World Sustainability Series

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Sustainable Development, Knowledge Society and Smart Future Manufacturing Technologies

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Sustainable Development, Knowledge Society and Smart Future Manufacturing Technologies

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Preface

The third International Conference on Integrative Approaches towards Sustainability, titled *Sustainable Development, Knowledge Society and Smart Future Manufacturing Technologies* called “KNOWLEDGE” in short—was organised during 27–30 June 2012, in Jurmala, Latvia. It was among the early international attempts to contribute to the debate on how to link the “classical” issues of sustainable development and those about the development of a “knowledge society”, currently growing in importance at the EU level including starting up the Horizon 2020 research agenda.

In 1987, the United Nations World Commission on Environment and Development (WCED) also known as the Brundtland Commission published its report *Our Common Future*. It introduced the concept of sustainable development to the political agenda with an overall substantial impact on the way we perceive the world and how political systems globally redirect themselves, since the report was published. Its substantial and deeply transforming implementation, however, has still to a large extent, to be established. The report led up to the three United Nations Conferences on Sustainable Development, starting in 1992 with the Rio de Janeiro conference on Environment and Development (UNCED also known as *the Earth Summit*) followed by the Johannesburg World Summit on Sustainable Development (WSSD) in 2002 and the 2012 world Conference on Sustainable Development, also in Rio and called *Rio+20*. All these events have had a substantial content of knowledge development in the fields being central to the concept of sustainable development. In 1992, the focus was on the “environment”, in particular on climate and biodiversity. In Johannesburg, the focus of its “Plan of Implementation” was on research, education and technology. It led among other things to the 2005–2014 UN decade of Education for Sustainable Development. Finally at the 2012 Rio Summit, the focus was on the economy, in particular the so-called *Green Economy*, and the transition process to achieve a sustainable society was summarised in the document *The Future We Want*, the main conference report. It is in this context also worth mentioning that the Nobel Peace Prize was awarded in 2007 to the former US Vice-President Al Gore dealing with exactly these issues. Thus the Nobel Prize could also be regarded as a contemporary recognition of the importance of knowledge for world peace and sustainable development.

The key role of knowledge for development has a long background. Sociologist and management guru Peter Drucker identified knowledge (different from information) as a key economic resource in 1969, and in his 1993 short book entitled *Post-Capitalist Society*, he pointed at knowledge rather than capital, as a key resource for development. Despite the fact that the Internet was still in its pre-browser infancy in 1993, Drucker believed that the developed-world economies were entering a new *knowledge-based* era—a leap in civilisation as large as the one from the agrarian based to the industrial era.

This change was also recognised by the EU as it included the priority *Citizens and governance in a knowledge-based society* as a domain for research in the Sixth Framework Programme in 2002. A few years later, in 2005, the UNESCO-led Report *Towards Knowledge Societies* was published. The Report underlines the role a knowledge society will have to promote human rights and equity, and establishes the principles for forming an equitable knowledge society in which all people have equal, inclusive and universal access to knowledge.

Information and Communication Technologies (ICT) and Internet (World Wide Web) particularly have key roles to ensure that a knowledge society is functional. The speed at which data and analysis of data can be searched, produced and distributed has been dramatically increased. Data and the resulting knowledge are now available at the tip of our fingers in unforeseen quantities in all areas of science and social life. The role of universities, leaders and policymakers is to reduce the digital divide ensuring that everyone has access to the training and skills needed to access, use, manage and produce knowledge at any time actively.

It is obvious that this development is of great significance to our efforts to approach a sustainable society. Yet it is difficult to find any publications, documents or policy papers where the two concepts—knowledge society and sustainable development—are discussed, analysed and investigated together. A few recent policy documents from, e.g. the OECD points to this important crossover field. Nevertheless, a search on "Google" where both terms are used together gives only a few articles or editions of interest. During recent years, the UN University (UNU) has shown interest on this topic.

The present volume *Sustainable Development, Knowledge Society and Smart Future Manufacturing Technologies* is meant to contribute to an analysis of the role of knowledge society to achieve sustainability. It is based on the above-mentioned conference with the same name. It includes conference papers and articles from conference speakers as well as a few articles from invited authors.

The title of the book highlights sustainable development, knowledge society and smart future manufacturing technologies together, and will hopefully serve as inspiration for further efforts to understand how the interception between sustainable development and knowledge society issues could lead to a better future.

The content of the book is only a small and modest contribution to the interplay between sustainable development and knowledge society. It is the last one in a series of three complementary conference books.[1]

The team of authors has a plan to upkeep the Forum *Sustainable Development and Knowledge Society* in Riga for the future.

Autumn 2014

Arnolds Úbelis
Lars Ryden
Uno Svedin
Walter Leal Filho

[1]Integrative Approaches Towards Sustainability in the Baltic Sea Region, Ed.: W. Leal, A. Úbelis, Peter Lang Europäischer Verlag der Wissenschaften 2004. 556 p.
Sustainable Development in the Baltic Sea Region and Beyond, Ed.: W. Leal, A. Úbelis, D. Berziņa, Peter Lang Europäischer Verlag der Wissenschaften 2006. 700 p.

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Part I
Plenary Lectures and Invited Contributions: Sustainable Development, Knowledge Society and Knowledge-based Economy—Policy of Education, Research, and Technological Development

Challenges for Planetary Stewardship at the Entry of the Period of the Anthropocene

Uno Svedin

Abstract

In the long human history from the period of the use of stone ax tools and the agricultural revolution to the various phases of the industrial revolution from the 18th century and onwards all sorts of innovative approaches have been applied by humans for the sake of survival and prosperity. In earlier days the environmental impacts due to these solutions were limited—although not always locally or even regionally negligible as the example of hunting of big animals illustrates. Closer to our times the character of the solutions, their systemic connections and the global width of application has drastically changed the situation. Today it is not only the "classical" industrial manufacture of products that have environmental repercussions, but the entire support system for daily life which includes a global connectivity of food provisions and new kinds of energy solutions as examples. These illustrate the integrated cross sectorial nature of the challenge due to their character, intensity and global embrace. Indeed, humans have during the latest generation taken over as the prime driving force with regard to global environmental impacts. And the character of the transformation is accelerating. Thus we are quickly moving into a new historical era—sometimes called the Anthropocene. This confronts us with issues about the relation between actions at different scales—including challenges regarding the material base for society and its natural environmental embedding. This has been referred to—in risk handling terms at global level—to a concern for living

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within a safe space set by “planetary boundaries”. The interplay between the global macro level and other levels, not least with regard to governance and responsibility considerations, i.e. “stewardship”, is at the core of our current societal situation. Systems and resilience considerations are now coming into the forefront when approaching this key “grand challenge”. But also the societal distributional aspects increase in importance. The basis of our knowledge production and handling in connection to the expressed and used value systems are here of central importance when we have to face what stewardship at different scale levels from micro to macro might entail.

Keywords
Anthropocene · Complexity · Culture · European outlook · Future outlook · Global development · Industrial revolution · Innovations · Knowledge production · Long term history · Manufacture · Perspectives · Regions · Resilience · Scale · Solutions · Sustainability · Systems · Uncertainty

1 Humans Acting in the Environment—From Stone Ax to the Industrial Revolution

Humans have for tens of thousands of years deliberately manipulated environment to survive and prosper. This can be seen through findings of the early Stone Age tool technology items such as stone axes of various kinds—some of early remnants have been found in caves in parts of Africa, and similar tools of later origins have been found in the European region and elsewhere. These tools technologically are often very smart in design, e.g. in terms of the choice of the material or the design of the cutting performance. Later in history the types of tool functions (knives, axes, swords, etc.) were—as we know—produced using other types of materials as expression of the advancement of technology and handling of a wider range of natural resources (e.g., various metals as tin and copper and their alloys, iron and its alloys with other materials—all the compositions designed to improve the functions).

With the onset of the agricultural revolution in the Middle East and later in parts of Europe—an outflow of domesticated species (plants and animals) and practices from the Anatolian high plateau in present Turkey gradually stretched out. We, the humans, got a more stable provision of food, materials and functions than what was available through hunter and gatherer practices. The talk is not only about technology of the tools, but also about the ways they were used—including the kinds of activities related to hunting, fishing, agricultural (including forestry) and mining practices.

This means that the growing technical and organisational capacity associated with the accumulated knowledge has been of central importance. Not only did creation of the knowledge matter, but also its general geographical dissemination and transfer to future generations. Under a variety of environmental landscape, resources, and climate, the knowledge has started on the local and regional basis. (For further elaboration of the knowledge theme with regard to agricultural practices—and its relevance to the future see, e.g., Barthel et al. 2013).

But as time went by and connections widened through trade and warfare, the knowledge structure combined the regional capacities with a more general understanding and procedural capacities as we can see in the spread of agricultural processes and also in the sequence of uses of different materials for prestigious and other, more practical everyday items made e.g. of bronze in ancient times (found in such geographically disparate areas as the Baltic region and regions in the South of China as in Sichuan—see Bagley 2001) and by iron-based technologies to plastics and high-tech "nano"-technologies in our times.

The first association with the word "manufacture" in semi-modern times that might come to mind is the kind of industrial production that relates to the industrial revolution in the 18th century expanding from its centre in the UK and continental Europe. Sectors that might be associated with that development—and, in this context—over the last few centuries, are the energy-intensive iron and other metal products (at various levels of intensity and composition depending on the historical period we are talking about) providing industrial machinery such as engines, vehicles, and transport devices (as railways, railway engines, and other related devises, ships of steel, later cars and airplanes) and infrastructural products (as steel bridges promoting the transport of goods and mobility of people), high-rising building structures etc. (improving the centralisation of control from urban centres).

A symbolic manifestation of these types of actions—and capacities—by humans that easily come in mind is the Eiffel Tower built from 1887 to 1889—i.e., the year France celebrated 100 years from the beginning of the French Revolution and hosted the world exhibition in Paris. Thus, the Eiffel Tower was built as a symbolic exclamation mark to demonstrate what was now made possible under the skies by (then) "modern" technology.

In a similar way—and about the same time—the largest railway bridge at the time (with a lengths of as much as 2.5 km) was built in the UK 1883–90 over the wide water strait the Firth of Forth in Scotland. The bridge kept its world primacy for over 40 years (according to Wikipedia) and has today even been suggested to be on the UNESCO world heritage list. Again we see an example of the breakthrough of "modern times" when the human innovative capacity connected with "modern science-based technology" arose to make earlier impossible creations possible.

In the USA the construction of the Brooklyn Bridge in New York connecting Manhattan (with its emerging potential) with Brooklyn (i.e. one of the leading industrial towns in the late 19th century) could similarly be seen as a symbolic expression of material connectivity made possible in the "new modern Era" of the late 19th century. And the Golden Gate Bridge in San Francisco could be seen as an expression of how the industrial "manufacture" capacities drove westward in the USA. Not only bridges but also the tall buildings are children of the same type of capacities and their symbolic expressions—not only in Manhattan or Chicago, but also in a vast variety of cities—i.e. providing a vivid scenery which today is presented by the modern parts of Paris, Beijing, Singapore, or Rio de Janeiro.

During the 19th century we also see development of tools and machinery for industrial production of various sorts. Production towns such as Manchester, Detroit, Berlin, Hamburg, Mumbai and Shanghai might provide an image of a wide range of these types of activities over the centuries.

Of special importance were the new (19th century) innovative devices for agricultural use (such as iron ploughs and other agricultural-support items—and later tractors) that emerged around the 1850s. We also take note of the connecting technology to the industrial upgrading of agricultural products e.g. for the use of processing of grown fibres such as cotton for textile production at larger and larger scale—increasingly involving global trade, e.g., cotton import from India to Europe was made available. In this context the manufacture of industrially produced chemicals for agricultural use (such as artificial nitrogen fertilisers—but later also pesticides and insecticides of various sorts) are of importance, with its early initiatives in Germany as a starting point at the turn of the century around 1900.

Thus, the word "manufacture" alludes to the production of industrial capacities of the modern world, its urban skylines and the connection between the urban centres by land, by sea or later by air and, in our days, into space as far as to the moon and (still without humans) to the planets in our solar system. But it also alludes to the production of support for the agricultural practices that produce food for global markets. In this way the word manufacture also alludes to the full range of the system of "modern" production and consumption of products and services, including the international trade—of global reach—distributing the products and services according to the expressed demands from the global markets.

In earlier phases of the human history the trade routes also extended over vast distances (e.g. the silk route connecting the Mediterranean parts of the world with East and South-East Asia and vice versa), e.g. with one of its peaks during the Tang dynasty in China—more than a millennium ago. But it is not until the period of our very close to generations of the 19th century that the material magnitude of these flows reached such an enormous and expanding size—especially in the period after the Second World War—which Will Steffen and others (see e.g. Steffen et al. 2011 and references in that article) have named the period of the "Great Acceleration".

2 From the Onset of Sustainability into the Period of the Anthropocene

During the last few decades—especially after the UN Stockholm Conference on the Environment in 1972 and its follow-up at the UN Conference on the Environment and Development in Rio 1992—a growing concern has been voiced regarding the needs to highlight sustainability features of the manifestations of "manufacture", i.e. to develop new rules for the production and use of the well-known industrial products and associated infrastructural expressions—in terms of tools, constructions, vehicles, buildings, and other material manifestations and processes. In short:

it is high time to drastically upgrade the constraints (ecological, economic and social) connected to the production and also the use of the items of the "manufacturing" world. Likewise the same concerns relate to the impact of "modern agriculture" and other forms of land-use. These important sustainability features were in the Brundtland Commission thought frame (1987) outlined to be considered within the three-dimensional space of connected ecological, economic and social dimensions of the development—and with a long-term multi-generational perspective—and all being seen as a systemically combined set of criteria of central concern. This holds true both with regard to "urban" as well as "rural" expressions and the combination of both.

We are in fact already expanding such ideas—although the implementation is still too weak in relation to the tasks ahead. To some extent we are touching what, in a broader sense, could stand for "actions by humans in order deliberately to influence his/her environment" to improve the practices from the earlier preindustrial and industrial connotations facing our contemporary sustainability challenges. When we reflect upon a longer historical time perspective it seems that we are now moving into a rapidly changing environmental situation that may threaten to move humankind outside the earlier environmental conditions of long-term stability (corresponding roughly to the last ten thousand years i.e., the period sometimes called the Holocene, during which stability conditions, e.g., provided a frame for developing agriculture).

As there are recent and strong signs that suggest that we are uncomfortably and speedily heading into a situation where we might be moving out of the period of stable conditions, we should—even for the close future—distinctly start working to prepare to match the challenges of the possible emerging of the period of Anthropocene.

The characteristics of this emerging period during the last few years have been discussed (Crutzen and Stoermer 2000, 2002; Steffen et al. 2004, 2007, 2011; Richardson et al. 2009; Svedin 2009) especially in terms of being the period in the history of this planet in which humankind has grown in its influence and impact to be equal or even dominant in comparison with the size of the natural processes that always have been the dominant forces in earlier history (Vitousek et al. 1997).

Here we e.g. refer to the human influence on agriculture and food related material cycles as those of nitrogen and phosphorus, or the energy-related carbon cycle (of key importance for the climate change processes through the net flow into the atmosphere of carbon dioxide and other "greenhouse gases"). In a very long time horizon the "agricultural revolution" since around 8000 B.C. could be seen as a growing global impact of human intervention in planetary cycles, modest before "our modern times", not disregarding the serious earlier regional disturbances, e.g., in empires such as Mesopotamian (in current Iraq and Syria) due to what now could be identified as agricultural malpractice at that time. The human endeavour has thus during the last ten thousand years constantly explored the possibilities embodied in various environments for survival and sometimes even expansion, i.e. for the intentional instrumental use by humans.

In this expanded perception of what the "manufacture" type of production could be seen to be—i.e. indicating human production of material conditions and "commodities" for a constantly growing world population and with increasing per capita demand—the importance of sustainability conditions is quickly increasing. This especially holds true since humans, due to the growing size of interference in the planetary material cycles, become more and more responsible for the health of the planet and for life on it. The combination of production and consumption will have to find new forms. This means that attention will have to be increasingly paid to how "production" is structured, organised and ethically pursued. These concerns also have to include a wider strategic consideration about how a "stewardship of the planet" in the period of the Anthropocene should be conceived and operationalised.

3 From Rural to Urban Futures—and Back

Thus, during the entire history of humankind a basically rural existence, with towns being an exemption, have been transformed into a heavily urbanised world of today. Still the seemingly two worlds—the rural and the urban—are not to be observed in isolation but as a connected systemic whole. A didactical expression of that is found today in the dense forests of Yucatan in Mexico where the ancient Mayan monuments hiding in the jungle are shown to the tourists. These old monuments are reminders of a glorious Mayan civilisation and making visible the urban nodal points of times gone half a thousand years ago (and, as we know, of a civilisation being crushed by European invaders). If we follow the recent findings of vast ancient systems of waterways below the land surface created—"manufactured"—in old times to provide drinking water and probably also irrigation for agriculture, we get a vivid expression of an ancient rural-urban system—the strong touch of humans—once and for all seemingly gone forever. However, if we in addition to just watching the visual appearance of the jungle landscape also listen to the local experts on Mayan botany, they tell us that we still today can see the organising human touch from the composition of plant species and through other indications in the basically unmanaged forest over the half a thousand years. For those who have eyes to see and the knowledge that 500 years gone have not demolished the signs of structural features of the rural and urban systems of a past civilisation connected in a combined and very deliberate way.

Similarly, we have to consider the strong systemic connectivity between the rural and urban worlds (Svedin 2011a) of our time. This is especially true in a situation of the still continuing growth of the world population—and of the fraction of the urbanised population expected to rise from around 50 % today to somewhere around 70–80 % in the next half century. This will indeed put pressure on the whole system, but it does not mean a decreasing importance of the rural system that will have to support the increasing urban population. The increased load will rather demand responsibilities of the rulers of the urban world for sustainable solutions to be expanded across the vast "hinterlands" of the rural support to the urban life

(Seitzinger et al. 2012). This connectivity—of systems solutions and the governance responsibility—will have to find its embodiments at all kinds of levels of the geographic scale from the global (in terms of collaborative measures between the major mega-cities) down to regional and semi-local integrated approaches.

It also means that the urban space will have to take a share of the production of local food in new ways. By development of computer networks and new facilities to operate societal functions regardless of geographical locus, i.e. through new processes in the work life earlier distinctly attributed to urban activities—e.g., regarding knowledge production—will spread geographically into new patterns of labour in earlier distinctly "rural" societies, i.e. based on rural practices. This will be a challenge also for Europe with its specific geographical, historical, cultural, political, infrastructural and economic conditions.

The keywords for the future relate to "understanding complexity" and implementation of connected management, multi-level micro-meso-macro connectivity (Liljenström and Svedin 2005), sustainability solutions, and interwoven systemic collaborative urban-rural arrangements. In this perspective, the rural development is more than sustainable agricultural development. As the rural and urban issues are strongly linked, the social aspects have to be considered distinctly when reflecting on handling the environmental constraints at all levels in broader sustainability connotations. Recent studies of the role and features of the future of agriculture—especially in relation to food security and the related structure of the demand for such commodities—strongly point to both the environmental and the social considerations in the rural-urban nexus (IAASTD 2009; Bengtsson et al. 2010; The 3rd EU SCAR Foresight 2011; UK Government Office for Science 2011; FAO 2011; Svedin 2012).

4 The Challenges of the Global Environmental Conditions

The social and structural changes alluded to above will have to be disposed to a drastically and quickly changing environment, not least in terms of climate conditions but also with regard to other often related changes of different sorts. The impact of the human enterprise on the planetary conditions is already raising concerns. Earlier in the 20th century it was relevant to reflect and take actions on *local* sustainability conditions (even before the word "sustainability" was in use) of the local and regional realities. But—as expressed symbolically by the focus of the Stockholm UN 1972 conference on the Environment through its international emphasis—there is a new historical need to watch closely what has been called "a safe operating space for humanity" at the planetary level (Rockström et al. 2009a, b). In such an analysis—exemplified by nine selected domains of challenges—the degree to which humankind already has reached, or is about to reach, that could be considered as serious "boarders" or "thresholds" that should not be transgressed under a further pressure of continued or increasing human activity. Especially

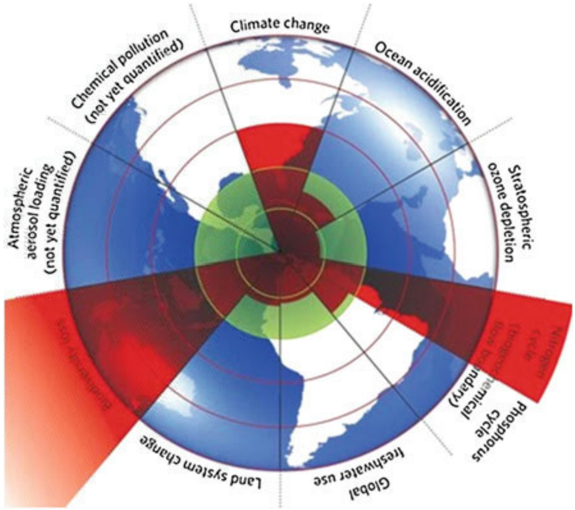

Fig. 1 Degrees of selected planetary risks (according to Rockström et al. 2009a, b)

critical issues in a broader historical perspective are the climate, the erosion of biodiversity and the nitrogen cycle. The chart in Fig. 1 provides an image of the state of the nine chosen categories. The degree of shading for the respective sector (from the centre out to the "risk periphery" represents the degree of human planetary involvement and related "risk") (Rockström et al. 2009a, b).

As emphasised in this analysis, the chosen issues are related not only to climate change, e.g. in terms of the overall change of the carbon cycle (with its close links to whatever happens in agriculture and forestry), but also to other cycles. In addition to the increasing importance of water conditions (in either "green", "blue" or other forms) (Falkenmark et al. 2009; Rockström et al. 2014), the nitrogen and phosphorous cycles have an integral relationship to agriculture—as does biodiversity (see e.g. Chapin et al. 2000).

With regard to the specific threats connected to climate change the IPCC report of 2007 (IPCC 2007) (enforced by the positions taken later in the IPCC reports presented 2013–14) provided an illuminative chart of a sequence of impact sectors (Fig. 2). The risk pattern of a specific "sector" is indicated through a multi-coloured vertical bar. At the bottom of the "bar" the risk is low and very high at the top. The interesting issue is how the risk panorama depends on the (vertically represented) state of global warming. In the lower part of the diagram the mean temperature is not considered to rise very much (+1 °C on global average) while the rise could be as high as 5°–7° at the vertical top level. The figure illustrates that problems quickly expand in almost all "sectors of impact" (top of the vertical bars) at a rise beyond 2°. One reason is an unpredictable increase of systemic risks when the rise of the global mean temperature exceeds 2°. The mean temperature increase is very sensitive to the degree of the possible emission reductions to the atmosphere that could be mobilised in form of deliberate countermeasures to the current rate of Green House Gas emissions. It is these potential reductions—especially with regard to the

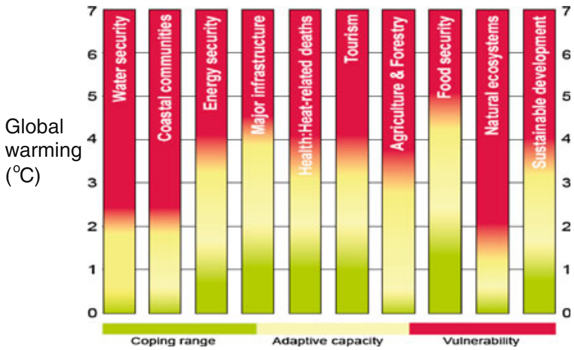

Fig. 2 The IPCC (2007) assessment of the risk panorama for global temperature increase distributed over a set of "sectors"

carbon dioxide emissions with the origin in fossil fuel use globally—that have to be implemented. This need was further empasized in the new update of the IPCC risk assessment in 2013–14, especially if the global mean temperature is expected to rise above the +2° level (for a set of scenarios) within the next half century, i.e. if the pace of the predicted change is faster than the tempo of implementing the current counter-measures.

Since the rate of growth of the global temperature depends on the counter-measures taken by humanity, the world policies—and their implementations—are of great importance. This holds true not least for already defined EU policies and their future implementation—striving for a low or zero net carbon outlet to the atmosphere by 2050—aiming to stabilise the global rise at the 2 °C level. Here efforts have to be mobilised to monitor the development, and to create model systems for transformation of the European societies by the policies and design of the political processes associated with these changes (COMPLEX 2012).

5 Regional Aspects in the Northern Europe—The Baltic Sea Region

The general issues alluded to above also have distinctly regional characteristics. With regard to the future potential climate situation in the northern region of Europe it is expected to be distinctly warmer and probably also characterised by more humid conditions. As with most of all future climate changes in general, more intense forms of weather driven phenomena are expected: storms and hurricanes, flooding—and also drought. Northern Europe will probably be characterised more by humid than dry conditions. This emerging general Northern European natural panorama combines with more specific features related to the Baltic Sea. One of these features is that of the eutrophication—mostly driven by the agricultural activities around the Sea. In addition, the outlets from sewage systems in most countries around the Sea also contribute to the water conditions. Fishing activities of varying intensity strikes the biodiversity situation in the aquatic ecosystem. This also holds true for industrial, especially the toxic, outlets of a number of sectors.

The kinds of outlets vary from legal to illegal kinds with a grey zone in between, such as outlets from marine vessels, from mining activities, and general types of urban outlets. Since the connection of the Baltic Sea to the North Sea and the Atlantic is fairly narrow, the conditions of the Baltic also depend on the streams and winds in the geographical interface areas, with considerable impact on the flows in and out of the Baltic Sea (Fig. 3).

Considering some of the flows already discussed above in the "planetary concern section", phosphorus (P) is a finite fossil mineral, which is mined for human use, and its use leads to increased amounts of P leaking into soils and from there into waterways, eventually causing pollution of the Baltic Sea. A major concern—highlighted in the article "Planetary Boundaries"—is the growing interaction, through human interference, of the nitrogen (N) and the P cycles. This interaction intensifies eutrophication (notably algae blooms) in rivers and coastal areas, as well as anoxia (severe reductions of oxygen levels in water eradicating aquatic life). Such challenges are well known in the Baltic (Zillén et al. 2008) and have been the object of considerable efforts at international negotiations and institutional platform designs, in an attempt to combat the problems during the last few decades.

Fig. 3 The watershed area around the Baltic Sea (Ref. The Beijer Institute at the Royal Swedish Academy of Sciences, Sweden). (For an overview of GIS information about the Baltic Sea Drainage Basin see e.g. Sweitzer et al. 1996)

How does this relate to the future of the Anthropocene with probably even stronger human impacts than the intense activities affecting the Sea today? The answer might be framed in terms of the balances of forces. On the one side the urban, industrial, sea transport, and agricultural activities might be even stronger than today. The demographic pressure of migration in the region could be stronger (due to various reasons of immigration: economical, political and environmental)—and the intensity of impacts might not slow down if the counter-measures are too weak. The political, economic and cultural connectivity however might become stronger in the future if a joint rational and wise governance effort is mobilised. The connectivity of all the EU states around the Baltic is already a sign of hope, although much more in terms of environmental protection and long-term collaborative actions to serve sustainability purposes is definitely required. But the emerging frame is there—and for the EU states the gradual step-by-step enforcement of common EU legislation and associated processes is under development, exemplified by the current implementation of the EU water directives.

A sense of common sustainability mission within the countries (including Russia) surrounding the Baltic to create common policy instruments, enhanced common institutions, and a broad cultural and economic understanding about the importance of common actions by the population around the Baltic Sea are needed. In a certain way the prospects here in this part of the world are much better than in others. There already exists a legal interstate framework and a high level of education in the involved countries. To some extent there is also a common history to be alluded to and a common economic interest not to ruin the biospheric basis by sloppy or illegal practices. Whilst the degree of future complications should not be underestimated, there exists a real need but also possibility for early and urgent action.

6 Challenges in the Period of the Anthropocene

6.1 On Complexity and Uncertainty

There are several major challenges entering the historical period of the anthropocene. The first deals with *the uncertainties connected with the nonlinear features* of the current socio-economical-cultural ecological system. The increased connectedness in that system provides all sorts of feedbacks and feed forwards opening drastic surprises. The uncertainties are of several kinds as has at an early stage been remarked e.g. by the late IPCC founder Bert Bolin. He considered three types of uncertainties that in different ways all relate to decision making. *The first* is due to present *insufficient knowledge* of various relevant systems that, in principle, could be addressed by further research. *The second type* is of a more complicated nature, but *although the detailed prognostic capacity is absent*, *there might be possibilities to make statements about a future "ensamble" of features of the system* in a probabilistic approach.

The third and most difficult group contains all those uncertainties that *are not reachable for prognostic statements in principle*. It might not always be easy to distinguish from situation to situation which of these types are at hand in a particular case. What could be said though is that, with regard to decision making, the three types will have to be handled in different ways. For the first category obviously more research is called for and also greater investments in the production of analytical knowledge. Here, also the connection between the research world and the decision making structures is important at various levels—from global to local.

This also holds true for the second category of uncertainties where it is important to find transparent ways to tell something about the nature of the limits, to make certain prognostic statements as an input to the dialogue between researchers and decision-makers. For the third category (intrinsically unknowable) the advice has to emphasise the need for development of flexible instruments and policies that could be mobilised when facing unknown events. Importance of finding ways to handle the different types of uncertainties increases in the period of the anthropocene. Here the interface between the system generating knowledge and the decision making world is of increasing importance (Svedin 2011b).

6.2 Biosphere Services

There are several specific issues that emerge in the context of the anthropocene. One deals with *the concern that capacity of the biosphere to continue delivery of fundamental services for humankind and to the rest of the natural world might be "eroded" by human action—knowingly or without really being sufficiently contemplated*. With the increasing human load on the biospheric system, the resilience issues are coming more and more into focus. Of particularly high importance is when considering the resilience of the whole system means to address the relationship between the societal processes and the changing flows and sizes of the natural cycles.

6.3 Systems Concerns and Resilience

One way to illustrate such features is to consider a specific system in relationship to its environmental context as a "ball" rolling in a constantly changing "topological landscape". If the landscape is tilting towards "the geographical left" (see the front part of Fig. 4), the ball is also rolling towards the left as time goes by.

If the landscape is changing by tilting towards the right as is illustrated in the back of the figure, the ball is moving towards the right. But sometimes the landscape is not flat as a plane but has features of "hills and valleys". In such cases the "ball" might find a (semi-) stable point. When the landscape is changing (i.e. along the dimension "conditions" in the figure), stability might be eroded and the earlier fairly stable situation is changed. Suddenly the situation has changed to such an extent that the ball just totally rolls out of its previous (semi-) stable conditions (see

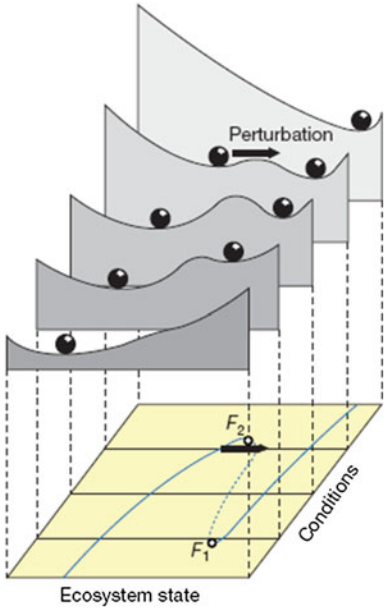

Fig. 4 Illustration of changes in the context of the "topological landscape" (see direction "conditions") and how they influence the features of stability conditions for a particular system (see distribution of the states—represented by "balls" in the "ecosystem state" dimension). (For an elaboration of changes in such a space see e.g. Folke et al. 2004). The figure can illustrate many different types of dynamic processes

Fig. 4). Here the resilience features depend on both the characteristics of the "ball" itself and on the surrounding contextual landscape—and their respective changes.

In the Anthropocene period onward, such "topological landscape changes" might be more frequent and potentially more drastic. The topological landscape of conditions in the Anthropocene might not be as smooth as earlier. The "ruggedness" of the topological landscape might be stronger—e.g., as an alpine mountain region differs from a landscape of smooth hills. This also means that when there will be changes in the new system of the Anthropocene i.e. when the "ball" starts rolling out of its earlier (semi-) stable position, it might fall quicker and steeper into the next valley—because the topological landscape looks more like a "mountainous landscape".

The increased load of global population (probably stabilising around 9–11 billion within a century) and its distribution over the earth might be seen as a facet of such a "changing landscape". The shift from a rural to urban population heading to 70–80 % of the global population dwelling in urban spaces is connected to the "topological landscape shift" (Seitzinger et al. 2012 and references in that paper). The shifts are going on in Europe, although the increase of the world population today takes place in other geographical parts. However, there are connections to the more general demographic panorama in terms of current and future migration into Europe and effects on the landscape of global production and consumption. Thus, global food security—affected by the climate change—will increasingly manifest itself in the European socio-ecological system.