. Nevertheless, the microchip is still dematerialised if compared with the size of computing machines required to

perform at the same level prior to the microchip revolution of the past few decades. Toxics-rich semiconductor chips are also a key component of mobile phones, computers and other handheld devices [51].

Many (if not most) electronic products are dispersed amongst millions of consumers and typically end up in landfill, where these elements leach into soil and groundwater. The future contamination threat from stockpiled and currently circulating electronic equipment is significant, and if current trends continue, product obsolescence will only exacerbate the situation.

Current stockpiles of computers were estimated at half a billion in 2002, compared to only 105 million in 1988. A further 500 million computers are currently in use, and United States research estimates that by 2005 for every new computer brought to market, a computer will become obsolete [52]. The situation with mobile phones is probably not far behind. In 2002 the number of worldwide fixed line installations (1.1 billion) was surpassed by the number of mobile phones currently in use (1.14 billion). By 2005, consumers will have stockpiled 500 million used mobile phone handsets, which could leach some 312,000 pounds of lead [53].

### ***Other Activities and Products***

End-use applications for all these elements from the earth's crust are endless. The activities highlighted above illustrate the major issues where the magnitude of un-sustainability is significant. Due to their relatively smaller scale of impact, there are many other products and applications which have not been covered. There are, however, two significant additional applications which deserve attention.

In terms of product applications, most industry sectors rely on various metals and minerals, not only for their end-products, but also for equipment used in the manufacturing processes. Like consumer electronic equipment, industrial equipment also contains many metals which need to be contained in tight technical loops and recycled. This is somewhat less of a challenge than consumer equipment, since the scale of product dispersal is somewhat smaller.

In terms of activity driven application, the availability of supply of mined elements acts as a catalyst for innovation. As discussed above, the mining

sector supplies different industries' demand for various metals and minerals as raw materials. In addition to demand-driven extraction, the reverse is also true. In the chemicals industry, the availability of mined elements as raw materials for production drives the innovation of new "man-made" substances (e.g. heavy metal compounds) which are foreign to nature and/or persistent. For example, the availability of petroleum acts as a feedstock of raw materials for the chemicals industry. In the United States, 11.7% of oil consumption is an industrial feedstock (see Figure 3.4 above). This issue is explored further under System Condition 2.

### **3.2.1.3 Key Drivers: Structures and Paradigms**

Many of the human activities listed above that violate System Condition 1 are reinforced through a complex web of structural barriers and underlying paradigms. The following are examples of some of the key drivers that support the status quo in each of the sectors highlighted.

***Energy.*** The global economy currently depends on growth rather than development. This growth is quite literally fuelled by cheap yet unsustainable energy sources which have been commoditized at great cost to society and the environment. According to the UNDP World Energy Assessment in 2000, the resource potential of renewable energy is more than sufficient to meet the world's energy needs [54]. Yet non-hydro renewable energy estimates account for only around 11% of current world primary energy consumption. This low market share reflects the fact that the economics of renewable energy are generally unfavourable when compared to the economics of conventional technologies utilising fossil fuels [55]. In addition, powerful lobbies protect the nuclear energy industry, especially given the significant investments required to establish and run nuclear power plants and the level of subsidies they currently attract [56].

***Transportation.*** The oil and automotive industries are both individually unsustainable and mutually reinforcing. The availability of cheap and abundant oil has led the automobile to become the dominant mode of transportation. Equally, the success of the automotive industry has driven demand for cheap and abundant oil. For example, in the United States, transportation accounts for 67% of oil consumption (see Figure 3.4). Another reinforcing factor behind the success of the automotive industry is the dominance of their advertising spending worldwide. In 1998, the

automotive industry spent \$14 billion in the United States alone, and a further \$9.9 billion throughout the rest of the world. In contrast, total advertising across all industry sectors in the United States totalled \$37 billion and a further \$28 billion throughout the rest of the world [57]. As a result, obtaining a drivers license is almost a rite of passage.

**Materials.** Much like the situation with energy, the global economy is also dependent on a regular supply of cheap raw materials for industrial manufacturing processes (see human activities listed above). These raw materials have become commoditized, further reinforcing dependence on unsustainable resource extraction.

**Electronics.** The fastest growing manufacturing industry is the electronics sector. A key driver behind this growth is product obsolescence, which is also a key driver behind rapidly growing electronic waste (e-waste). E-waste typically ends up in landfill and in United States, is responsible for 70% of heavy metals found in landfills [58]. In spite of the Basel Convention, an international ban on the trade of toxic waste, as recycling legislation comes into force in many industrialised countries trade in e-waste is increasing, driven by low-cost labour and weak regulatory systems. For example, 50-80% of e-waste collected for recycling in industrialised countries is shipped to Asia, where it is 10 times cheaper to recycle than domestically. Interestingly, in the United States, the only industrial country not to ratify the Basel Convention, it is still legal to export e-waste, which has recently been made exempt from export regulation [59].

### **3.2.1.4 Potentials to Build On**

The following are some examples of potential successes to build on, in order to achieve compliance with System Condition 1.

Given their vast potential to meet global energy needs in a sustainable way, and the successes achieved to date in the development of alternative renewable energy technologies such as solar, wind, biomass etc., there is a need to scale up the installed infrastructure capacity to convert these alternative sources into electricity. Table 3.2 below shows that this process is already starting to happen. In 1998, installed capacity represented around 2% of total world energy consumption. Between 1995 and 1999, the installed capacity of wind and solar photo-voltaic renewable technologies

increased by 30% per annum. Further investments in research and development could significantly increase the pace at which installed capacity ramps up.

<b>Renewable Technologies</b>	<b>Worldwide Operating Capacity 1998 (MWe)</b>	<b>Increase in Installed Capacity 1995-1999 (% per Annum)</b>
Biomass	40,000	3.0
Wind	10,000	30.0
Solar – Photovoltaic	500	30.0
Solar – Thermal	400	5.0
Hydro - Small Scale	23,000	3.0
Hydro - Large Scale	640,000	2.0
Geothermal	8,239	4.0
Tidal Wave	300	0.0

**Table 3.2. 1998 Renewables: Installed Capacity [60]**

With regards to materials consumption, many recycling activities are already taking place. In addition to re-use of metals, switching from primary materials to secondary sources generates the following energy savings: aluminium 95%, copper 85%, steel 74%, and lead 65%[61]. As pressure to recycle increases, the manufacturing industry is starting to design products so that they can be disassembled at the end of their useful life, and returned to the factory for re-manufacture into new products. A leader in this field is the Scandinavian mobile phone manufacturer Nokia. Since the long term benefits from recycling metals are limited unless recycling is linked to a net decrease in mining, there is a need to increase research and development on material substitution (using different source materials) and true dematerialisation that uses less total materials per product [62]. In addition the focus of corporate strategy and business models needs to shift from a focus on product throughput to service-based growth, as demonstrated by United States carpet manufacturer Interface.

Innovative policy could also significantly boost the transition to more sustainable practices by not only creating attractive market opportunities for investors but also making unsustainable options less economically viable. Policy can be a driving force in levelling the competitive landscape by tapping into “destructive” subsidies and diverting these funds to sustainable alternatives such as renewable energy sources, carbon trading to curb

emissions, cleaner production methods and technologies, and supporting public transportation [63].

A good example of such a policy potential, which addresses the issue of electronic waste, is the new European Commission Waste Electrical and Electronic Equipment (WEEE) Directive, which comes into force in 2005. The directive holds individual companies responsible for collecting and recycling all new goods produced from this time forward, while holding all firms in the relevant sector collectively responsible for electronics put on the market before that date. In addition, the directive also prohibits the use of certain toxins in electronics, including lead, mercury, cadmium, chromium, and some brominated flame retardants.

### 3.2.1.5 Key Players

The main players to engage are those that have a significant influence on current practices and activities through their size in terms of the rest of the market<sup>4</sup> (\*indicates market capitalisation), the scale of their impact, or those that are already innovating new methods and practices. It is important to consider the supply side in terms of production activities as well as the consumption of products and services on the demand side. Key players in relation to System Condition 1 include [64]:

- Oil and Gas Multi-National Corporations (fossil fuel exploration and production), for example: Shell, BP, Exxon Mobil (\$289bn\*), Esso, etc.
- Mining and Metals Industry Sector (extraction and processing), for example the top 10 players: Alcoa (\$26 bn\*), BHP Billiton (\$25bn\*), Rio Tinto (\$24bn\*), Anglo American (\$17bn\*), Norsk Hydro (\$9bn\*), Alcan (\$8bn\*), CVRD (\$7bn\*). Other stakeholders include developing countries with abundant natural resources and high foreign debt to service, as well as non-governmental organisations such as the International Council on Mining and Metals (ICMM), and the Global Mining Initiative (GMI) who are starting to look at what sustainable development means for the industry.
- Automotive Industry Multi-National Corporations (consumption of metals), for example: Ford, General Motors, Toyota, Honda, etc.

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<sup>4</sup> \* Indicated in terms of market capitalisation in 2001

- Electronics Industry, (consumption of metals) for example: General Electric (\$469 bn\*), Matsushita, Phillips, ST Micro-Electronics, etc.

## 3.2.2 System Condition 2

*“In a sustainable society, nature is not subject to systematically increasing concentrations of substances produced by society.”*

### 3.2.2.1 Introduction

System Condition 2 (SC 2) concerns the accumulation of two types of substances produced by society: those that are foreign to nature (e.g., DDT and CFCs) and those that already exist in nature (e.g., CH<sub>4</sub> and N<sub>2</sub>O) [65]. The first part of this section outlines the main flows of both these types of substances that are currently problematic under System Condition 2 and demonstrates the gap between current human activities and sustainable practices.

Because many of the problematic areas under SC 2 are related to energy/fuel use and are therefore touched upon under SC 1, the second part of this section focuses on persistent synthetic chemicals (foreign substances) in order to provide a more complete understanding of opportunities for change. The focus on chemicals examines structural barriers and paradigms impeding progress toward complying with SC 2, suggests some players we can gather to create change and highlights potentials we can build upon to move toward sustainability.

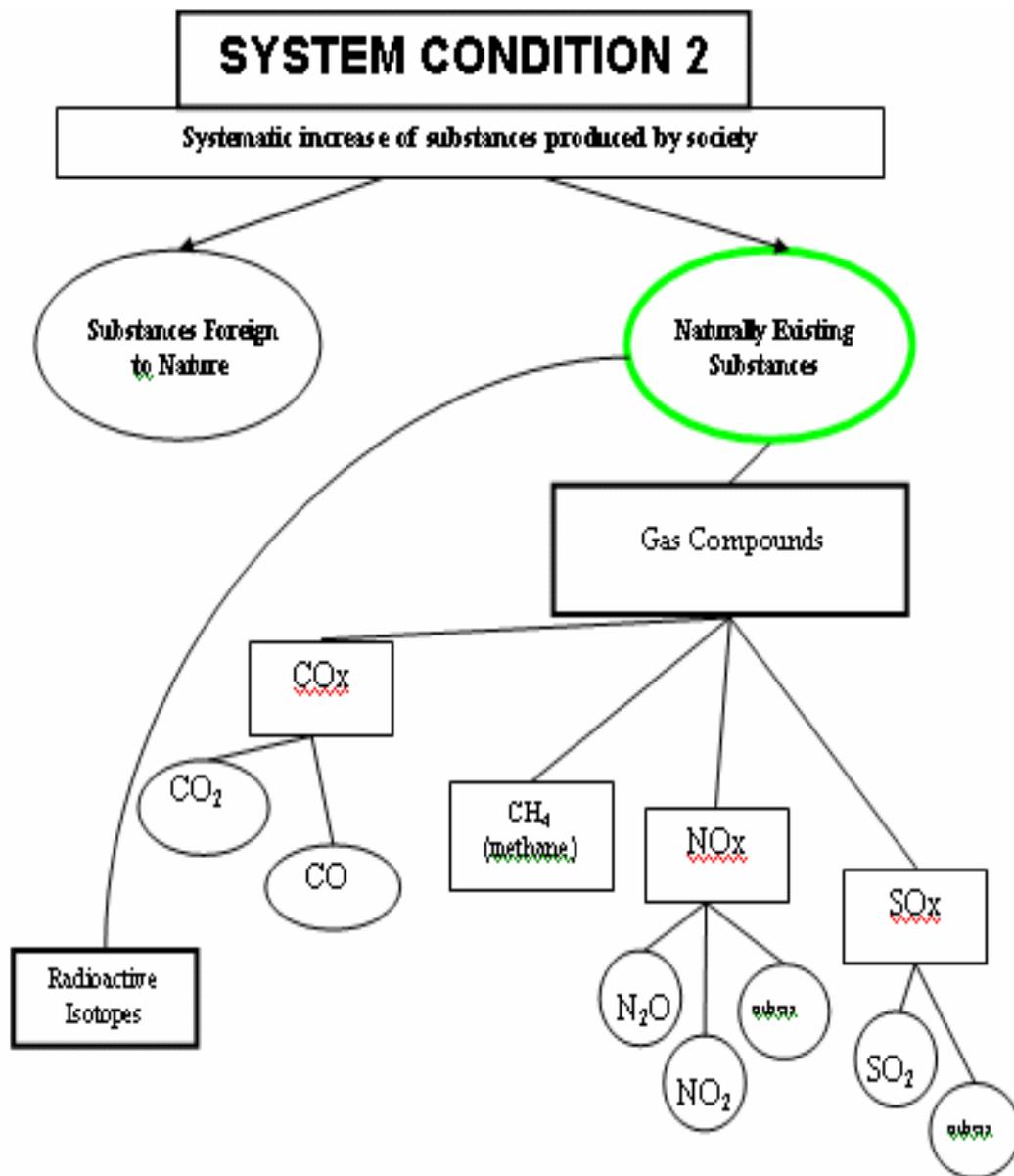
This section concludes with an overview of the primary violations of SC 2 with regard to both natural and foreign substances and their related human activities, as well as suggested opportunities for change.

### ***Key Concepts***

System Condition 2 means that “substances (molecules and atomic nuclei of different kinds) must not be produced faster than they can be broken down and integrated in the biogeochemical cycles or deposited in final deposits in the lithosphere. Otherwise, such substances will accumulate somewhere in the ecosphere and the concentration will increase towards often unknown limits beyond which damages occur. In practical terms this

means we must decrease intentional and unintentional production of substances that can accumulate [66].”

***Naturally Existing Substances.*** The map below gives an overview of the *naturally existing substances* that are currently systematically increasing in concentration in nature due to human activities. Within this part of SC 2, there are gas compounds and radioactive isotopes. Please note that *this map is not exhaustive, but represents the current main flows of concern.* For example, it will change as we phase out fossil fuels and find new substances that are problematic.



**Figure 3.5. Natural Substances of Concern (SC2)**

Source: Holmberg, J. 1995 [67].

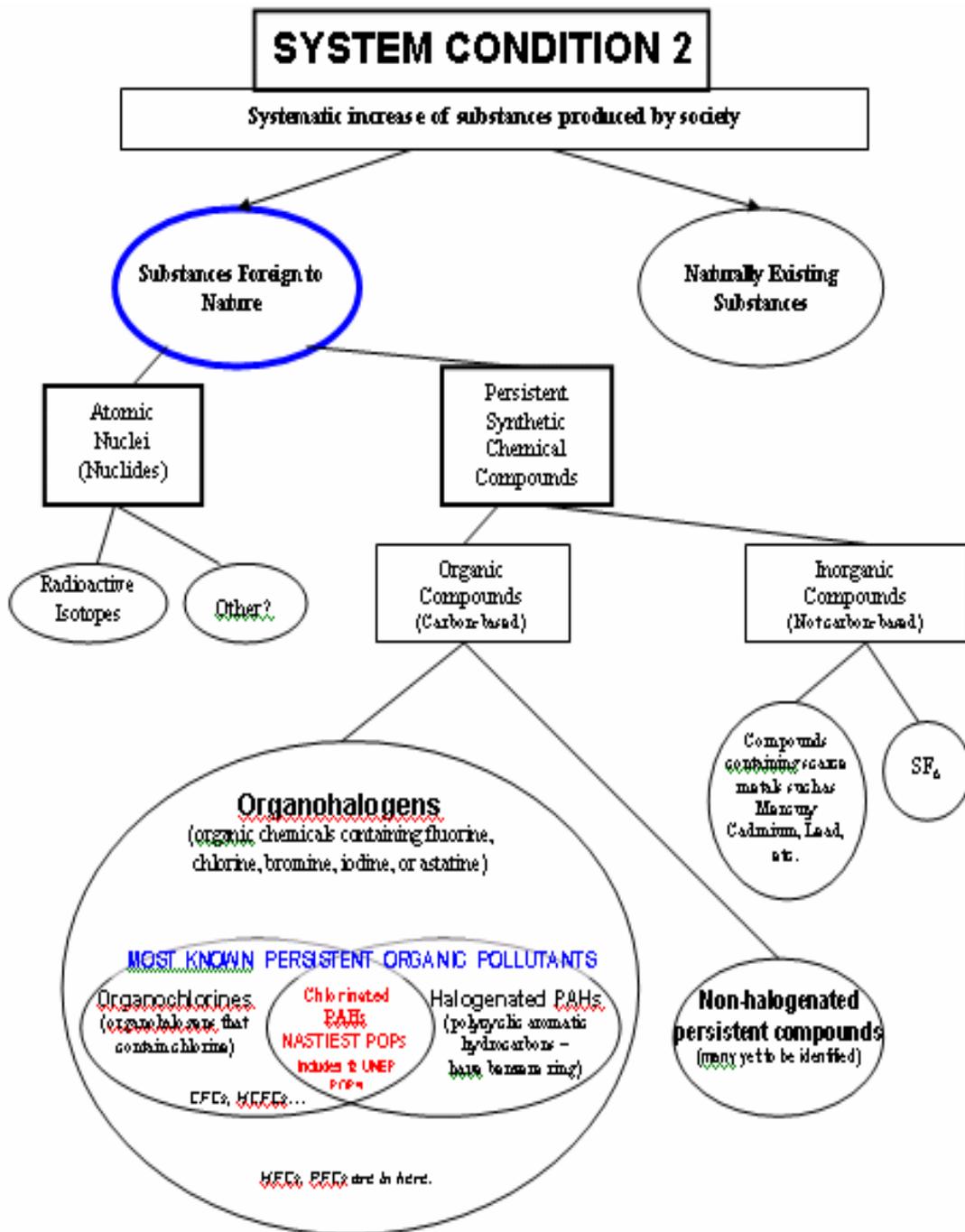
**Example 1: Methane (CH<sub>4</sub>).** Most people are aware that carbon dioxide is contributing to the greenhouse effect, but not as many know that methane (CH<sub>4</sub>) emissions are the second most significant contributor caused by human activities [68]. The flow of methane from anthropogenic sources is 1.4 to 4.1 times the natural rates of methane production [69]. The primary sources of anthropogenic methane are from decomposition of wastes at

landfills, raising large numbers of domesticated animals whose digestive processes produce methane gas (e.g., cows, goats, horses, buffaloes, sheep, camels), and energy related activities such as coal mining, oil drilling and exploration, decomposition of plants in areas flooded to create reservoirs behind dams, and leakage of natural gas during transport.

System Condition 2 highlights the fact that even though a substance is natural, it can become toxic to humans and ecosystems. The point at which increasing concentrations of a substance leads to toxicity varies depending on a number of factors, including the compound's biodegradability, how scarce it is in the biosphere and therefore how potentially toxic it is in relatively small concentrations, how far away the aberrant concentration level is from natural levels, and many others.

There are several mechanisms by which humans are currently increasing the amounts of the natural substances in Figure 3.5. The overview of major human activities (Section 3.2.2.2) explains how they are being created.

***Substances Foreign to Nature.*** The other portion of SC 2 is *substances foreign to nature* which divides into two main categories – persistent synthetic chemical compounds and radioactive atomic nuclei. The map below shows the current territory of concern. Again, the map is not intended to be exhaustive, but to show the primary flows that need attention.



**Figure 3.6. Foreign Substances of Concern (SC2)<sup>5</sup>**

Sources: Platt, A. 2000 [70], Holmberg, J. 1995 [71].

<sup>5</sup> Not drawn to scale

**Example 2: Chlorofluorocarbons (CFCs).** A recent example of synthetic chemicals that illustrate SC 2 is chlorofluorocarbons (CFCs). CFCs are persistent synthetic substances that cause ozone depletion and contribute to the greenhouse effect. (In Figure 3.6, they are within the organochlorines group). Since the 1987 Montreal Protocol, there has been an international effort to phase them out quickly. Between 1988 and 1997, global emissions of CFCs were reduced by 87% [72]. This close call with the ozone layer illustrates how important it is to recognize that we may inadvertently exceed a threshold and by the time we realize what is happening, ecological systems may be irreversibly on their way to collapse.

If we were to use System Condition 2 as a guide for the creation of chemicals, we would be able to prevent such potentially deadly (and expensive) mistakes because we would avoid creating compounds which persist in nature. Unfortunately, when the chemical industry rushed to create substitutes for CFCs, they manufactured new persistent substances called HFCs which have turned out to be powerful greenhouse gases, most of which remain in the atmosphere for 13 to 260 years [73]. This underscores an important implication of SC 2: if a certain persistent substance is absolutely necessary, it must not be emitted by society at rates faster than nature's capacity to degrade and cycle or absorb that substance. Furthermore, a *non-persistent* substitute for that substance should be found as quickly as possible.

In summary, flows of all substances must integrate into natural cycles safely. This means that if natural substances or breakdown by-products of foreign substances are being emitted as a result of human activities at a rate faster than they can be assimilated in nature, then those emission flows must be reduced through dematerialization. As for substances foreign to nature which are also persistent, any leakages will lead to concentration increases. Therefore, for such substances, dematerialisation will not be enough - substitutes must be found for the substances themselves or the practices which underlie their use. In some cases, it may be possible to develop the technological means to deposit substances safely into the lithosphere or contain them in extremely tightly controlled loops within the technosphere. When looking at the feasibility of this task, possible violations of SC 3 and SC 4 must also be examined.

The next section highlights the societal activities where we need to focus our creativity to change our practices and products in order to come into

compliance with SC 2 as well as an introduction to the magnitude of the task.

### **3.2.2.2 Overview of Major Human Activities**

To see the opportunities for change and innovation, it is helpful to know the activities that are currently causing our main violations of SC 2 and to gain inspiration to act from the magnitude of unsustainability they represent. Our choices in energy systems, transportation, chemical production and use, agriculture, and solid waste management create the main impacts with regard to SC 2 and therefore reveal tremendous opportunities for sustainable development.

The primary major human activities contributing to systematic increases in the substances mapped in Figures 3.5 and 3.6 are detailed below. The section on Synthetic Chemicals contains more detail to heighten awareness and understanding of its relevance as a sustainability issue.

#### ***Energy Use & Transportation***

***Fossil Fuels.*** The extraction and use of fossil fuels (oil, coal and natural gas) have the following impacts with regards to SC 2:

- *Carbon dioxide* (CO<sub>2</sub>), the most problematic human-caused greenhouse gas, is released to the atmosphere when fossil fuels are burned. This is by far the largest anthropogenic contributor to carbon dioxide emissions. The use of fossil fuels is associated with producing electricity, heating, cooking, and powering automobiles and other combustion engines.
- *Methane* (CH<sub>4</sub>) is the second most problematic of the six greenhouse gases restricted under the Kyoto Protocol. It is emitted during the production of coal, natural gas, and oil. There is also leakage during transport in natural gas pipelines and because of accidents. Methane is also emitted during combustion of fossil fuels, although this is a smaller source than the other methane-emitting activities listed in this section. Energy related activities account for 23% of global methane emissions [74].

- *Nitrous oxide* (N<sub>2</sub>O), another of the top six greenhouse gases, is emitted during combustion of fossil fuels in automobiles, power plants and industry.
- *Other NO<sub>x</sub>* (Various nitrogen oxides in addition to N<sub>2</sub>O) are created when nitrogen (N<sub>2</sub>) from the air, which is normally inert, reacts with oxygen in the presence of high heat during combustion processes (for example, in automobile engines). NO<sub>x</sub> is a key ingredient in ground level ozone.
- *Sulphur dioxide* (SO<sub>2</sub>), a major cause of acid rain, is emitted primarily by coal and oil burning plants<sup>6</sup>. In fact, 86% of anthropogenic emissions of sulphur dioxide are from energy activities [75].
- *Various persistent, toxic chemicals* which have a wide range of impacts on human and ecological health are produced from petrochemical feed stocks. Because we are already pulling petroleum out of the ground for fuel, it is economical to use some of it to make chemicals, many of which are problematic.
- *Mercury compounds* which cause neurological disorders and other persistent toxins are released into the atmosphere when fossil fuels are burned (see System Condition 1).

***Nuclear Energy.*** Radioactive elements (plutonium, U235, etc.). The use of nuclear energy creates radioactive isotopes (both foreign and naturally existing ones) which are highly toxic and persistent (sometimes with half-lives of 1000s of years). No solution for their safe, permanent containment has been proven effective yet.

***Hydroelectric Energy.*** Methane (CH<sub>4</sub>) is released from rotting plant matter in areas that have been flooded to create reservoirs [76].

***Biofuels: Wood and Dung.*** Carbon dioxide (CO<sub>2</sub>) is released to the atmosphere when wood, wood products and dung are burned. However, wood burning is considered “carbon neutral” as long as tree re-growth is occurring at a rate greater than or equal to the rate of logging. Unfortunately this is not the case. Taken together with burning fossil fuels, all energy-related activities account for 78% of anthropogenic CO<sub>2</sub> [77]. It

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<sup>6</sup> In the case of the largest sources of CO<sub>2</sub> and SO<sub>2</sub> emissions, it is combination of System Condition 1 and 2 which causes the systematic increase. First carbon and sulphur are dug from the ground in the form of coal (SC 1), and then coal is burned in a power plant which causes the carbon and sulphur to oxidize and disperse into the biosphere as gases (SC 2).

is important to note that combustion of all kinds is the key cause of CO<sub>x</sub>, SO<sub>x</sub>, and NO<sub>x</sub> emissions.

### ***Agricultural Activities***

- *Methane* (CH<sub>4</sub>) emissions result from the raising of livestock, both from cud-chewing digestive processes and in manure decomposition. A smaller proportion comes from rice cultivation and the burning of agricultural residues.
- *Nitrous oxide* (N<sub>2</sub>O) is emitted through soil management practices and the use of chemical fertilizers. Another major contributor to global emissions is through concentrations of livestock and their faeces. Burning agricultural residues also makes a small scale contribution.
- *Various persistent, toxic chemical substances*. Some highly toxic and persistent pesticides, herbicides, fungicides are still in use [78].

### ***Solid Waste Management***

- *Methane* (CH<sub>4</sub>) is emitted during the decomposition of organic wastes in municipal solid waste landfills and other waste dumps.
- *Carbon dioxide* (CO<sub>2</sub>) is released to the atmosphere when solid waste is burned.
- *Nitrous oxide* (N<sub>2</sub>O) is emitted due to the way we deal with human sewage and during combustion of solid waste.
- *Various persistent, toxic chemical substances*. Many toxic substances leak out wherever they are stored as waste or end up in landfills which may eventually leak into groundwater or contaminate soil.

### ***Industrial Activities***

- *Carbon dioxide* (CO<sub>2</sub>). A large anthropogenic source is cement manufacturing. The manufacture of lime is also a significant contributor.
- *Sulphur dioxide* (SO<sub>2</sub>) is emitted from smelters and industrial boilers.
- *Nitrous oxide* (N<sub>2</sub>O) emissions are connected to the industrial production of nylon.

- *Various persistent, toxic chemical substances* are produced by individual industries from stock chemicals provided by the chemical industry. Also, many are produced inadvertently as by-products of industrial processes themselves, such as dioxins.

### ***Use of Persistent Synthetic Chemical Compounds***

Persistent synthetic chemicals cover a wide subset of systematically increasing substances produced by society. There are two main branches of persistent chemicals to consider (see Figure 3.6). Under organic compounds, we are concerned with the organohalogens which are carbon based chemicals that contain chlorine, bromine, fluorine or another halogen. Under inorganic compounds, the main target is compounds containing rare elements such as mercury, lead, cadmium or chromium. Some of the health effects of persistent chemicals and these rare elements (highlighted in Table 3.3) include nervous system disorders, birth defects, cognitive impairment, disruption of endocrine system function, and cancer.

<b>Health Effects</b>	<b>Main Chemicals</b>
Cancer	arsenic, benzene, chromium, vinyl chloride <i>Probable</i> : acrylonitrile, ethylene oxide, formaldehyde, nickel, perchloroethylene, PCBs*, PAHs, metals, others
Cardiovascular disease Endocrine disruption	arsenic, cadmium, cobalt, lead aldrin*, aluminum, atrazine, cadmium, dichlorvos, dioxins*, DDT*, endosulfan, furans*, lead, lindate, mercury, Nonylphenols, phthalates (including DEHP), PCBs*, styrene, tributyltin, vinyl acetate
Nervous system disorders/ Cognitive impairment	aluminium, arsenic, benzene, ethylene oxide, lead, manganese, mercury, many organic solvents
Osteoporosis Reproductive effect (such as birth defects and miscarriages)	aluminium, cadmium, lead, selenium arsenic, benzene, benzidine, cadmium, chlorine, chloroform, chromium, DDT*, ethylene oxide, formaldehyde, lead, mercury, nickel, perchloroethylene, PCBs*, PAHs, phthalates, styrene, trichloroethylene, vinyl chloride

**Table 3.3. Health Effects of Some Chemicals [79]**

Since the list of chemicals of concern is long, this section gives an overview of the types and some uses of problematic synthetic chemical substances included in Figure 3.6. These are covered in more detail under the section on Magnitude of Unsustainability.

- Persistent Organic Pollutants* (POPs) are a diverse subset of persistent and toxic chemicals within a group of synthetic chemicals called organohalogens (See Figure 3.6). Table 3.3 shows the health effects of some POPs such as aldrin, dioxins, DDT, furans, and PCBs (with asterisks\*), all of which are included on the list of 12 POPs both UNEP and the Stockholm Convention have identified for immediate phase-out. (The others on the list of 12 are chlordane, dieldrin, endrin, heptachlor, HCBs, mirex, and toxaphen). *PCBs* are still of great concern because their levels are not decreasing like other POPs which have been banned. There is concern over marine mammal and other animals' reproductive,

neurological and immune systems. In the Faroe Islands population, pregnant women showed elevated serum levels of PCBs which were 3 to 4 times the levels found in pregnant women in the United States, Germany or the Netherlands [80]. There are hundreds of other chemicals not slated for elimination yet which are persistent, toxic and systematically increasing. This gap is discussed in the Magnitude of Unsustainability section. POPs are used in everything from pesticides and plasticizers to flame retardants, pulp bleaching and wood preservatives.

- *Heavy Metal Compounds* contain scarce metals that are toxic to biological systems. They are used in products such as electronics, batteries and paints. Table 3.3 shows some health effects of arsenic, cadmium, chromium, lead, mercury, nickel, and others, as well as some toxic chemicals which are not persistent.
- *Ozone Depleting Compounds* (e.g. CFCs, HCFCs) are organochlorines that are actually POPs, but since they are covered under the Montreal Protocol which addresses phasing out ozone depleting substances, they are typically talked about separately.
- *Greenhouse Gases* (e.g. HFCs, PFCs, SF<sub>6</sub>). These examples are very powerful greenhouse gases that are not naturally occurring (as opposed to CO<sub>2</sub>, CH<sub>4</sub> and NO<sub>2</sub>) and whose emissions are addressed in the Kyoto Protocol. *Hydrofluorocarbons* (HFCs) were designed to replace CFCs as refrigerants and are also used in electronics. *Perfluorocarbons* (PFCs) are generated during aluminium production. *Sulphur hexafluoride* (SF<sub>6</sub>) is used in dielectric fluid (see Figure 3.6) [81].

### ***Magnitude of Unsustainability***

To underscore the urgency of the need for innovation, this section shows the magnitude of the main current unsustainable flows of both natural and foreign substances under SC 2.

**CO<sub>x</sub>, NO<sub>x</sub>, CH<sub>4</sub>.** Since the beginning of the Industrial Revolution in 1750, the atmospheric concentration of CO<sub>2</sub> has increased by about 30% due to human activities [82]. Other greenhouse gases have also increased in concentrations since the year 1750 (e.g., CH<sub>4</sub> by roughly 145%, N<sub>2</sub>O by approximately 15%) [83]. Table 3.4 below shows these increases in parts per million (ppm) and parts per billion (ppb). Even though The Kyoto

Protocol (ratified in April of 2005) addresses reductions of the top 6 greenhouse gases (CO<sub>2</sub>, NO<sub>2</sub>, CH<sub>4</sub>, HFCs, PFCs and SF<sub>6</sub>), we will need to take more drastic measures to reduce emissions to stabilize CO<sub>2</sub> levels and avoid additional global temperature increases and their ecological consequences [84].

Greenhouse Gas	Pre-industrial (1860) concentration	Present concentration <sup>1</sup>	GWP <sup>2</sup>	Atmospheric lifetime <sup>3</sup> (years)	Anthropogenic sources <sup>4</sup>
Carbon Dioxide (CO <sub>2</sub> )	288 (ppm)	372.3 (ppm)	1	Variable	Fossil fuel combustion
Methane (CH <sub>4</sub> )	848 (ppb)	1843/1729 (ppb)	23	12	landfills; animal agriculture; natural gas production, transportation, and use; coal mining
Nitrous Oxide (N <sub>2</sub> O)	285 (ppb)	318/317 (ppb)	296	114	agricultural soil management; fossil fuel combustion; fertilizers; industrial production of nylon

**Table 3.4. Scale of Important Greenhouse Gases [85]**

1 Present tropospheric concentration estimates are calculated as annual arithmetic averages; ppm = parts per million (10<sup>6</sup>), ppb = parts per billion (10<sup>9</sup>).

2 The Global Warming Potential (GWP) is typically used to contrast the relative radiative effects of greenhouse gases relative to CO<sub>2</sub>. In other words, the figure indicates the relative impact of the gas on a molecule-for-molecule basis, independent of how much of the gas is in the atmosphere. Unless otherwise indicated, GWP's taken from: IPCC 2001. [Climate Change 2001: The Scientific Basis](#). J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg, and K. Maskell. Cambridge University Press, Cambridge, UK, 944 pp. (see [Technical Summary \(TS\)](#) of the Working Group 1 Report, page 47).

3 IPCC (2001), [Table 4.1](#).

4 Information on anthropogenic sources is from the United States EPA.

**Radioactive Substances.** As of the year 2000, nuclear energy constituted 6.8% of the total primary energy consumption globally [86] and 17% of the total energy sources used to generate electricity [87]. Some nations are looking to nuclear as the solution to alleviate their dependence on fossil fuels. If this happens, we will be replacing one unsustainable solution with another since increasing reliance on nuclear energy will result in systematic increases in radioactive substances in the biosphere. Furthermore, if global nuclear energy use increases, uranium, the fuel for nuclear fission reactors and a limited resource, will run out much faster. Even if a foolproof way is

found to contain the radioactive waste forever in the lithosphere, we still have the safety of the nuclear plants themselves and the proliferation of nuclear warheads to consider. Both contribute to the possibility of terrorist attacks and subsequent dispersal of radioactive substances. As an outgrowth of the availability of nuclear fuel from reactors, there are currently enough nuclear warheads to destroy all of human society several times over.

***Synthetic Chemical Compounds.*** When defining the magnitude of global violation of SC 2 with regard to manufacture of synthetic chemical compounds, it is important to outline the lack of information to make this determination.

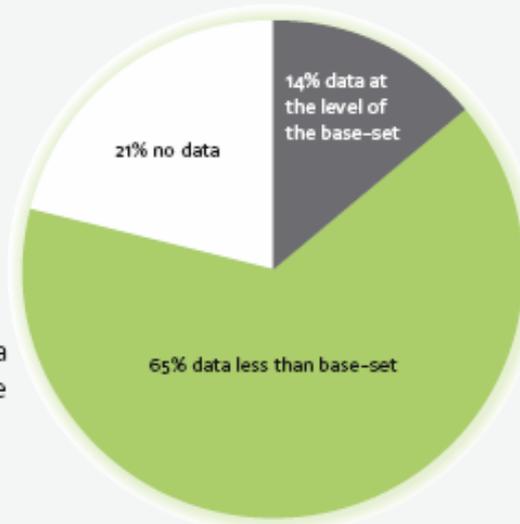
- We do not have a full inventory of what chemicals are being produced. “The European Inventory of Existing Chemical Substances (EINECS) compiled by industry in 1981 identified 100,195 chemicals that year (although it is uncertain how many were actually marketed) and approximately 3,000 ‘new’ substances have been brought onto the European market since that time (European Commission, 2001) [88].”
- There has not been adequate testing or data on the health impacts of those chemicals. The majority of high production volume chemicals in the EU have not been tested and studied enough to determine whether they are dangerous to human health, wildlife, or ecosystems. The chart below (figure 3.7) gives the magnitude of lacking data with regard to the safety of such chemicals in the EU as of 1999.

Fig 2.

**Data gaps on the basic properties of chemicals.**

A base set of data is the minimum amount of data required to make a reasonable, informed judgement as to whether or not a chemical is likely to be dangerous.

Source: European Chemicals Bureau



**Figure 3.7. Data Gaps in Basic Chemical Properties [89]**

- In the United States, 71% of the most widely used chemicals have not been adequately tested to determine their potential effects on human health or the environment [90].
- Of the chemicals that have been found to be hazardous, only a few countries measure toxic emissions of them and this data is limited. For example, the United States Toxics Release Inventory (TRI) requires toxic emissions reporting by large manufacturers only. They must give data on 650 designated chemicals, but only on emissions that occur during manufacture, not during use or disposal [91].
- For the 12 UNEP POPs, we are still phasing them out, finding where they are stockpiled, and learning how to eliminate them safely [92].
- Out of the 23 categories of persistent chemical compounds in Table 3.5 below, note that 5 of the 12 UNEP POPs are within the one category - “Cyclodienes” [93]. DDT, HCB, PCB, PCDD/F (dioxins and furans) cover 5 other UNEP POPs. Under the HM (heavy metals) category, some mercury, cadmium and lead reductions have been legislated. Under the Oms (organo-metallics) category, tributyltin used in ship paint is slated for reductions. For the other categories, much awareness-raising and policy-making work is left to be done.

Main sources and uses of some environmentally persistent chemicals

Abbreviation	Type of chemical	Applications/sources
ACB	Alkylated chlorobiphenyls	PCB substitutes
CP	Chlorinated paraffins	C <sub>10</sub> -C <sub>30</sub> alkanes with 30–70 % chlorine, plasticisers for use in polymer manufacture, metal working fluids, flame retardants, paint additives
Cyclodienes	Aldrin, endrin, dieldrin, endosulfan, chlordane, heptachlor	Pesticides
DDE	4, 4-dichloro-diphenyl-dichloroethene	Degradation product of DDT
DDT	4, 4-dichloro-diphenyl-trichloroethane	Insecticide (still used in tropical developing countries)
HAC	Halogenated aliphatic compounds	Volatile halogenated solvents such as tri- and tetrachloroethylene and ethylene dichloride tar
HCB	Hexachlorobenzene	Formerly used as a fungicide; also a combustion by-product
HCH	Hexachlorohexanes	Used as insecticide. Several persistent isomers including lindane (gamma isomer)
HMs	Heavy metals	Large numbers of potential sources e.g. combustion by-products, industrial processes, water treatment sludges, batteries, paints, anti-fouling coatings, zinc and cadmium from car tyres, mercury in dental amalgam, nickel from diesel, cadmium from phosphate fertilisers, arsenic, copper and chromium from wood preservatives
NPN	Nonylphenol	Stable degradation intermediate of nonylphenol ethoxylates used as detergents and additives in latex and plastic goods
Oms	Organo-metallic compounds	Mainly mercury, lead and tin compounds; mercury in paints; seed disinfectants; anti-slipping agents; lead in petrol; tin in marine anti-fouling agents
PAC	Polycyclic aromatic compounds	Heterocyclic aromatic compounds, derivatives of PAHs (such as nitro-, chloro- and bromo-PAHs)
PAE paint	Phthalatic acid esters (phthalates)	Plasticisers (e.g. in PVC — polyvinyl chloride); additives, varnishes; cosmetics; lubricants
PAH	Polycyclic aromatic hydrocarbons	Crude oil; by-products of incomplete combustion by-products of fuel and wood; creosote wood preservative; coal tar
PBB/PBDE	Polybrominated biphenyls/diphenyl ethers	Intermediates for chemical industry; brominated flame retardants
PCB	Polychlorinated biphenyls (and their degradation products)	More than 200 substances (but not all congeners are found in technical product or in the environment); insulating fluid in transformers; cables; plasticisers; oil and paint additives; hydraulic fluids; combustion by-products
PCC	Polychlorinated camphenes	Pesticides e.g. toxaphene, campechlor
PCDD/F	Polychlorinated dibenzo-p-dioxins/dibenzofurans, collectively referred to here for simplicity as 'dioxins'	More than 200 substances; mainly by-products from combustion and other chemical processes, such as incineration; paper pulp bleaching and metal refining; as contaminants impurities in PCBs, PCP, transformer oils; and chlorinated phenolic herbicides; contaminants; incinerators; paper pulp bleaching
PCDE	Polychlorinated diphenyl ethers	By-products of PCP manufacture; PCB substitutes; pesticide additives
PCN	Polychlorinated naphthalenes	Insulating fluids in capacitors; flame retardants; oil additives; wood preservatives, pesticides; combustion by-products
PCP	Pentachlorophenol	Fungicides; bactericides; wood preservatives
PCS	Polychlorinated styrenes	By-products of chemical processes
PCT	Polychlorinated terphenyls	PCB substitutes

Table 3.5. Environmentally Persistent Chemicals [94]

### 3.2.2.3 Key Drivers: Structures and Paradigms

The main human activities which are currently violating SC 2 run across several sectors. Since energy, transport, agriculture, solid waste and industrial activities also have significant unsustainability issues addressed in the sections on SC 1 and SC 3, the following three sections on SC 2 will focus on persistent synthetic chemical compounds to raise awareness of their importance. The spotlight is on the organohalogen arm of the map in Figure 3.6, specifically on the subgroup of “Most Known Persistent Organic Pollutants.” These sections examine the chemical industry’s structures, paradigms, potentials and players, and are intended to serve as a template for how future research could address sustainability issues for *all* of the current (and future) substances of concern mapped in Figures 3.5 and 3.6. The final section, “Implications for Global Sustainability,” returns to the big picture of the entirety of SC 2, summarizing both the challenges and the opportunities for society to address.

#### ***Structural Barriers in the Chemicals Industry***

- *Drivers.* There are essentially two main drivers of growth in the chemical industry and hence the proliferation of toxic chemicals: customer demand for products based on new uses of chemicals and the availability of feedstock from the petrochemical industry such as ethylene, benzene and propylene for creating new chemicals [95].
- *Burden of Proof.* Right now, the burden of proof of the safety of a chemical lies with the consumer. Chemicals are released onto the market without adequate testing and the public is left to prove that a chemical is toxic enough to be removed or controlled. “As structured, our current system puts the focus on which risks are acceptable rather than which are necessary and unavoidable [96].”
- *Responsibility.* There are currently no structures in place giving chemical manufacturers cradle to cradle responsibility for the chemicals they produce.
- *Costs, Awareness, Infrastructure.* “Fortunately, there are alternatives to POPs. The problem is often that high costs, a lack of public awareness, and the absence of appropriate infrastructure and technology have often prevented their adoption. Solutions must be tailored to the specific

properties and uses of each chemical, as well as to each country's climatic and socio-economic conditions [97].”

- *Lack of Information Flows.* Currently there are not widespread international efforts to label products or otherwise inform the public about the dangers of POPs and heavy metal compounds. Although policy supports are in place to facilitate phase-out of POPs (see Potentials to Build On), without public and end-user industry demand driving the chemical industry, these policies may not be sufficient to curb production quickly enough [98].

### ***Paradigms within the Chemicals Industry***

- The burden of proof of the safety of chemicals is on the consumer.
- Once the chemicals leave the factory, it is not the producer's responsibility where they go, what happens to them, or what impacts they have.
- Creating persistent, toxic chemicals that are foreign to nature is ok.
- Toxicity is acceptable as a trade-off for benefits such as beautiful colours or durable products that make ships, house paint, wooden structures, etc.
- If the chemical industry makes something really toxic, it is acceptable to sell or dump it in developing countries to minimize losses.
- Insects and rodents carry disease/are revolting/annoying and should be killed with toxic chemicals because this is an efficient, effective method.
- Chemical fertilizers, herbicides, pesticides, fungicides are necessary for high production volumes of food.
- We must increase growth to increase profit to keep our shareholders happy. This necessitates the creation of more kinds and higher volumes of chemicals.

#### **3.2.2.4 Potentials to Build On**

The need to phase out persistent toxic chemicals represents an enormous opportunity for innovation and sustainable development. Focusing on the chemicals industry, this section gives an overview of some current policies supporting change, highlights some emerging business opportunities and

gives a few exciting examples of where the chemical industry is heading to inspire leaders who want to be the forerunners.

## ***Policies and Legislation***

***Stockholm Convention.*** Under the Stockholm Convention on Persistent Organic Pollutants ratified in May of 2004, signatory countries “will examine any new pesticides and industrial chemicals ‘with the aim of preventing’ additional persistent organic pollutants. Governments are also obligated to screen existing chemicals and reduce the use and release of those with the characteristics of a POP [99].” The Stockholm Convention gives countries “the option to require - not simply promote – substitute materials, products or processes; and a broad commitment to the precautionary principle [100].” It also requires industrial countries to provide funding to assist developing countries with the costs of eliminating POPs and finding alternatives to DDT. Some points to address include:

- The Stockholm Convention could be strengthened with a clear definition of how persistent chemicals can actually become a mechanism for destruction of society. Defining compliance with System Condition 2 (and the other System Conditions) as a design constraint for the chemical industry would make the convention stronger toward sustainability because it would prevent the creation of such chemicals in the first place.
- The Convention contains provisions for how to add newly identified POPs for elimination. Adding the systems perspective provided by the System Conditions could be a quick, comprehensive and less expensive way to identify the majority of substances for immediate phase-out.
- Getting rid of toxic wastes is not so easy. Incineration of wastes may create highly toxic pollution such as dioxins and furans. Recycling substances such as heavy metals encourages their ongoing use, possibly discouraging the development of safe alternatives which would not violate the SCs [101].

***Basel Convention.*** The 1989 Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal prevents export of hazardous wastes from industrialized countries to developing countries with its 1995 amendment which bans such activity [102].

***EU REACH Legislation.*** The EU Registration, Evaluation and Authorisation of Chemicals (REACH) legislation is an attempt to inventory, register and test existing and new chemicals and control persistent bio accumulative substances by requiring prior authorisation for their manufacture and use. A key point to address is that under this legislation, persistent bio accumulative substances may be authorised if proof of ‘adequate control’ through risk assessment can be provided by the manufacturer. To support sustainability, substitution should be required for persistent and scarce substances, and authorisation only granted where control within tight technical loops can be proven [103].

### ***Business Opportunities***

- *Substitution: New Products and Services.* Companies who innovate sustainable substitutes for the uses currently served by POPs and heavy metal compounds from Table 3.5 will be positioned for long term success. Market niches to be filled include green plastics and plasticizers, metal working fluids, flame retardants, non-toxic durable outdoor paints and finishes, organic pest controls, safe mosquito control, environmentally friendly solvents, fungus inhibitors, energy storage systems, green batteries, lubricants, fuels, wood protectors and green means of enhancing longevity of building materials, natural building materials production, seed storage, ship paints or protective finishes, natural cosmetics, hydraulic fluids, weed control methods.
- *Design Method Training.* Teams of designer-teachers could work as consultants to train others in using the System Conditions to frame product and factory design parameters. This would encourage green, closed-loop production in the chemical industry (and all industries) and could prevent the creation of POPs and heavy metal compounds (and CO<sub>x</sub>, SO<sub>x</sub>, NO<sub>x</sub> and methane as well).
- *Dematerializations and Phase-Out Technologies.* Examples include: finding ways to use plants to break down chemicals slated for phase-out (phytoremediation); creating new processes which avoid the use of POPs, such as a substitute for paper bleaching; finding ways to save steps in production to dematerialize; developing food, medicine, fuel and clothing production based on organic polyculture, Integrated Pest Management, permaculture, and biodynamic agriculture methods.

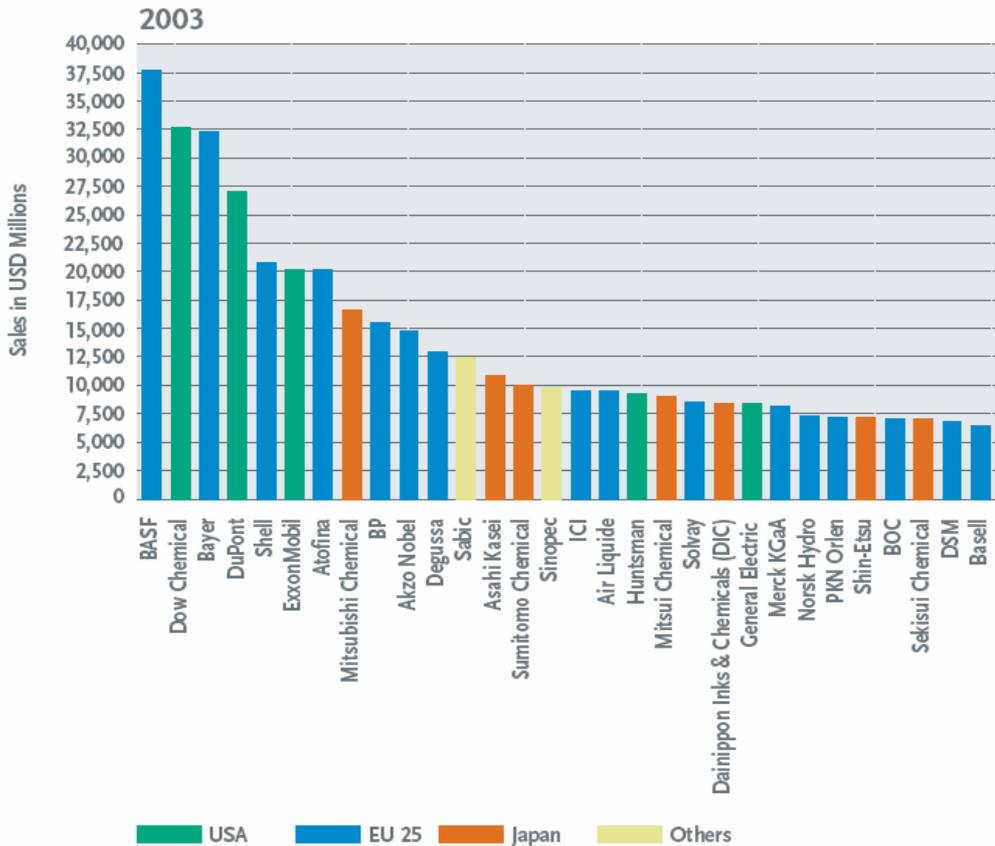
## ***Green Chemistry & Substitution***

- “One company has developed plates, bowls, and other food containers from a mix of potato starch, limestone, and post consumer recycled fibre. The packaging has been used by several hundred McDonald’s restaurants [104].”
- “Recently...thousands of rice farmers in China demonstrated that growing multiple varieties of rice in the same paddies could double yields without the use of any synthetic chemicals [105].”
- Cargill-Dow chemical company is spending \$300 million on a new facility to manufacture plastic from corn sugar [106].
- The Green Chemistry Research and Development Act of 2005 (H.R. 1215) establishes academic-industry partnerships in the United States to retrain chemists and chemical engineers in green chemistry.
- According the website of The Green Chemistry Institute of the American Chemical Society, worldwide there are currently 21 university programs, 10 NGOs related to Green Chemistry, and a set of 12 Principles of Green Chemistry. Principle 10 reads, “**Design for Degradation.** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment [107].”

### **3.2.2.5 Key Players**

The main players relevant to creating a sustainable chemicals industry which complies with the SCs include those who currently have high stakes in chemicals and/or those who have high levels of toxic releases. It would also be beneficial to include players such as those mentioned above who are already engaged in creating substitute products and practices. Figure 3.8 shows the top chemical companies in the world (2003), including BASF, Dow Chemical, Bayer and DuPont, who could be gathered around a table to lead the move toward sustainability.

Chart 1.12: 30 Top chemical companies\* in the world



In 2003, 16 of the 30 world chemicals majors\* have their headquarters in the EU 25 - representing a significant part of the world chemical sales

Sources: Cefic & Chemical Insights

\* List of 30 top chemical companies reproduced with the kind permission of Reed Business Publishing - Chemical Insight, but adjusted by using average rather than year end exchange rates

Figure 3.8. 2003 Top 30 Global Chemical Companies [108]

In terms of identifying main players with high toxic emissions, the United States Environmental Protection Agency's Toxic Release Inventory (TRI) was established by the Emergency Planning and Community Right-to-Know Act of 1986. Major industrial facilities are required to report their releases, disposal and waste management of over 650 toxic chemicals. This database is useful for pinpointing players by their toxic emissions in the United States.

According to the TRI the top 3 emitters of toxic substances in the United States in 1999 were the metal mining sector, the energy sector, and coming in third was the chemical industry. Looking at the subset of air pollution, the global ship building and maintenance industry is the largest polluter, with 5 times the amount of toxic releases to the air as the chemical industry. Chemical and plastics manufacturing are also among the top ranks in contributing to toxic air pollution [109].

Table 3.6 below shows 2002 data from the TRI, organised by the top toxics-releasing operations in the United States.

	<b>Facility</b>	<b>U.S. Pounds</b>
1	Red Dog Ops.	481,578,816
2	Newmont Mining Corp. Twin Creeks Mine	291,128,400
3	BHP Copper N.A. San Manuel Ops.	248,695,440
4	Kennecott Utah Copper Mine Concentrators & Power Plant	113,640,793
5	Barrick Goldstrike Mines, Inc.	79,410,838
6	Newmont Mining Corp. Lone Tree Mine	58,686,703
7	Newmont Mining Corp. Carlin South Area	43,143,578
8	Kennecott Greens Creek Mining Co.	37,103,243
9	Asarco Inc. Ray Complex Hayden Smelter & Concentrator	34,941,191
10	U.S. Ecology Idaho Inc.	28,895,378

**Table 3.6. 2002 Top US Chemical-Releasing Industries <sup>7</sup> [110]**

<sup>7</sup> Ranked by total environmental releases.

### 3.2.2.6 Implications for Global Sustainability

*Conclusion for Naturally Existing Substances.* We need to redesign our energy, agriculture, transportation and other systems to avoid systematic increases of natural substances. The largest portion of our problems stem from our societal dependence on fossil fuel based energy sources for electricity and transport, use of nuclear energy and reliance on the combustion of all kinds. Conserving energy, dematerialization, minimizing transport and switching to renewable, sustainable energy are crucial for coming into compliance with System Condition 2. Careful design of our cities and communities to cleverly integrate workplace, home, electricity generation, agriculture and other systems can minimize transport and energy use. In addition, agricultural fertilizing methods, milk, beef and other meat production, and solid waste systems are currently set up in such a way that we systematically add more nitrogen and phosphorus compounds, carbon dioxide, methane and other natural substances to the ecosystem. We need to change our food producing practices to create closed loop systems and the same is true for all industries in order to eliminate solid waste. These system design problems represent great opportunities for innovation and great examples of solutions already exist.

*Conclusion for Foreign Substances.* Based on our lack of understanding of ecosystem complexity and the unknown thresholds of allowable concentrations of persistent substances before health is compromised, we need to design such substances out of our systems entirely. Substances which are foreign and persistent such as POPs, heavy metal compounds and radioactive nuclides must be phased out of use, carefully disposed of and no new ones should be created. Persistent substances for which no viable substitute has been found should be used temporarily and monitored carefully to assure their containment in tightly controlled closed loops until green chemistry and renewable energy innovation can find suitable substitutes. New and traditional methods of agriculture such as permaculture, integrated pest management, and biodynamics can be used to replace synthetic fertilizers and pesticides.

### **3.2.3 System Condition 3**

*“In a sustainable society, nature is not subject to systematically increasing degradation by physical means.”*

#### **3.2.3.1 Introduction**

A sustainable society does not affect ecosystems in a way that systematically impedes its ability to function, its capacity for production or its diversity. From an anthropological point of view, society depends on natural systems to provide vital life support goods and services. Goods refer to renewable and non-renewable resources that provide society with food, fibers, building materials etc. Services refer to the vital life support services such as oxygen production, regulation of climate, detoxification and recycling of waste, production of pharmaceuticals, regulation of the chemical composition of the oceans, maintenance of soil fertility, pollination, protection against cosmic and ultraviolet radiation and countless other services [111].

It is interesting to note that it is living organisms that create water, the atmosphere, soil and all forms of energy (except the sun) and even the winds depend to a large extent to the vegetative patterns around the globe [112]. Therefore, protecting living systems is paramount to human survival. Further, as with any living system, damaging any part of the global system may ultimately impact the integrity of the whole system.

Human society is inextricably linked to the global cycles of interlocking, interdependent sets of systems. At the most fundamental level, the water that flows through our cells or the atoms that make up our bodies are all part of the same flows of water and atoms that cycle throughout our world. So, from a scientific perspective we are nature.

Degradation occurs when society takes more resources from natural systems than such systems are able to replenish [113]. This can occur through, for example, tree harvesting, fishing, water extraction (from lakes, rivers, underground aquifers etc.), hunting, collecting medicinal or ornamental plants, etc. A sustainable society, therefore, essentially lives

on the “interest” that ecosystems provide and does not draw down its “capital”.

Degradation can also occur through systematic displacing, altering or other forms of manipulation of natural systems [114]. Examples of such activities include conversion of forest to farmland, filling in wetlands, constructing break walls along shorelines, clear cutting forests, constructing buildings and roads, allowing soil erosion, channeling water into storm drains, agricultural practices that lead to a loss of soil nutrients and microorganisms, damming of rivers etc. Another form of degradation occurs when society affects the processes and flows of natural systems through artificial gene manipulation (genetic engineering) or animal and plant breeding in such a way that a loss of biodiversity occurs [115].

A sustainable society is mindful that it is not separate from nature. It is truly embedded within a multitude of interconnected systems. It therefore, does not systematically degrade its world through over harvesting or other forms of manipulation.

### **3.2.3.2 Overview of Major Human Activities**

We are able to identify a number of human activities that are at odds with System Condition 3 by asking the question “In what ways is our global society dependent on activities that are systematically increasing degradation of nature by physical means?” This section is intended to identify and substantiate some of the more significant human activities where the greatest urgency for change is necessary relative to System Condition 3.

#### ***Agriculture***

Agriculture is directly connected to the green cell and its unique ability to convert energy from the sun to reassemble dispersed matter into new structure, which it does without degrading any resources or spreading any pollutants. In fact, life-enhancing oxygen is the by-product of photosynthesis. Agriculture will most likely be relied on more heavily as we lessen our dependence on non-renewable energy sources. Further, an

expanding world population will place increased demands on agriculture for food, energy and raw materials (such as oils and lubricants, fibres, starch etc.) [116]. Encroachment, typically onto forested lands is a key form of physical degradation. Degradation of agricultural lands as well as adjoining ecosystems also occurs as a result of farming practices. The following provides a sampling of the kinds of degradation that are associated with our present global agricultural activities:

- More land has been converted to cropland since 1945 than in the eighteenth and nineteenth centuries combined. Cultivated systems now cover one quarter of the Earth's terrestrial surface [117]. Much of this conversion has been at the expense of forested lands [118].
- Not only is the availability of cropland per capita decreasing as the world population grows, but some 40 percent of arable land has been degraded in the past half-century by erosion, salinization, compaction, nutrient depletion, pollution, and urbanization [119].
- Agriculture expansion has also been at the expense of valuable wetlands. Wetlands not only provide unique habitats but also play a key role in water storage and purification.
- Valuable nutrients and humus are being lost from soils due to the linear nature of our agriculture systems where organic waste from plants and animals are not being put back into the soil.
- A cubic meter of healthy soil contains "billions of interdependent organisms linked together by unbelievably complex flows of energy, water, carbon, sulphur, oxygen and nitrogen" [120]. The tilling of soil can physically damage soil ecosystems.
- Management practices that rely on chemical fertilizers, pesticides and herbicides contribute to damaged soil and other ecosystems including the loss of valuable pollinator species.
- Loss of genetic diversity of seeds (i.e. more than 2,000 rice varieties were found in Sri Lanka in 1959, but just five major varieties in the 1980s (WCMC 1992:427). Further, the Millennium Ecosystem Report notes that genetic diversity has declined globally especially within cultivated species [121].
- The use of heavy machinery on agricultural lands causes soil compaction. In Sweden, approximately 30% of agricultural land has compression damage which corresponds to a 10 to 20% reduction in productive capacity [122].

- Agricultural practices account for approximately 70% of total global water use. From 5 to 25% of global freshwater use (for all uses) exceeds long-term accessible supplies and is now met either through engineered water transfers or overdraft of groundwater supplies. Some 15 – 35% of irrigation withdrawals exceed supply [123].

## ***Forestry***

The forest is of great value as a renewable resource and has a long list of social functions. It influences precipitation, wind and the air's percentages of oxygen and carbon dioxide. Trees act as filters and cleanse the air. The forest (together with grasslands) provides our most effective land protection – it creates and sustains an essential water cycle in large parts of the world. It influences not only “its own” area where it grows, but it also has a positive influence on the Earth's entire environment. Forests are so much more than simply an assemblage of trees. In fact, the trees themselves depend on the interrelationships with other plants of varying ages and species, mycelium, insects, and micro organisms for their own health and survival. Currently almost a third of the Earth's ice-free land area is covered by forest, including the relatively sparse savannah forest. The following provides a sampling of the kinds of degradation that are associated with our present global forestry activities:

- Before humans began to interfere on a large scale with nature, the amount of forest was about twice what it is now; in other words, the forest covered about two thirds of the land on Earth. Estimates by the FAO in 1990 indicate that the reduction of tropical forest today amounts to about 16 million hectares per year. In 1980 this number was 11.5 million hectares per year. Of the forests that do remain standing, the vast majority are no more than small or highly disturbed pieces of the fully functioning ecosystems they once were [124].
- The highest rates of deforestation in the world currently take place in the tropics (FAO 1999), where rates can sometimes be as high as 4% per year for extended periods [125].
- In dry areas with a high population density, forest losses can be up to several percent per year, caused by overgrazing and firewood gathering, which can result in expanding deserts.

- Forestry practices and other human activities are principally responsible for species extinction. In fact, over the past few hundred years, humans have increased the species extinction rate by as much as 1,000 times background rates typical over the planet's history [126].
- The use of heavy machinery and the removal of whole sections of forest can result in the loss of valuable nitrogen fixing mycelia and other soil micro-organisms.
- Deforestation results in erosion of valuable soil cover. It takes nature tens of thousands of years to build soil. Since 1950 erosion due to deforestation is responsible for the loss of 580 million hectares of fertile land worldwide, an area bigger than all of Western Europe [127]. Much of the remaining forests in most areas of the globe are situated on steeper slopes. Deforestation of these areas can result in even greater loss of soil cover.
- The removal of woody "debris" for incineration can lead to nutrient cycle/humus loss and soil compaction.
- Deforestation reduces the globe's capacity to sequester CO<sub>2</sub>.
- Reforestation with monoculture results not only in a loss of biodiversity but also increases the susceptibility of these forests to disease or pest infestations.
- Deforestation is resulting in degradation of the globe's water cycle.

## ***Fisheries***

"Fish and shellfish provide about one-sixth of the animal protein consumed by people worldwide. A billion people, mostly in developing countries, depend on fish for their primary source of protein" [128]. In an article appearing in the Feb. 6, 1998 issue of the journal *Science*, UBC Fisheries Centre Prof. Daniel Pauly notes that our marine fisheries are in a global crisis. His data indicates that as larger predators at the top of the food web are decimated, fishers move down the web to more abundant plankton eaters, such as anchovies. "By removing big predators and going after their smaller prey, we are ripping the fabric of these webs, and endangering their ability to produce harvestable fish at any level and if present exploitation patterns continue, in about 25 years the only fish in the seas will be lantern fish, jellyfish and krill" [129]. The following provides a sampling of the kinds of degradation that are associated with our present global fishery activities:

- Over-fishing of oceans, seas, inland lakes and waterways is causing loss of commercial fish stocks. In fact 70 percent of global fisheries are over-fished or fished at their biological limit [130].
- Fishing methods, such as the use of dragnets, are causing severe damage to coral reefs and the ocean floor. “In a study by Australian federal authorities, it was found that a single pass of these trawl nets removed up to 25 percent of all the organisms on the ocean floor, and 13 passes destroyed 90 percent of all its life forms” [131].
- Coral reefs, a primary habitat for thousands of fish species and other aquatic life are experiencing severe stress and decline from human activities including global climate change. “Approximately 20% of the World’s coral reefs were lost and an additional 20% degraded in the last several decades of the twentieth century” [132].
- Aquaculture has the potential to become a key supplier of fish protein provided however, that it is practiced in sustainable ways. Current practices are causing degradation of nature in the following ways:
  - An increasing share of aquaculture use carnivorous species which require wild fish as protein and thereby place increased pressure on other fisheries [133].
  - Salmon, a carnivorous fish species, requires a total of 2.7 to 3.5 tonnes of wild fish to make 1 tonne of farmed salmon resulting in a net loss of wild fish [134].
  - Heavily populated monocultures are susceptible to disease and parasites and are thus treated with antibodies, drugs and pesticides.
  - The release of effluent, including antibiotics, drugs and pesticides is degrading adjoining ecosystems.
  - Non-native species, such as Atlantic salmon grown along the Pacific coast, can escape from their net cages—often by the thousands—and displace fragile wild stocks from their habitat [135].
  - Mangroves which provide important fish rearing habitat and shoreline protection are being removed in favour of shrimp and prawn farms. Approximately 35% of the World’s mangroves have been lost over the last several decades [136].
- Underwater sonar is believed to negatively impact (or have the significant potential to negatively impact) the marine environment and marine animals [137].
- Gillnet and trawler fishing result in the unnecessary loss of other fish and aquatic species

- Siltation of estuaries/coastal wetlands river and stream beds etc. from urban runoff is creating significant losses of valuable fish spawning and rearing areas. Similarly, nutrient runoffs from agricultural lands are creating dead zones within ocean areas. In fact, a “dead zone” of roughly 18,000 km<sup>2</sup> has been created in the waters in the northern Gulf of Mexico due to a tripling of the nutrient pollution carried to the coast by the Mississippi River over the last 40 years [138].
- Hydroelectric dams can significantly change water flows and thereby negatively affect fish habitat and ecosystems.

### ***Built Environment***

Although urban land use occupies less than 2% of the land area on earth (Gubler 1994; Lambin et. al. 2001) the area required to support such populations is much larger. For example, it has been estimated that Hong Kong requires an area equivalent to 2200 times the built up area of the city in order to support its inhabitants with essential ecosystem goods and services (Warren-Rhodes and Koenig 2001) [139]. It has been estimated that over the 33 year period between 1945 and 1978 in the United States the removal of natural areas for buildings and pavement alone accounted for an area equivalent to Ohio and Pennsylvania. Further, almost half of the land taken for housing and highways was the most productive United States agricultural land [140]. The built environment includes urban land use, dams, utilities, roads, airports, etc. The following provides a sampling of the kinds of degradation that are associated with our present global built environment activities:

- Residential accommodation, especially single family dwellings and their associated lawn, parking areas, playgrounds, parks etc. are typically constructed on natural areas and in some cases on lands previously converted to agricultural use. Additional losses result from the construction of access roads, parking areas and from corridors for services such as underground and above ground sewer, water, electrical, gas, communications, etc. as well as their supporting facilities, buildings, access roads, and parking areas, etc.
- Commercial, office, utility, institutional and industrial buildings and their associated service and support infrastructure typically follow

expanded residential areas, leading to further loss and disruption of natural ecosystems.

- Natural ecosystems that are adjacent to such urbanized areas are typically also negatively impacted through the construction of walking, bike and motorized trails that are frequented by humans and their pets.
- Roads require continual inputs of aggregates (gravel) for construction and maintenance. Aggregates are used for roadbeds and as additives to concrete and fossil fuel based pavement. Further, in snow regions, sand may be added to the road surface. Sand and aggregates are essentially a non-renewable resource and where resources are scarce they are created from the extraction and pulverizing of larger rock matter. These extraction activities require the removal and degradation of ecosystems.
- Tourism is one of the fastest growing industries in the world. By 1999 it accounted for 11.7% of the world's GDP [141]. Around the world there is an ever-increasing pressure on unique "undiscovered" areas for tourism development. Such pressure includes the removal of natural areas to make way for the construction of tourism accommodation of various types along with recreational facilities (golf courses, pools, tennis courts etc.) and trails for various modes of travel from walking to motorized excursions. Additionally, such infrastructure requires support services such as water, sewage, electricity and communications as well as housing for the increased demand for employees to the area; all of which result in further degradation of natural ecosystems. Natural areas beyond the tourism destination are impacted due to the increased demand for new or expanded airports, building materials, roads, warehousing, and transport facilities and for additional food supply. Typically once these areas become overbuilt new "undiscovered" areas are sought out where the development process repeats itself.
- Materials for buildings can result in further degradation of natural areas through mining of metals, forestry, rock quarries, removal of aggregates for back fill and concrete additives etc.
- Bridges, culverts, and shoring up of water bodies physically remove or damage riparian and aquatic habitats.
- Dams for irrigation and hydroelectric power generation flood vast areas of terrestrial ecosystems as well as damage upstream and downstream riparian and aquatic habitat due to changed flow regimes. They can also affect segments of society through displacement of communities or loss of livelihoods. According to the Millennium Ecosystem Report the amount of water impounded behind dams today has quadrupled since

1960, and three to six times as much water is held in reservoirs as in natural rivers [142]. Approximately 60 percent of major river basins are strongly or moderately fragmented by dams [143].

- Channelization of waterways to prevent flooding such as construction of beams or spillways not only damage critical riparian habitat but also the adjoining ecosystems that rely on such flooding. Additionally, such measures result in valuable soil sediments to be deposited in the bottom of lakes, seas and the ocean.
- Channelling water from buildings, roads and parking areas into storm drains does not allow the water to seep into the ground where it can provide vital services for soil ecosystems and recharge groundwater aquifers.

### **3.2.3.3 Key Drivers: Structures and Paradigms**

The following provides a sample of key structures and paradigms that can act as barriers to aligning our activities with System Condition 3.

- *Agriculture.* Heavily subsidized industrial agriculture makes it difficult for small scale organic agriculture to compete in economic terms. Increased consumption of protein from animals is seen as a sign of ones affluence.
- *Forestry.* The perception that it is much more economical to clear cut a forest than to selectively log results in decisions to clear cut forests for purely economic reasons. For example, demand on land to yield an economic profit for current owners, results in a much greater long term cost to society.
- *Fisheries.* Aquaculture operations result in lower costs and thereby place greater pressure on wild stocks. Furthermore, demand generated by increased reliance on protein from animal sources further reinforces this pressure.
- *Built Environment.* “An undeveloped resource is a wasted resource” [144]. This paradigm drives a vicious cycle of land development for its own sake as is often the case with urban sprawl. New houses built in quick succession reinforce the case for further infrastructure development such as roads, malls, office parks etc.

### 3.2.3.4 Potentials to Build On

The following provides a sample of current activities or opportunities that can help move society towards sustainability:

- *Agriculture.* The 1989 collapse of Soviet Union cut Cuba off from its supply of agriculture inputs (fuel, chemical fertilizers, pesticides, herbicides etc.) and forced them to develop what is proving to be a very successful organic agricultural system. In fact, “teaching sustainable farming to other farmers, researchers, academics and activists from around the world has also become a growth industry in Cuba.”[145]
- *Agriculture.* The World Resources Institute found that farmers yields of wheat, corn, and sorghum doubled when they switched from industrial, high external input agriculture to “biodiversity-based, low input,” organic polycultures.[146]
- *Agriculture.* A plant based diet requires considerably less energy and land area than a meat based diet. Meat production requires 10 to 20 times more energy per edible ton than grain production. A meat-based diet requires 7 times more land than a plant-based diet [147]. Further, plant-based cuisine is healthy for the body and can help in the prevention of heart disease, cancer, and many other diet-related diseases.
- *Forestry.* Collins Pine, USA is a good example of a sustainable forestry business that has been in operation since 1855. Its forests are bio diverse, multi-age and self-sustaining and contain more wood today than they did 100 years ago and yet employ over 1000 people directly and gross about \$230 million (U.S.) a year [148].
- *Forestry.* Trees on the West Coast of Canada don’t mature until some of them are 300 or more years old. That means that by the age of 60, a tree is the equivalent of a 12-year-old human. If left to grow, it will put on 5 times as much timber in its second 60 years and 5 times as much again in its third 60 years, before finally slowing down.
- *Forestry.* Paper production is a major consumer of forest products. Between 1961 and 1994, per capita consumption of paper increased by 86 percent globally and by 350 percent in developing countries. Pulp for paper production, however, can be obtained from Hemp. A 1916, United States Department of Agriculture special bulletin #404, noted that one acre of hemp, in annual rotation over a twenty year period, would produce as much pulp for paper as 4.1 acres of trees being cut

down over the same twenty year period; and this process would only use 1/5 to 1/7 as much sulphur based acid chemicals to break down the glue-like lignin that binds the fibres of the pulp. Further, hemp paper process does not require the use of chlorine bleach.

- *Fisheries*. Aquaculture has the potential to sustainably supply an increased proportion of future demand for fish protein especially in the form of non-carnivorous fish species such as carp or tilapia.
- *Fisheries*. The designation of marine protection areas has shown that fisheries ecosystems in such areas undergo a significant increase in fish numbers and diversity. For example research has shown that the average population density of marine life is 91 percent higher within the world's relatively few protected marine areas than outside them. Further, species size is 31 percent greater and diversity is 23 percent higher [149].
- *Built Environment* . There are a number of urban areas like Kitsilano in Vancouver, Canada that are developing as neighbourhood centres with a strong sense of community and where residences, commercial structures, community gardens and places of work are all clustered together within walking and biking distance.

### **3.2.3.5 Key Players**

System Condition 3 highlights a number of complex issues impacting wide groups of stakeholders. Partnerships have a crucial role to play in creating leadership towards sustainability, an example of which is the work being done by the World Wildlife Fund (WWF) with Unilever, a large British-Dutch food conglomerate, to develop a certification system that would identify fish products being harvested on a sustainable basis.

The following provides some examples of the key players who, by engaging in partnerships and shifting their current activities, can play a significant role in leading society towards sustainability:

- National and regional government agencies especially those responsible for agriculture, forestry, fisheries, municipal affairs and finance.
- Municipal governments, city planners, community lobby groups and local NGO's who all play a role in local decision making, particularly with regard to the built environment and societal infrastructure.

- Multinational companies such as Weyerhaeuser Co. (forestry), Monsanto (agriculture), etc.

Examples of players to engage who are already leading society towards sustainability include:

- Cuba as a leader of a country-wide sustainable agriculture effort
- Permaculturists who have gained an understanding of sustainable agricultural practices and integrated functional design
- Hemp producers as opportunities for paper fibre production
- Collins Pine as an example of a sustainable forestry operation

### **3.2.4 System Condition 4**

*“In a sustainable society people are not subject to conditions that systematically undermine their capacity to meet their needs.”*

#### **3.2.4.1 Introduction**

Humans are, by nature, a social species. We care for and depend on each other in order to meet our needs. We have done so for as long as recorded history and likely even before that. As hunters and gatherers we banded together to help each other and to socialise. Our own well being was dependent on the overall well being of our tribe or social group.

Today we are no different; we still depend on each other, except that today’s society has become much more global. As such, our interactions are no longer face to face and we are often not aware of the effects of our decisions. Further, we have enormous power to act in ways that have major impacts far removed from where we live and work, in distant regions of the world. Self-regulation requires visible feedback, however in our current global society there is little or no feedback on our unsustainable actions, thereby making significant impacts invisible.

Further, despite our best intentions to improve the well being of everyone around the world, we are finding that the fabric of our global society is deteriorating. Social cohesion is breaking down because politics, business and the general public lack a vision, a relevant story of meaning which explains why it is important that we exist. There is no framework for us to gather around to organize our attempts to advance society. At the same time, there are many distractions and temptations *not* to look at any story of meaning such as the fast pace and competitiveness of cultures in many industrialized countries. In the developing world, the capacity to have a story of meaning is compromised by a struggle for survival at the hands of global economic policies, environmental degradation, lack of democratic governance and corruption.

### 3.2.4.2 Goal of Society

A primary goal of society is to improve the overall well being of people. Society's well being is, by today's paradigm, typically attributed to the well being of its economy. The key indicator of economic well being is the Gross National Product (GNP). This indicator would suggest that on average, the well being of much of the world is improving. In fact, according to the Worldwatch Institute, the Gross World Product (an aggregate of all nations GNP's) rose from \$6.7 trillion U.S. dollars or \$2,641 per person in 1950 (measured in 2001 dollars) to 46.9 trillion or \$7,617 per person in 2001 [150]. GNP however, essentially measures the amount of money spent within society regardless of what that money is spent on. As such, GNP may not be a good indicator of society's well being. This notion is illustrated by following quote:

*“The Gross National Product includes air pollution and advertising for cigarettes and ambulance to clear our highways of carnage. It counts special locks for our doors and jails for people who break them. GNP includes the destruction of the redwoods and the death of Lake Superior. It grows with the production of napalm, missiles and nuclear warheads. And if GNP includes all this, there is much that it does not comprehend. It does not allow for the health of our families, the quality of their education or the joy of their play. It is indifferent to the decency of factories and the safety of our streets alike. It does not include the beauty of our poetry, the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. GNP measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country...”*

Robert F. Kennedy, March 18, 1968 [151]

Alternative indicators have recently been pioneered that attempt to account for such discrepancies in an effort to better measure quality of life. One of the more notable indicators, the Index for Sustainable Environmental Welfare (ISEW) [152] later refined into the Genuine Progress Indicator (GPI) [153] found that Austria, Chile, Germany, Italy, Netherlands, Sweden, Australia and the United States all followed similar trends. For each of these nations GNP steadily increased and the quality of life

indicator followed but only up to approximately the 1980's where it began to noticeably decrease. This declining trend is most conspicuous in the United States. Nevertheless, the primary goal of almost all nations is to maintain an ever-increasing GNP.

Has our monetary system and the economy moved away from its original intent of facilitating the meeting of human needs to becoming a goal in itself? Why is it that there is more money made today on the speculation of currencies rather than on actual production and exchange of goods? These and many other serious questions are being raised about the nature of our ever-expanding globalized economy and its ability to improve the general well being of human society. This sentiment is echoed by a UN-commissioned report, which interviewed over 2000 people, and summarises current public debate on globalization as follows:

*“The current process of globalization is generating unbalanced outcomes, both between and within countries. Wealth is being created, but too many countries and people are not sharing in its benefits. They also have little or no voice in shaping the process. Seen through the eyes of the vast majority of women and men, globalization has not met their simple and legitimate aspirations for decent jobs and a better future for their children. Many of them live in the limbo of the informal economy without formal rights and in a swathe of poor countries that subsist precariously on the margins of the global economy. Even in economically successful countries some workers and communities have been adversely affected by globalization. Meanwhile the revolution in global communications heightens awareness of these disparities. These global imbalances are morally unacceptable and politically unsustainable.” [154]*

When the primary goal of society is to continually increase GDP it is easy for basic human values such as trust to erode. Yet it is trust that enhances our ability to cooperatively work towards improving our social and ecological conditions. Treating each other with respect by applying the “golden rule” can act as a powerful guiding principle. The golden rule of treating each other as we would like to be treated is a principle that transcends all cultures and appears in all religions around the world [155].

Is pursuing continued growth of GNP a relevant and appropriate goal? Should development's primary goal be on improving people's quality of

life? If so, doesn't quality of life depend on the possibilities people have to adequately satisfy their fundamental human needs? What are fundamental human needs and how can they be realised or not realised?

### **3.2.4.3 Human Needs**

There have been many excellent attempts to understand human needs. Manfred Max-Neef, a Chilean economist who has contributed much to the dialogue of development and human needs, has identified nine fundamental human needs [156]. These are inborn needs that must be realised in order for people to remain physically, mentally and socially healthy. These needs are considered to be universal, however what changes both over time and through cultures, is the way and means by which needs are satisfied. The nine identified needs are subsistence, protection, affection, understanding, participation, idleness, creation, identity and freedom. It is important to note that a need is not synonymous with a want or a desire. Therefore, the manner in which needs are realised are referred to as satisfiers. Further, human needs must be understood as a system in which all human needs are interrelated and interconnected. When looking at a global societal system, except for the need of subsistence, there is no hierarchy of needs within that system.

Pre-dating Max-Neef's approach, Maslow's hierarchy of needs is a popular theory of human needs originating from the field of psychology [157]. According to Maslow's hierarchy, basic survival needs must be met first before a person can move on to higher level needs. Furthermore, each lower level of needs must be satisfied before the next level of needs can be met, granting lower level needs greater priority over those higher on the pyramid. From this perspective, it makes sense for an individual to first focus on acute, survival needs such as air, water, food and shelter. However, when considering needs at the global societal level, it is not enough to focus only on basic subsistence needs; we also need to address other needs for example, those related to mental health, to our search for purpose and meaning etc. In a sustainable society, we will have to satisfy all basic human needs in order for the social fabric to prevail; therefore relative acuteness of different unmet needs is less important. This is why Max-Neef talks about a set of nine universal human needs and not only the subsistence ones.

Like Maslow, Max-Neef recognises that physical human needs have greater urgency for individuals; however, when looking at society on a global scale to identify upstream activities that undermine human capacity to meet needs, any hierarchy beyond the subsistence level is not useful. For example, at the global societal level, there is a connection between the unmet subsistence needs of developing country populations (although relational needs are still met through strong social ties), and the poverty of relational needs in industrialized countries, which often manifests as over-consumption.

Max-Neef stresses the importance of understanding that there is a clear distinction between needs and satisfiers and that there is not a one-to-one relationship between the two. A satisfier may contribute to meeting many different needs and conversely a need may require many satisfiers in order to be met. Furthermore, the relationship between needs and satisfiers varies over time, place and circumstance, which in essence helps to distinguish cultural diversity. Max-Neef notes that:

*“It is the satisfiers which define the prevailing mode that a culture or a society ascribes to needs...satisfiers may include, among other things, forms of organization, political structures, social practices, subjective conditions, values and norms, spaces, contexts, modes, types of behaviour and attitudes, all of which are in a permanent state of tension between consolidation and change.”[158]*

A need can be viewed as both something that is missing and a potential for something to be gained. For example, the need for creation is also a potential for creation. Further, it is interesting to note that the majority of human needs can be realised through human contact and social interactions rather than through material goods. It is possible therefore, for society to have more satisfaction with fewer material goods. It is not the materials and energy that provide satisfaction, but the degree to which basic needs are met. In other words it is possible to have more of what people want (i.e. safe, healthy and attractive communities and environments) and less of what they never wanted (i.e. violence, fear, abuse, pollution, etc.).

Our current development paradigm, however, focuses on the creation of material goods as the primary satisfier of human needs. Max-Neef suggests that when goods become conditioned as satisfiers of needs (especially needs which do not actually require goods in order to be met), then such

alleged satisfiers not only fail to satisfy the underlying need but also become drivers for the continued demand for more and more goods. This in turn can lead to an alienated society engaged in a senseless productivity race [159]. So for example: a person's unrealised need for leisure might be expressed as "I need a vacation". The offering of a two-week vacation at a tropical beach resort might be viewed as the perfect need satisfier. This however, might not meet the unrealised need for leisure when on Monday morning following the two week vacation that person finds herself stuck in traffic on her way to a job that consumes on average 12 hours of her day.

With respect to sustainability it is not so important to come to a consensus over the actual list of human needs, rather the importance is to understand that a sustainable society does not create conditions that systematically undermine people's capacity to meet their needs (regardless of the classification of needs). So the larger question has to do with understanding the mechanisms that undermine people's capacity to meet their needs.

#### **3.2.4.4 Overview of the State of Global Society**

The following examples serve to illustrate current conditions that are systematically undermining people's capacity to meet their needs.

##### ***Equity***

- "In 1960, the per capita gross domestic product (GDP) in the 20 richest countries was 18 times that in the 20 poorest countries, according to the World Bank. By 1995 the gap between the richest and poorest nations had more than doubled—to 37 times. To a large extent, these vast income gaps drive global consumption patterns. Disproportionate consumption by the world's rich often creates pollution, waste, and environmental damage that harm the world's poor. For example, growing demand for fish for non-food uses mainly animal feed and oils, is diminishing the source of low-cost, high-protein nutrition for a billion of the world's poor people. Carbon dioxide emissions, about 60 percent of which come from industrial countries, are threatening the very existence of poor island nations and the agricultural productivity of many developing ones"[160].

- “Of all high-income nations, the United States has the most unequal distribution of income, with over 30 percent of income in the hands of the richest 10 percent and only 1.8 percent going to the poorest 10 percent. Data from the United States Census Bureau indicate increases in household income inequality between 1968 and 2001, which follow decreases between 1947 and 1968. In particular, the richest 5 percent of the population have experienced the greatest percentage gain in income, and within that group, the top 1 percent gained more than the next 4 percent” [161].
- “Many changes in ecosystem management have involved the privatisation of what were formerly common pool resources. Individuals who depend on those resources have lost rights to the resources” [162].

## ***Trade***

- “Despite the growth in per capita food production over the past four decades, an estimated 852 million people were undernourished in 2000-02, up 37 million from the period 1997-99” [163].
- The fact that ecosystem services are finite and potentially hold significant value provide powerful incentives for individuals or groups to try to gain privileged access and rights-of-use over many ecosystems and their services. “They do this by influencing the political, economic, and social institutions that govern their access, management, and use (Ostrom 1990; Acheson 1993; Alston et al. 1997; Ensmiger 1997). Commonly, powerful individuals or groups prevent the establishment of institutions. Existing bodies that mediate the distribution of goods and services may also be appropriated for the benefit of powerful minorities. Agricultural subsidies in western industrial countries are an example of this.” [164]
- “Government subsidies paid to the agricultural sectors of OECD countries between 2001 and 2003 averaged over \$324 billion (U.S. dollars) annually, or one-third the global value of agricultural products in 2000. A significant proportion of this total involved production subsidies that led to greater food production in industrial countries than the global market conditions warranted, promoted overuse of fertilizers and pesticides in those countries and reduced the profitability of agriculture in developing countries” [165].

- Subsidies for unsustainable activities amount to nearly \$1.9 trillion per year [166].

## ***Finance***

- “...the efforts to establish a New International Economic Order and a new international division of labour have been unable to alleviate the economic, financial, technological and cultural relationships of dependence of Third World countries on industrialised nations. The increasing power wielded by financial capital has restricted further the capacity and the right of debtor countries to determine their own destiny” [167].
- According to the Global Policy Forum, a New York based NGO with consultative status to the United Nations: “The foreign exchange market is the largest market in the world, with an estimated \$1.9 trillion currency traded per day (2004). This means that in less than one year, currency worth 10 times the global GDP is traded. Of this massive amount, international trade in goods and services that requires foreign exchange accounts for only a small percentage (\$9 trillion per year) of the total trading. Meanwhile exchange rate speculation accounts for at least 80 percent of the global currency market. These speculative movements, which can take place rapidly and unpredictably, threaten to empty central banks' currency reserves and trigger financial crises such as those in Mexico (1994), East Asia (1997-98), Russia (1998), Brazil (1999), Turkey (2000) and Argentina (2001). These crises have had far-reaching socio-economic consequences, throwing millions of people into poverty and unemployment” [168].
- “Capital formation is a social process built on present and previous generations of human labour. Businesses use both economic and social infrastructure, and natural resources. For these reasons there is both a social and an ecological mortgage on all capital – corporations have a debt to pay back to both society and nature. This ‘stored value’ of capital provides legitimate grounds for putting obligations on investors” [169].

## ***Governance***

- “The problems we have identified are not due to globalization as such but to deficiencies in its governance” [170].
- "Governance involves interaction between the formal institutions and those in civil society. Governance refers to a process whereby elements in society wield power, authority and influence and enact policies and decisions concerning public life and social upliftment" [171].
- “Global markets have grown rapidly without the parallel development of economic and social institutions necessary for their smooth and equitable functioning. At the same time, there is concern about the unfairness of key global rules on trade and finance and their asymmetric effects on rich and poor countries. These rules and policies are the outcome of a system of global governance largely shaped by powerful countries and powerful players. Most developing countries still have very limited influence in global negotiations on rules and in determining the policies of key financial and economic institutions. Similarly, workers and the poor have little or no voice in this governance process” [172].
- Examples of effects of abuse of power include unfair distribution of resources, misuse or squandering of resources by those with more than their fair share, over-harvesting resources at a rate of consumption that is creating inter-generational debt.
- “One measure, the “ecological footprint,” looks at per capita use of renewable resources and compares this to the capacity of Earth to generate them. This conservative estimate, which does not include the needs of other species, nonrenewable resource use, or pollution, finds that ... humanity is withdrawing resources 20 percent faster than Earth can renew them and is consequently depleting the world’s ecological assets.”[173]
- “Corruption - the misuse of public power for private benefit - is hard to measure because officials who take bribes try to hide such activity. Since Transparency International (TI), a Berlin based non-governmental organization, published its first global Corruption Perceptions Index in 1995; however, opinion surveys have become a widely used tool to gauge corruption. The index combines 15 surveys from nine institutions that ask business people, risk analysts, and residents about corruption among public officials and politicians. In 2002, the index

covered 102 countries. Of these, 70 nations scored less than 5 out of a clean score of 10, and 35 scored less than 3.1 [174].”

- “According to the Stockholm International Peace Research Institute, world military expenditures amounted to a conservatively estimated \$839 billion in 2001, the most recent year for which data is available. This works out to \$2.3 billion each day—almost \$100 million an hour. And with the “war on terrorism” in full swing, spending appears set for substantial further increases, particularly in the United States [175].”

### 3.2.4.5 Key Drivers: Structures and Paradigms

This section highlights examples of some of the underlying structures and paradigms prevailing in society today. These barriers reinforce everyday activities in society which undermine people’s capacity to meet their basic human needs.

#### ***Structural Barriers***

- ***Equity.*** Poverty is both an effect and a cause of environmental degradation. Key barriers to global equity include global capital flows driving unsustainable activities, currency speculation, poor governance, powerful vested interests and the inability of many stakeholders to legitimately participate in determining their future. Furthermore, subsidies and unfair trade rules reinforce success to the successful, and the continuation of the poverty cycle wherein the people and the resources of less developed countries are exploited by those countries who command more power.
- ***Trade and Finance.*** “Increasingly, global capital flows and FDI concentrate on the resource extraction industries, and high-tech chemicals and electronics” [176]. “Hazardous industries are increasingly concentrated in countries where safety practices and environmental enforcement and monitoring are rudimentary” [177].
- ***Governance and Communication.*** Power is concentrated in the hands of a few; the powerful create the rules of engagement in the global system; and the rules are self-reinforcing. This culture of global governance results in and is reinforced by a dominant communication style characterised by debate rather than dialogue, that is, oscillating

between modes of attack and defence, rather than active listening to create understanding. Furthermore, at this critical stage of our evolution, when communication and participation are critical, we are simultaneously benefiting from the technology revolution, and creating an infrastructure barrier to full participation and access to information for all (commonly referred to as “the digital divide”).

## ***Paradigms***

- “Consumption will produce happiness (and consumption is “needed”). If consumers stop buying, then people will lose jobs [178].”
- “The future is to be steeply discounted” in the economic models which drive current decision-making without taking the health of people or ecosystems into account. For example, “buy now-make no payment until next year [179].”
- “Present consumption is preferred to investment in (or conservation for) the future. Short-term rewards and punishments are greatly overvalued relative to long-term consequences in the calculus of decision making [180].”
- “Growth is good. GDP must always increase [181].”
- “Free-market capitalism is the best system. Communized costs, privatized profits [182].”
- “Paying less (for something) is better than paying more. Keep prices as low as possible by externalizing whatever costs possible [183].”
- “If it ain’t broke (yet) – don’t fix it. Collapse occurs long after an ecosystem’s carrying capacity has been exceeded. We don’t need to act for the sake of “uncertain” projections about, for example, global warming, ozone depletion, food shortages, etc. If it’s not my problem, it’s not a problem (e.g. social security, starvation) [184].”
- “Until scientists can prove a phenomenon beyond scientific doubt, society doesn’t need to act on it [185].”
- “Risks should be managed by the free market [186].”
- “Ecological threats are more like people (innocent until proven guilty) than like drugs (guilty until proven innocent) [187].”
- “Innovations (technological and others) can push back biological limits indefinitely [188].”
- “We don’t need to worry about unintended, negative consequences of technological “solutions”. The “next” technological breakthrough will solve the problem [189].”

- There isn't enough. My needs are more important than yours because we can't all meet our needs.

### 3.2.4.6 Potentials to Build On

Some examples of potentials to build on include:

- **Trade.** Ethical trading initiatives such as the UN Global Compact, supply-chain codes of conduct, the Fairtrade movement [190] and the worldwide Co-operative movement [191], the development of Corporate Social Responsibility (CSR) and the advancement of the Global Reporting Initiative (GRI).
- **Finance.** Initiatives in the finance sector include moves towards Socially Responsible Investment (SRI), the development of Equator Principles for sustainable finance, and the advancement of funding and infrastructure for micro-credit lending.
- **Governance.** “There cannot be a successful globalization without a successful localization” [192]. As such, global society should be focused on enabling local self-organisation to meet needs. “The growing interconnectivity among people across the world is nurturing the realisation that we are all part of a global community. This nascent sense of interdependence, commitment to shared universal values, and solidarity among peoples across the world can be channelled to build enlightened and democratic global governance in the interests of all” [193]. Over 60 years of United Nations multi-lateral peace building efforts, and the establishment of democratic process has brought global society to the point where the 1992 Rio Earth Summit and the 2002 Johannesburg World Summit could become a reality. Outcomes such as the Local Agenda 21 programme focused on implementation of environmental objectives, and the emphasis on partnerships for sustainable development arising from the 2002 Summit have generated significant awareness and a vast array of initiatives around the issue of sustainability. Such momentum should be harnessed, and people's energy, passion and commitment channelled towards a shared vision of the goal of sustainability.
- **Communication.** There is a growing international network of people practicing and teaching non-violent communication (using a language of empathy), searching for common ground, using mediated dialogue,

practising active listening, dynamic facilitation and other communication models in an attempt to foster a culture of genuine open dialogue. With regards to communications infrastructure, access to information and the ability to participate are key means to balancing power amongst stakeholders. Initiatives such as the Global e-Sustainability Initiative are working in partnership with the IT and Telecommunications industry to play its role in sustainable development, including bridging the Digital Divide [194].

### 3.2.4.7 Key Players

Addressing social sustainability is a significant societal challenge, and will require the involvement of many organisations, community groups, and citizens at large. The following highlights some of the organisations who will most likely need to play an active role in being part of any solution in this regard:

- *Equity.* Many international development agencies are actively working on the issue of equity, particularly UN agencies such as UNEP, UNDP and ILO, and non-government organisations (NGO's) such as the World Economic Forum, and the World Social Forum which aim to promote dialogue and understanding around the major complex issues of our time.
- *Trade and Finance.* The World Bank, the International Monetary Fund (IMF) and the World Trade Organisation (WTO) have a key role to play in influencing the conditions under which global trade is conducted. Equally, multinational corporations need to be engaged as key drivers of unsustainable activities, and key beneficiaries of the weaknesses of societal governance. Furthermore, member-based non-government organisations such as the World Business Council for Sustainable Development (WBCSD) and the Global Reporting Initiative (GRI) have a role to play.
- *Governance.* Tackling the issue of governance requires actively engaged leadership, democratic process and a participating electorate at each level, be it community level, municipal, national or global governance structures. Therefore, it requires everyone's participation, regardless of capacity as leader or electorate.

- *Communication.* The IT, telecommunications and media sectors have a key role to play in making the benefits of the technology revolution work for all, and enhance the transition to a sustainable society, however they cannot lead this agenda without active involvement on the part of civil society and national and local governments to enable this to become a desirable reality in communities.

### 3.3 Step C: Moving Toward the Vision

The second and third research questions ask:

- *“What are potential elements of a global vision of a sustainable future in terms of human activities, structures and paradigms?”*
- *“What are some opportunities for moving toward this global vision?”*

To answer these questions, this section starts by presenting an overarching global vision of a sustainable society where the System Conditions have been met. To guide solutions and actions, this overview is elaborated upon with second order principles focused on overall design and on seven key human activities. Identifying these guiding principles and looking at the results to the B Step (Question #1) helps to generate a brainstormed list of opportunities for moving toward the vision. To facilitate and provide ongoing support for these efforts in sustainable development, principles for structures at community, institutional and governmental levels are described. Finally, we propose paradigms or underlying assumptions that would stimulate and enable new structural changes needed to create a sustainable society.

#### 3.3.1 Global Vision of a Sustainable Society

*Our global societal goal is to no longer contribute to:*

1. *Systematic increases in concentrations of substances from the earth’s crust.*
2. *Systematic increases in concentrations of substances produced by society.*
3. *Systematic physical degradation of nature.*
4. *Conditions that systematically undermine people’s capacity to meet their needs.*

*The following society is envisioned:*

It seemed an impossible goal – a global society where people are able to meet their needs while at the same time ecological systems, biodiversity and the services that ecosystems provide are healthy, and regenerating. In

fact, continual improvements in the quality of life, air, water, and soil, amongst others are being experienced globally.

A shift in people's worldview seems to have been the key to reaching this goal. A worldview where taking care of the planet and each other became the driving force. Once that force started taking hold it became contagious and the incredible power of human potential emerged like never before. People everywhere began shifting human systems to more closely reflect and respect the eco-cyclic principles upon which all life functions, while they at the same time respected and understood the value of diversity, self organizing abilities and interdependence of all humans and societies around the globe.

The emergence of new institutions and businesses focusing on the socio-ecological conditions for a sustainable society facilitated the successful transition. They were also instrumental in stimulating the emergence of a strong and robust social fabric and the restoration of previously polluted and degraded ecosystems. Cooperation amongst all sectors of global society accelerated progress towards the common goal.

Basic human subsistence needs such as food, water, shelter and clothing is a right and no longer merely a privilege. People also have the capacity to meet all needs through a variety of culturally diverse ways. In fact, poverties created by unmet human needs are no longer a systemic problem (in other words, human needs no longer go unmet on a continuous basis) [195].

Society has completely changed its relationship to metals and minerals, so that neither is increasing in concentration in natural systems. Substances from the earth's crust are now treated as valuable, limited resources. Allowing any to dissipate is viewed as a problem that is continually being rectified.

Containing metals in systems where they can be used over and over again is far more efficient than trying to collect their dispersed atoms. Therefore, smart recycling systems are in place to ensure the reuse of all metals. Despite all best efforts, however, some metals can still dissipate through normal human use. Society has, therefore, phased out the use of scarce metals such as mercury, chromium, uranium, cadmium etc. in favour of those metals that are more abundant in nature. Similarly, society has valued

substances from the Earth's crust in a way that ensures reserves for future generations.

The majority of society's materials and products contain chemicals that are commonly found in nature and break down quickly. Occasionally, human made substances that are foreign to nature or are relatively persistent are still used, but in ways that tightly contain them to avoid dispersal. The chemical industry is cleverly discovering new ways of creating substances that are not harmful to society or ecological systems.

Agriculture and forestry rely on natural processes as well as societal systems for recycling of nutrients so that there is no longer a need for continual inputs of extracted minerals as fertilizer. Further, natural and holistic practices have significantly reduced or eliminated the need for unnatural pesticides, fertilizers and herbicides as well as antibiotics, genetically modified seeds and growth hormones.

Allowing carbon dioxide, mercury, sulphur dioxide and other greenhouse gases and pollutants to be dispersed through the burning of fossil fuels is an activity no longer practiced. Renewable energy from sustainable technologies now powers our activities. Further, conservation measures and smart technologies that minimize the need for energy have enabled greater human utility from energy.

Natural areas everywhere are revered and no longer subject to practices that result in degradation by physical means or through genetic or other forms of manipulation. Chemical and other unnatural inputs that were adversely affecting ecosystems and ecosystem services are no longer used or even needed for agriculture (including animal husbandry), aquaculture and forestry as these systems are now managed in ways that mimics natural systems and processes. Fisheries and forests are harvested in a sustainable way so that no more than the annual growth is taken. In other words only the interest is harvested and not its capital. Soil that takes thousands of years to build and contains incredibly diverse ecosystems, are protected from erosion, toxicity, compaction etc. through appropriate forestry, agriculture, and other societal activities and practices.

Society's buildings and infrastructure are planned and designed in ways that minimize physical encroachment on agricultural or natural areas. For example, intensification of development has resulted in the creation of

compact, pedestrian friendly and human scale residential areas that are integrated with commercial uses and places of work. Increased local production of food and other goods have reduced the need for land consuming, long distance transportation. Further, systems for moving people and goods are designed to minimize and in some cases enhance or restore ecological systems and processes.

Society has generally moved towards the provision of services rather than simply the provision of products. So for example, a company that manufactures and sells carpet may have transformed to a company that focuses on the provision of floor covering for its customers. The company is then responsible for the carpet through its life cycle including its manufacture, installation, longevity of service, removal and recycling so that its resources can be used again for the manufacture of new carpet. This focuses the company's attention on providing a service that is dependable and requires minimal resource or energy inputs while meeting their customer's needs. The customer then pays a fee for service [8].

All of society's activities were examined relative to meeting the global sustainability goal. This was done by identifying ways in which the activity was not complying with the conditions of a sustainable society by asking key questions such as: System Condition 1 – does this activity contribute in any way to increasing concentrations of substances extracted from the Earth's crust? This line of questioning was undertaken for each of the four System Conditions. This then enabled us to begin conceptualizing new ways of doing things that complied with the conditions of a sustainable society through a visioning exercise. Implementation was a matter of prioritizing actions that moved society towards sustainable activities.

A key strategy has been to dematerialize and/or substitute wherever possible. Dematerialization has led to an overall reduction of the amount of metals, chemicals and renewable resources needed for the same human utility. Through substitution, society has found ways to change the kinds of metals, chemicals and renewable resources used to meet human needs as well as finding different ways to satisfy human needs. These have been achieved by various means such as simply consuming less, designing goods to last, using fewer materials in manufacturing of products, reusing and

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<sup>8</sup> This is the kind of business model that Interface Inc., is working towards as part of its operations.

recycling, changing management practices etc. These strategies have resulted in the freeing up of resources for a more equitable global distribution [196].

Today's society is mindful that we are not separate from nature. We recognize that at the most fundamental level, the water and oxygen that flow through our cells and the atoms that make up our bodies are all part of the water, oxygen and atoms that cycle throughout the planet. Therefore, from a purely scientific perspective we are nature. As such, our human systems and processes are in harmony with the eco-cycles of our planet.

### **3.3.2 Guiding Principles**

The socio-ecological principles as minimum constraints tell us what not to do. They act as the boundary line providing a space within which to create our desired future. Within this “white space”, it is also helpful to have guidance for the creative process itself. With this in mind, generic and system- or activity-specific guiding principles have been identified to provide guidance as to what we can do. They essentially represent second order principles to the four System Conditions, and are not intended to be exclusive or sufficient.

#### **3.3.2.1 Overarching Principles for Sustainability**

The following are examples of principles that serve as foundations for action towards our global sustainable society. These are referred to as overarching as they apply to all aspects of society's activities and systems.

- Design is for long use, re-use, recycle-ability, repair-ability, resource efficiency. Also, human scale, appropriate scale, appropriate longevity, appropriate speed are important design criteria. Novelty is valued in the context of these design goals.
- Products and services are directly connected to meeting real needs and there is ongoing awareness and questioning of how well those needs are being satisfied throughout the design process and lifetime of the product/service. The concept of “enough” is widely discussed,

accepted, recognized and practiced; therefore, the need for creating a product in the first place is questioned up front.

- The focus is on service and flow models as in Natural Capitalism rather than ownership of goods.
- Cradle to cradle producer responsibility for products is commonplace.
- Emphasis is on building social capital in designing all human systems and products.
- The metabolism of society is designed to be cyclical.
- More abundant and easily biodegradable substances are substituted for scarce and persistent substances.
- Metals in products are recycled over and over again and designed for ease of recycle.
- Energy conservation and resource efficiency are the norm.
- Beauty is coupled with function and the above design goals.
- Long distance transport is limited to goods and services that cannot or should not be produced locally or regionally. Local control over resources gives residents a vested interest in its sustainable use.
- Gender equality and education for all are institutionalized. In addition to honouring the development of human potential, studies by the FAO and United Nations have found that “the higher the educational level and social status of women the fewer the number of children which is a potential solution to a growing World Population” [197].
- Nature is mimicked for design inspiration and know-how while honouring the intrinsic worth of all beings in the process and avoiding harm to animals and nature in general.

### **3.3.2.2 Principles for Key Systems and Activities**

Reaching the global vision means that many of our activities and systems must be adapted in alignment with the System Conditions. In addition to the overarching principles highlighted above, second order guiding principles are also helpful for various specific systems and activities in order to help guide appropriate adaptations. The following are examples of such guiding principles for those systems and activities that pose the greatest threat to global sustainability.

## ***Agriculture***

- The functions, biodiversity and integrity of soil ecosystems are maintained, enhanced and restored.
- Biological diversity is enhanced within the whole system.
- Organic waste from plants and animals are put back into the soil, thus minimizing the use of non-renewable resources such as phosphate and potassium.
- Agriculture relies on crop rotations and polyculture in order to avoid the need for unnatural substances such as pesticides and herbicides.
- Seed selection and collection is practiced to ensure genetic diversity.
- Compact planting and growing plants that are conducive to the climatic conditions (i.e. annual rainfall) that they are grown in as well as natural selection of seeds that have adapted to such climatic conditions is practiced in order to eliminate or significantly reduce the need for watering.
- Urban and rural agricultural systems are designed according to principles which integrate functions and uses of sites, including how the buildings, water flows, plants, people, animals and their activities/uses interconnect to make closed-loop systems in order to increase efficiency of land and water use.
- Lighter farm equipment, crop rotation, and increased reliance on perennials for food production eliminates the problems associated with soil compaction, degradation of soil ecosystem (through tilling) and soil erosion (through exposure).
- Solar energy and natural processes are relied on for nitrogen fixing in soils to eliminate the need for nitrogen fertilizers that are produced from fossil fuels.
- Solar energy that produces food through photosynthesis is the primary energy input that fuels human and animal labour to run farms (i.e. for cultivation, animal grazing and other farming activities).
- Food needs are met primarily through local production with any excess traded for non-native varieties. Further, overall excesses in some areas are used to supply areas that are not capable of meeting their population's dietary needs.
- Food packaging and containers are in continual circulation.
- Farm implements and equipment are contained within a closed loop system where at the end of their useful life their resources are recycled into new products.

- Animal husbandry relies on holistic principles that mimic the animal's natural tendencies in order to ensure animal health and to avoid the need for substances such as hormones and antibiotics.
- Land provided for raising cattle is balanced against land used for meeting nutritional needs of all people and preserving biodiversity worldwide.
- Arable land is protected from conversion to societal infrastructure except in rare or exceptional circumstances. Conversely, in some instances previously covered arable lands are reclaimed for agricultural purposes.
- Sustainable agriculture, relying on energy from the sun, is the primary supplier of society's food, fibres, lubricants, oil, fuel, medicines, and materials.

## ***Energy***

- Energy is conserved through thoughtful design to reduce transport and electricity demand (which saves money that would otherwise have been spent on providing new power plants, thereby enabling investments in renewable energy). Industrialized countries cut their consumption of energy as part of realizing global equity in sustainable resource use. International cooperation aids the replacement of wood and dung burning as fuel sources, and enables rural electrification within the constraints of the System Conditions to support sustainable development goals.
- Society's energy comes from renewable sources such as the sun, wind, wave, tidal, geothermal etc. provided that such system and infrastructure respects the sustainability principles.
- A mix of renewable energy sources utilizing the best local conditions (i.e. wind generation in windy areas, solar in sunny areas etc.) are connected to a common grid in order to provide a secure energy supply.
- Society's buildings, infrastructure, products etc. utilize smart design and technologies that minimize the demand for energy thereby allowing higher human utility per unit of energy.

## ***Forestry***

- The ecological functions, biodiversity and integrity of *existing* forests are maintained.
- The ecological functions, biodiversity and integrity of *forest plantations* or existing logged areas are enhanced, restored and then maintained.
- Sustainable harvest takes no more than the forest's annual growth such that only the interest is harvested and not the forest's capital.
- Selective logging is a preferred practice as it protects and maintains the integrity of forest ecosystems
- Forest plantations are relied on sparingly and if so, are managed in a fashion that is similar to the principles for agriculture
- Lighter forestry equipment eliminates the problems associated with soil compaction, degradation of forest and soil ecosystems and erosion.
- Forestry equipment is contained within a closed loop system where they are recycled into new products at the end of their useful life.
- Forests are protected from conversion to societal infrastructure except in rare or exceptional circumstances. Conversely, in some instances previously covered arable lands are reinstated with forest ecosystems.

## ***Fisheries***

- The ecological functions, biodiversity and integrity of fisheries are maintained, enhanced or restored.
- Sustainable harvest takes no more than the fisheries annual growth such that only the interest is harvested and not the fisheries' capital.
- Aquaculture that is designed to protect the integrity of local ecosystems supplements the demand for protein from aquatic species.

## ***Metals***

- Metals are contained in systems that do not allow any to dissipate and provide for ease of separation and recycling.
- Scarce elements are not used except in exceptional circumstances and in such cases they are carefully contained throughout their life cycle to avoid dispersal.

## ***Chemicals***

- Man-made substances mostly contain chemicals that are commonly found in nature and break down quickly.
- Substances that are foreign to nature or relatively persistent are used in ways that tightly contain them to avoid dispersal.
- Man-made chemicals must be proven to be safe prior to their use.
- Producers have cradle to grave responsibility for chemicals or products, using the “service and flow” model of Natural Capitalism and/or other innovations to enable recycling and dematerialization wherever possible.

## ***Societal Infrastructure and Buildings***

- Physical development is contained within existing built up areas through intensification and the establishment of neighbourhood commercial centres in order to eliminate sprawl.
- Land use planning and urban planning work with nature and pattern understanding. Integrating principles (such as those found in permaculture) are used to connect the flows of wind, sun, rain, snow, people, animals, etc. on a site into ecosystem-like relationships which encourage energy, water and resource conservation [198].
- The design of new or the retrofitting of existing buildings and structures utilize “green building” products and technologies (i.e. products that are easily recycled and employ minimal use of metals and man made substances especially the scarce and persistent ones).
- Landscape design mimics the indigenous landscape and as such requires minimal or no use of watering, pesticides, herbicides or chemical fertilizers.
- Trees, shrubs and herbaceous perennials providing energy, fuel, food, medicine, building materials, and wildlife habitat are integrated into landscapes.
- Planning regulations encourage compact, pedestrian friendly and human scale residential areas that are integrated with commercial uses and places of work. Social spaces and common areas are created to facilitate the meeting of relational needs.
- Agricultural land is protected from development.
- Floodplains and natural ecosystems are not disturbed.

- Storm drainage mimics natural processes so that water is put back into its natural cycle as quickly as possible.
- Rainwater collected off roof tops is stored for later use where practical. Excess water is shed away from buildings while allowing needed water to slow down long enough to soak into the soil. Ideally, water is slowed and stored near the top of the drainage system to optimize use of potential energy and gravity feed and is used as many times as possible from source to sink [199].
- Natural water bodies and waterways as well as their associated riparian areas and floodplains are protected from disturbance.
- Societal infrastructure is designed to minimize the use of water and as much as possible re-uses water on-site.
- Sewage and water treatment employ processes that minimize the use of chemicals.
- Where possible, human waste is dealt with upstream through such innovations as solar-pasteurizing composting toilets which do not require the use of water and which allow nutrients to be cycled back into the soil on site with minimal transport.
- Citizens are engaged in the visioning and planning of their communities.

### **3.3.3 Brainstorm of Strategies and Actions**

With the vision of a sustainable society in mind, together with the guiding principles identified above, the following section provides a brainstorm of strategies and actions (or steps) that can move society towards a sustainable vision. Rather than being prescriptive, these examples illustrate possibilities envisaged using the sustainability principles as constraining factors. The appropriateness of each action will vary among nations, governments, communities and individuals around the globe. The primary intent of this list is to illustrate the kinds of ideas that can emerge when a clear understanding of the goal is used to frame our thinking.

#### ***Agriculture***

- “Investment in, and diffusion of, agricultural science and technology that can sustain the necessary increase in food supply without reliance on excessive use of water, nutrients or pesticides” [200] or GMO’s.

- “Application of a mix of regulatory and incentive – and market – based mechanisms to reduce overuse of nutrients” [201]
- Careful preservation and dissemination of traditional agricultural methods appropriate to an area, and use of traditional design principles for conserving energy, land use and water such as those collected in permaculture design [202]
- Shift agricultural subsidies towards sustainable agriculture practices.
- “Use of response policies that recognize the role of women in the production and use of food and that are designed to empower women and ensure access to and control of resources necessary for food security” [203].
- Introduce perennial-based food production in open city spaces, such as growing fruit, nut and berry plants in parks and provide space for community gardens.

## ***Energy***

- Invest into the research and development of new photovoltaic, wave, photosynthesis, and hydrogen fuel cell etc. technologies.
- Identify areas where the greatest benefit can be gained from various forms of renewable energy production such as wind farms, solar, geothermal etc.
- Allow private energy systems such as photovoltaics, windmills etc. to supply energy to local electrical grids
- Encourage the use of sliding scale billing for utilities to encourage conservation. Under such schemes proportionately higher rates are paid by those who use more energy.
- Support the development of bio-fuels to power motor vehicles.

## ***Forestry***

- Shift subsidies towards forestry operations that are certified by the forest stewardship council.
- Encourage the establishment of community forests (i.e. management rests with local community).

- “Integration of agreed sustainable forest management practices in financial institutions, trade rules, global environmental programs and global security decision making” [204].

## ***Fisheries***

- Invest in aquaculture that focuses primarily on the production of non-carnivorous fish species.
- Support and enhance the efforts of the Marine Stewardship Council to move towards a sustainable global fishery.
- “Establishment of appropriate regulatory systems to reduce detrimental environmental impacts of aquaculture” [205].
- “Strict regulation of marine fisheries both regarding the establishment and implementation of quotas and steps to address unreported and unregulated harvest” [206].
- “Establishment of marine protected areas including flexible no take zones” [207] as a strategy to enable the regeneration of fish species and genetic diversity.

## ***Metals***

- Influence product design processes with the goal of dematerialization and substitution wherever possible.
- Develop a common coding system for metals to ease the recycling process
- Investigate ways to separate metal alloys for ease of recycling.

## ***Chemicals***

- Develop plastic additives that are not persistent.
- Encourage the phase out of persistent chemicals with funding for development of sustainable substitute chemicals and practices (e.g., in agriculture, pest control, etc.).
- Add the System Conditions to the Stockholm Convention to strengthen the international mandate to phase out all persistent synthetic chemicals.

- Expand university training in Green Chemistry and set industry standards aligned with the above. Promote biomimicry concepts.

### ***Societal infrastructure and buildings***

- Support policies that encourage the development of compact neighbourhood commercial centres and human scale densification.
- Consider the development of innovative transportation solutions such as fuel celled carbon fibred monorail that communities and major hubs within communities while another form moves people and goods within communities.
- Support green building design and technology that emphasizes for example natural lighting, water recycling, reliance on renewable materials, fibres, glass, abundant metals etc.
- Protect valuable arable land and support urban agriculture.
- Introduce naturescaping that mimics existing ecosystems in order to reintroduce natural habitat.
- Higher levels of Government, as well as regional or national planning organizations jointly produce sustainable community guidelines for use by local communities and planning bodies.
- Conduct evaluations to identify choice areas for various forms of sustainable energy production and distribution – e.g. windy areas for wind turbines, sunny areas for photovoltaics etc.

### ***Other***

- Awareness is key to shifting society towards sustainability and therefore should be encouraged to manifest through various mediums including:
  - Media and the entertainment industry
  - Schools and higher level education that focuses on the provision of transdisciplinary education
  - Research and development including partnership arrangements between government, business, NGO's etc. in order to comprehensively explore sustainable technologies
- Shift taxation away from people and towards resources, especially non-renewable resources.

- Introduce concept of double dividend taxation whereby, for example, a company that is taxed for its carbon emissions will have their employee taxes reduced proportionately
- Encourage loans for building retrofits that are paid back through energy savings.
- Use life cycle analysis in decision making for materials, production and construction techniques.
- Create a system for labelling all goods and services in accordance with the conditions for sustainability. By doing so, consumers can make informed choices which fosters the further development of sustainable goods and services.
- Legislation that requires producers, especially chemical producers, to prove something is safe rather than society having to prove something is unsafe.
- Landfill mining – although in many countries this activity is already being practiced there are a number of existing buried landfills around the world that contain metals, plastics, glass etc. that can be mined for their valuable resources. Such mining must be done with the utmost care to ensure worker’s safety and to prevent dispersal of materials. Further, such sites should be properly covered and refurbished.
- Adaptive management can be a useful tool for reducing uncertainty about ecosystem management decisions.

### **3.3.4 Supporting Change**

In order to implement these strategies and actions toward sustainability, our societal structures must support such change. All our structures, such as families, communities, clubs, nongovernmental organizations, churches, businesses, municipal governments, regional cooperatives, educational institutions, international organizations, etc. need to assist society in maintaining its overall vision within the constraints of the System Conditions. Within these societal structures, there are existing paradigms which significantly influence decision-making. These underlying paradigms therefore need to change, in order to build awareness and understanding of sustainability that will continually reinforce progress towards this goal.

### **3.3.4.1 Principles for Societal Structures**

The following second order principles explore how our societal structures might deliver ongoing health and development in alignment with the System Conditions.

#### ***Across All Levels***

The following principles apply to all levels of societal structure including communities, the municipal level and national or global structures:

- We gather and process information regarding compliance with the four Sustainability Principles to monitor our sustainability, and then feed it back into the appropriate systems for any needed redesign, re-planning, or celebration of a job well done. For example, our structures track how well human needs are being met, take stock of any needed resources, training, education, technology, human power (i.e. in disasters), etc. and orient self-organization and decision-making to respond with resources.
- Institutional and environmental governance at both the global and national levels are established and appropriately designed to deal with the coordinated management of common pool ecosystems and the services they provide.
  - We design our structures to be flexible enough to change to align with our changing understanding of what sustainability is, what our beneficial role within nature is, and what universal human needs are.
  - Physical structures provide healthy surroundings which encourage opportunities for humans to interact to get their relational needs met.
  - Our decision-making structures at all levels provide opportunities for people to engage in ways that meet their needs for participation and freedom.
  - Checks and balances exist in resource use planning to ensure that with limited pure drinking water, arable land, and resources to develop energy sources, all people are able to access what they need for subsistence.
  - Our structures support awareness of the present moment through a pace of activity which ensures time and space for self-reflection on the choices we are making and the reality we are creating from our choices.

- Governments at all levels (local, regional, national) are encouraged to engage citizens in the preparation of future oriented visions of a sustainable society.
- Dialogue is actively used as an instrument of change [208].
- Societal institutions at any level are driven by truly democratic principles and charters, and are self-regulating
- Democratic, transparent and accountable global institutions regulate abuse occurring as a result of global systems. Democratic, transparent and accountable local institutions regulate abuse occurring as a result of local actions
- The web of societal institutions hold individuals accountable, responding at the appropriate level based on the capacity or authority through which action originated (e.g. public figure, corporate role, citizen etc)
- Health care is preventive as opposed to reactive. By eliminating structures which undermine people's capacity to meet their needs and preventing the dispersal of toxic metals and man made substances, as well as practicing sustainable agricultural and animal husbandry, many health-related problems are prevented.
- A healthy society advocates the development of every person and of the whole person [209].
- Self-reliance should be encouraged at the individual, local, regional and national levels. "At the personal level self-reliance stimulates our sense of identity, our creative capacity, our self-confidence and our need for freedom. At the social level self-reliance strengthens the capacity for subsistence, provides protection against exogenous hazards, enhances endogenous cultural identity and develops the capacity to generate greater spaces for collective freedom" [210]
- "Only governments can set the framework for the progress necessary to reach sustainability by:
  - Acknowledging the situation, and working out a view of where they want to be in the next decades and putting into place policies that can bring us there. This requires a systems perspective rather than just "fixing problems" which often induces subsequent problems.
  - Combing the great engine of market economy with an economical framework that understands to utilize its effectiveness.
  - Recognizing the full economic value of the natural resources, in particular materials and land.

- Implementing a socio-economic system which is compatible with life and welfare; that is, a system without perverse subsidies and introducing taxation that reflects social and ecological values.
- Embedding this systemic approach into education and research.
- Agreeing on comprehensive indicators for adequate social, ecological, and economic performance.
- Supporting international trade in such a way that it is consistent with the required changes and with consideration of the need to bridge the gap between the rich and the poor in the entire world.
- Using their enormous purchasing power to these ends” [211].

### ***Global Level***

- There is an effective multilateral system for institutionalising fair globalisation [212] (e.g. The United Nations is reorganised and strengthened to perform this function.)
- Controls are in place to curb currency speculation and stabilize global markets. (E.g. International financial transactions are taxed with the Tobin Tax. [213])
- Global media is independent of corporate or political interests; its primary role is to support just and sustainable development by holding private and public social actors accountable for their actions.
- Third world debt is resolved in a fair and equitable way.
- Disarmament for World peace whereby all weapons would be phased out while at the same time an international police force made up of an equal number of members from each nation under a collective command would be set up in one or more regions of the Globe [214].
- Global flows of capital serve just and sustainable development of the public good as the goal.
- Corporate and private profit is a by-product of economic activity, not the goal of the global economy.
- Global rules of trade and investment hold corporations accountable to society, and enable nation-states to protect and reinforce local self-reliance.
- Global institutions are transparent democratic systems of interaction, with in-built self-regulation mechanisms for creating and maintaining balance of power, rather than accumulation of power.
- Global sustainability certification is standardized for goods/services.

## ***National Level***

- GNP and other monitoring tools are restructured to reflect concepts like Gross National Happiness<sup>9</sup> or human well being.
- With national support, local financial institutions are encouraged, created and supported in order to:
  - promote local creativity and support community initiative
  - encourage self reliance
  - encourage the maximum circulation of money at the local level
  - enable savers or generators of surpluses to decide on the allocation of their resources
  - be managed in a cooperative way by people in the community and
  - Be protected against any potential liquidity crisis through for example a central bank or other public banking agency [215].
- National policies support development of the “invisible sector” (i.e. micro organizations that have emerged primarily in third world economies in order to meet local needs). Support can be in the form of training programs, credit and technical assistance etc.
- The state encourages synergic processes at the local, regional and national levels [216].
- The role of state and of public policies is to identify, reinforce and to help multiply local initiatives in self-reliance [217].
- Key national indicators of success focus on the ultimate goal of sustainability, rather than the intermediate means (the economy).

## ***Community Level***

- Encourage the establishment of local food and other Co-operatives.
- Global society should be focused on enabling local self-organization to play a key leading role in development that is geared to satisfying fundamental human needs
- Resilient, diverse and self-sufficient local economies meet the needs of residents and build on the unique characteristics of the community to the greatest extent possible [218].

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<sup>9</sup> Refers to the concept of Gross National Happiness as used in Bhutan.

### 3.3.4.2 Paradigms for Sustainability

All societies are built upon a set of underlying assumptions that enable it to make sense of its world order. In order to create the structures described above, we may need to shed a number of basic assumptions identified in the B Step that are driving the unsustainable nature of society. The following provides a sample of paradigms that build a new kind of awareness and understanding to underpin strategies and actions driving society towards a sustainable future.

- **Everything is interconnected. The world is made of nesting wholes. There is no separation. We are nature.** What I do to ecosystems, I do to myself. What I do to you, I do to myself. We live in the reality of everything's interconnectedness. We play a symbiotic, interdependent, helpful role in the health and evolution of the planet and its ecosystems. We recognize the interdependence inherent in meeting human needs, and therefore strive to enable and support the health of one another and the ecosystems on which we depend. As individuals, communities, members of institutions, organizations and societies, we feel a sense of universal responsibility to promote and contribute to the common good. We understand life as nested systems of wholes, such as:
  - Cells *within* tissues, *within* individuals, *within* families, *within* communities, *within* ecosystems, *within* society, *within* bioregions and watersheds, *within* the global community, *within* the biosphere.
- **We create our own reality.** Humans choose where to place our attention, which determines what gets our energy and action. We focus that attention through the lens of an attitude which determines how we experience the world. Our perception of the world then shapes how we engage with the world – what we decide to act upon and how we decide to act (or not act). Therefore, where one's attention is placed and the attitude one is operating out of in any given moment is important to creating the reality one wants. As a corollary of this paradigm, we accept the importance of personal responsibility for what we are creating, and accountability for our actions. We recognize that what we have created in the outer world is a reflection of our inner world.

- **Presence, empathy and connection empower us to meet our needs. Treat others the way you would like to be treated (The Golden Rule).** Everyone likes to be truly heard and understood. Everyone wants to be treated with respect. Being sensitive to others and to what one is observing is valued as essential information to have clear communication, to understand, and to make good decisions.
- **Wealth is meeting everyone's needs.** In making decisions and resolving conflict, connection to oneself and others with creativity focused toward finding a way to meet everyone's needs is the goal. This is facilitated by accepting that there are multiple, abundant strategies to meet any given need. This awareness enables the stamina required to look for a win-win situation in any conflict [219]. "A change of lifestyle does not necessarily mean making sacrifices in terms of satisfying fewer needs. Rather, reversing the trend of deterioration in living conditions will be experienced as a positive rather than sacrificial development" [220]
- **Subsistence is a right.** Lack of the means for subsistence is recognized as both a cause and effect of environmental degradation in addition to being a huge barrier to achieving human potential [221]. Therefore, access to the means to meet one's basic subsistence needs (i.e. clean air, water, and food, warmth, clothing and shelter) is a basic human right [222]. Poverty is defined as the lack of meeting any universal human need over an extended amount of time [223].
- **Enabling self-organization and self-reliance leads to success.** Our structures aid people in self-organizing and achieving community-determined, co-created self-reliance. Success of individuals and of organizations of all kinds is recognized relative to their ability to enhance the capacity of others to meet their needs. Power and leadership are understood as facilitating one other to unleash creativity to meet the most needs with any given endeavour or strategy.
- **Democracy and co-creation empower people.** A direct and participatory democracy provides a solid foundation for good governance. Emphasis is on democratic, transparent decision-making processes where participation can occur more easily [224]. Power-

sharing, co-creation and equality are also favoured as opposed to having power over others in a hierarchical structure.

- **All life has intrinsic worth.** [225]
- **Love is more fun.** People recognize that doing things out of love, connection and compassion is more fun than doing things for any other reason. Society is motivated more by love than by fear. Humans deeply enjoy knowing that they are contributing to the enrichment of life. “Care for the community of life with understanding, compassion and love” [226].
- **We continue to evolve. Human potential is precious.** There is a strong planetary culture that advocates the inherent value of each human being and the desire for all humans to realize their full potential. Emphasis is on the development of social well-being and “intangibles” such as understanding, creativity, and equal justice, connection and quality of life rather than on the material side of life. Our planetary culture celebrates the examples of past evolutionary changes and works to continue the ongoing raising of awareness and human potential.
- **Ideas are to be shared.** For the mutual benefit of everyone, knowledge and technology are shared globally. “If I have one idea and you have one idea that we share then we each have two ideas” [227].
- **Sustainable economic paradigms.** “The economy is there to serve people and not people to serve the economy” [228]. “No economic process is possible in absence of ecosystem services. The economy is a sub-system of a larger system in which growth is finite and therefore, continual physical growth is an impossibility” [229]. Sustainable development can go on, physical growth cannot. “Growth is not the same as development and development does not necessarily require growth” [230]. “Development is about people and not objects” [231]. Social well being does not equal material well being. “There cannot be a successful globalization without a successful localization” [232].

## 4 DISCUSSION

### *1. What current human activities, structural barriers and paradigms impede global society's progress towards sustainability and what potentials can we build upon?*

When we step back and look at the whole system through the lens of all four System Conditions to see the activities that are currently unsustainable, three primary patterns emerge. The first is that we have structured society to meet human needs based on a growth paradigm which does not adequately consider the ongoing health of ecosystems or the sustainable functioning of society itself. We are currently hitting physical limits to growth due to the size of our population and our consumptive strategies for meeting our needs. The second pattern is that Agriculture, Energy, and Transport are nexus points where high magnitude violations of all four System Conditions occur. The third pattern is the extent to which we rely on domination-based power structures to meet needs. The result is a system that reinforces gross inequity through governance, trade and financial rules that systematically undermine people's capacity to meet their basic needs. The rich get richer (and more reliant on power and control to meet their needs), while the poor get poorer as their access to resources decreases.

These patterns are driven by the underlying paradigm that the economy is an end in itself, by the worldview that separates human beings from nature, and by the illusion that we need to dominate nature and fellow human beings and control resources in order to secure the capacity to meet our needs.

In addition to these beliefs, we have focused on consuming material goods to satisfy many of the nine human needs identified by Max Neef when this is not actually necessary or even optimal. Disproportionate consumption on the part of the world's wealthiest people occurs at the expense of the freedom, participation and even the subsistence of large portions of the world. Yet many in the "developed" world suffer from feelings of isolation, lack of community and unmet relational needs. Everywhere the gap between the rich and poor is widening. Advertising and other media reinforce the tension of this gap while privatization of the commons, free trade and subsidies often undermine local community self-reliance.

Taking a closer look at the main unsustainable human activities, our dependence on fossil fuels as energy sources for electricity, heating, and transport is one of our most pressing structural barriers. Transportation by gasoline combustion engine automobiles, including the associated materials use and infrastructure is another large contributor to unsustainability. Use of petroleum as a resource to make persistent toxic chemicals adds to the urgency of phasing out this energy source.

The need for sustainable energy sources becomes even more evident when we consider the 2 billion people who are currently without electrification and who therefore spend hours gathering fuels and carrying water. In addition, using traditional fuels for cooking and heating contributes to deforestation, CO<sub>2</sub> emissions, and health problems from indoor air pollution.

In the effort to meet electricity demands, use of hydropower causes land and biodiversity degradation, methane overproduction, and massive relocations of people. Nuclear energy does not provide a more promising solution with its radioactive waste and the potential for proliferation of nuclear weapons. On the other hand, if we used all our current global fossil fuel subsidies and energy related military expenditures on developing renewable energy, we could eliminate many of the current violations of the System Conditions.

The way we choose to feed ourselves presents another nexus point for leveraging change since current agricultural practices involve large scale fossil fuel-based mechanization, problematic chemical fertilizers and toxic pesticides in addition to long distance travel. Overdependence on animal proteins (cattle and fish) result in methane overproduction, forest clearing, eutrophication from concentrated faeces, freshwater and ocean ecosystems decline, land degradation and loss of biodiversity.

In addition to these three main activities, it is important to look at how we approach the design process. Unfortunately, creativity is often geared unknowingly toward unsustainable pursuits such as material-intensive building, creating sprawl with new construction rather than conserving old materials and land, and wasteful use of water and other resources through poor design and planned obsolescence of goods. Right now, corporate strategy is focused on product throughput rather than service and flow to dematerialize, or cradle to cradle product responsibility to enable recycling.

Just the fact that we have the concept of waste (solid waste, waste water, sewage, etc.) is revealing. It shows that we often do not recognize ourselves as part of nature's cycles and that we believe we are somehow not subject to the same laws (i.e. we can't throw something 'away' – there is no such place as 'away').

Throughout history, cultures have been eradicated and wars have been fought to control resources. Access to resources meant survival and territorial expansion meant perpetuation of one's culture and world views. Now we have entered an era where our survival is dependent upon cooperation and the recognition that we are all interconnected. The enormity of the problem calls for urgent, orchestrated action. Currently, the mainstream view is still that environmental problems are acceptable "impacts" for the benefit we receive from using resources. We no longer can afford this worldview. A full systems view with a clear understanding of sustainability is required to galvanize vision and motivation for rapid change.

Potentials demonstrate that progress towards sustainability is already happening. Examples include the introduction of renewable energy sources and the increase in public transportation; dematerialisation and substitution of products; recycling and the design of products for reuse, recycling and remanufacturing; organic polyculture methods, permaculture, biodynamic farming, and integrated pest management; self organization of communities for self-reliance.

Using foundational principles of a sustainable society, we discovered that much of the information available regarding our current reality focuses on downstream effects rather than upstream causes. As such, it is easy to get lost looking at detailed effects rather than the activities that are driving them. It is important to focus on driving activities, and to look even deeper into underlying structures and paradigms to enable change. Interestingly, by taking a step back from these detailed downstream effects, it reduces complexity and enables us to really question what our purpose is on this planet. It also frees our minds to creatively vision solutions for a sustainable society.

***2. What are potential elements of a global vision of a sustainable future in terms of human activities, structures and paradigms? And***

### *3. What are some opportunities for moving toward this global vision?*

Through this project it has become evident that the changes needed to move towards sustainability are not too complex to understand. What is difficult to overcome is overwhelm, fear and denial generated by a reductionist mindset intent upon focusing on details in an attempt to understand the whole. A systems approach, where the mechanisms of destruction of the system serve as design constraints, actually allows us to prevent unsustainability upstream.

Where access to upstream solutions is difficult, understanding the system and the goal enables us to choose lower leverage points and still be effective. Small adjustments to human activities can result in much larger ripple effects through the whole system. For example, shifting subsidies away from industrial agriculture can create opportunities for viable organic agricultural systems that could significantly reduce or eliminate the use of chemical fertilizers, pesticides, herbicides, genetically modified organisms, heavy farm equipment, techniques that cause soil damage and erosion, fossil fuels for long distance transport, etc. while at the same time contributing to the development of a strong local community and an enhanced social fabric.

The principle based vision that we created in question number two helped to facilitate the brainstorming of a list of actions for various major human activities. When we step back and look at the whole system, the pattern that emerges is that Agriculture, Energy, and Transport are nexus points where high magnitude violations of all four System Conditions occur. These are areas society can target for focused action to gain leverage in moving toward sustainability.

Having written the list of opportunities, it quickly becomes clear that some of them will require major changes of societal structures and the mindsets which created those structures. “A complex set of factors drives the search for new values. Both angst and desire—the concern about the future and its lure—play roles. Anxiety over ecological and social crises leads people to challenge received values. This is the “push” of necessity. At the same time, visions of a more harmonious world and richer lives attract people toward the new paradigm—the “pull” of desire. Together they lead to a revised notion of wealth that underscores fulfillment, solidarity and sustainability” [233].

Change needs to be addressed at all levels, and can be enhanced through the creation of networks and alliances of positive action amongst all types of players. The power of networks is evident in the highly globalized fields of higher education, the entertainment/media industry, the medical profession and the financial sector.

Nexus points for building awareness and changing values include education, information flows, harnessing the power of the media, using design as a leverage point, and stimulating self-organization in communities, NGO's and the private sector. City planning, as a place where agriculture, transport, and energy coalesce, could be a strategic intervention point. Other key aspects include the need to evolve governance to support community action, to build community self-reliance, and to develop practical examples on the ground. Conservation of diversity is a key component.

#### ***4. What are the strengths and limitations of this research?***

On first glance, this thesis may appear to be yet another collection of interesting facts from a range of sources. For example, the annual publication of the *State of the World Report* is a great resource for key trends that track the increasing impacts of unsustainable activities [234], the publication series *Global Change and the Earth System* offers a more scientific perspective on the state of the planet based on detailed research [235], and the *global scenarios* developed by the Global Scenarios Group and others explore how the societal journey might unfold as we respond to these issues [236]. Much work has already been done at the global level, yet we still appear to be drowning in information, starved of wisdom.

The core strength of this research project is the identification of major human activities that are driving current violations of the System Conditions, as opposed to focusing on the numerous and significant effects resulting from these violating activities. Cutting through this complexity to understand driving activities, enables a strategic approach to decision making that avoids trade-offs between effects and/or shifting problems into the future. Furthermore, the identification of nexus points highlights some interesting opportunities for high leverage intervention.

A key insight that emerged from the research process is the extent to which it is possible to get bogged down in understanding the problem of unsustainability, and therefore how important it is to focus on the vision and current potentials to find creative solutions. To this end, this thesis represents an overview or outline which can be built on by future research as more of these potentials and opportunities emerge. Equally, since we have focused on the major flows in violation, there is scope for adding information pertaining to the smaller flows to the overall body of knowledge.

Through this process, we discovered that understanding the goal of sustainability framed by the four System Conditions contributes great clarity to creating an overarching vision of a sustainable global society, identifying second order principles for guiding human activities, and brainstorming ideas and solutions. The most significant result was that through identifying the inspiring actions already happening in Question 1 and then writing a full vision in Questions 2 and 3, we each experienced a transformation of hope and promise that sustainability is truly possible. This really drove home how powerful it is to understand the goal of sustainability and to have a shared mental model for how to approach it. Furthermore, we experienced first hand the power of creating a shared vision. We now believe that it is not only possible for society to be sustainable but that our current situation creates a tremendous opportunity to forge a better global civilization.

Reflecting on the ABCD methodology, a practical issue arose during the research process in relation to Step C. There is a need to separate the creation of a vision, from the process of brainstorming actions (steps towards the vision). For practical purposes, the vision was referred to as C1, while the steps were referred to as C2.

A key limitation in this research is the fact that time constraints prevented completion of the D step. Planning at the global scale is a difficult undertaking; however it is no less important to prioritize efforts. We therefore recommend this as a topic for future research.

## 5 CONCLUSION

The perspective and structure provided by systems thinking in the A, B and C steps helped to make actionable sense of the complexity of global sustainability. The System Conditions gave clarity to the goal and allowed us to create a clear vision by developing second order principles to guide our activities. Backcasting from this principle-based vision enabled us to identify actions to move toward sustainability.

For future research, the next step would be to do an analysis of the D step at the global level to prioritize actions for global sustainability. Since prioritization at this scale is a major challenge, another area for future research would be to see if systems dynamics could inform our understanding in setting priorities. To this end, another topic for future research could be whether the D step would benefit from a fourth question: “How does this action leverage the system toward sustainability?”

In concluding this thesis, which aims to identify opportunities for global sustainability, one thing is clear. There is no silver bullet. There is not one action that will lead society towards sustainability, but rather a number of things that require participation from everyone at some level.

*“Problem solving belongs to the realm of knowledge and requires fragmented thinking. In the realm of understanding, problem posing and problem solving do not make sense since we deal with transformations that start with, and within, ourselves. It is no longer the “we are here, and the poor are there, and we have to do something about it, so let us devise a strategy that may solve the problem.” It is rather that “we are part of something that has to be transformed because it is wrong, and, since I share the responsibility for what is wrong, there is nothing that can stop me from starting the process by transforming myself.”*

*Manfred Max-Neef, Chilean Economist, 1991 [237].*

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