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## Abstract

Increasing environmental challenges have led to the concept of the 'Anthropocene'. In a broad sense it denotes the period since the Neolithic revolution during which Homo sapiens has become a geological force on the planetary surface. More narrowly it refers to the period after the industrial revolution, especially since the 1950s, during which the effects on the environment from human activity have accelerated. In the Anthropocene the biosphere is deeply affected by human society and almost the whole physical world we encounter is man-made.

The Anthropocene leads to a number of 'Grand Challenges', most of them related to sustainability and social inclusion: Climate change, demographic change, exploitation of global commons (for example oceans, fresh water resources, soil, biodiversity), food security, poverty and increasing inequality. In many contexts in which these challenges are discussed, such as in the UN Sustainable Development Goals, the importance of institutional and technical change is recognized. Still the innovation and development research community have been slow to react. In this paper we argue that there is a kind of denial of the seriousness of the problems, which together with a lack of environmental ethics may explain why innovation studies in our opinion hasn't responded adequately to the serious innovation challenges raised by the Anthropocene. We argue that the much too vague and ambiguous concept of sustainable development has to be reformulated in terms of planetary boundaries based on scientific data and methods. This means that learning, competence building and development of innovation capabilities may be placed at the centre of the sustainability discourse instead of being a side-track as now.

**Keywords:** Anthropocene, Anthropocene denial, grand challenges, planetary boundaries, sustainability, environmental ethics.

## Grand Challenges

"The Times They Are A-changing" Bob Dylan wrote in 1964. They always are, in different ways, but now references to 'grand challenges' in the process of development seem to become more and more common. We are entering "the age of man", the Anthropocene, and a number of such challenges have to be met. They are of different kinds but above all related to sustainability and social inclusion: Climate change, population change (growth, age profile and migration), exploitation of global commons (for example oceans, fresh water resources, soil, and biodiversity), food security, poverty and increasing inequality.

Increasing attention to a broad set of values common for all humankind implies a broader and different notion of development with less focus on the economic competitiveness and growth of firms and national economies. Increasing and unrestricted global resource mobility (in terms of information and knowledge, trade, finance, investments, and labor-power) is not enough as the main driver of global development, as it is still often framed in mainstream economic and political thinking. In this paper we argue that there should be more attention to the need for both increased international cooperation including governance of the global commons and participation of a broader set of stakeholders than today.

The new and increasing challenges lead to changes in both policy-making and research. According to the UN Global Sustainable Development Report (UN 2015), the industrial policy consensus has shifted over time. Very crudely formulated: In the period from the end of World War II to the mid-1970s development was basically seen as industrialization and structural change.

After this followed a period to the end of 1990s in which stabilization and liberalization were emphasized and development was seen as fundamentally market-led. The dominant policy model was based on a limited state intervention and government failures were regarded as more problematic than market failures. Commonly known as the Washington Consensus, policies based on these neoliberal principles did, however, not produce the desired results. The World Bank, together with IMF the main driving organizations behind this development policy, concluded this in its Global Monitoring Report (World Bank 2005).

In the first decade of the present millennium globalization and the knowledge economy came into focus and development was to a large extent seen as driven by productivity growth through innovation. Industrial policy should accordingly be designed to support innovation both by top-down and bottom-up initiatives.

The emerging themes in the basic conceptualization of development in the 2010s are -the learning economy, and value creation in global systems of innovation and value chains. There is an increasing, but still rather restrained, focus on ecosystem preservation and different kinds of planetary boundaries for continued expansion of production and consumption.

This tendency is continued and accentuated with the UN Sustainable Development Goals. Environmental sustainability issues play important roles in 12 out of the 17 goals and the importance of institutional and technical change is widely recognized. The 17 goals imply major changes in existing structures and tendencies and they often refer to technical and institutional innovation as both necessary and effective instruments. The scientific background for these suggestions is, however, rather dispersed over the different departments and organizations that have participated in the preparations for the UN Sustainable Development Goals. There doesn't seem to be an easily accessible coherent scientific argument for the goals and their realization, but several countries are now developing statistics to follow the implementation of them. UNECE (2016) coordinates statistics to measure the progress, and it sees itself as a watchdog in relation to policy-making in this area in Member States.

When it comes to research about development leading international organizations like OECD, EU, and some UN divisions have argued for connecting it closer to big and often global social, economic and political challenges – Grand Challenges – as exemplified above.

An expression of these new ambitions in the EU context can be found in "The Lund Declaration" (2009). It calls upon Member States and European Institutions to focus research on the grand challenges of our times by moving beyond rigid thematic approaches and aligning European and national strategies and instruments. In spite of how deep and difficult the challenges are, the declaration is an expression of hope rather than despair. The tone in its formulations is positive regarding "Europe's ability to meet contemporary and future Grand Challenges and use knowledge as a tool to turn problems into opportunities and progress."

Another expression of the new research ambitions is 'Horizon 2020' (The EU Framework Programme for Research and innovation) in which there is a section on "societal challenges" which are described as:

- Health, demographic change and well-being;

- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bio-economy;
- Secure, clean and efficient energy;
- Smart, green and integrated transport;
- Climate action, environment, resource efficiency and raw materials;
- Europe in a changing world – inclusive, innovative and reflective societies;
- Secure societies – protecting freedom and security of Europe and its citizens (European Commision, n.d.).

A natural-science based expression of Grand Challenges has been formulated in a number of publications about planetary boundaries from the Stockholm Resilience Centre. Researchers have identified a number of "planetary boundaries" related to human-induced changes in the environment. These boundaries define a "safe operating space" for human activity. Crossing them is likely to cause irreversible and self-reinforcing environmental damage, ultimately destabilizing the Earth System and its complex interacting subsystems, the cryosphere, atmosphere, hydrosphere, biosphere and stratosphere.

The state of the safe operating space has continually been evaluated and four out of nine planetary boundaries are now thought to be crossed as a result of human activity: Loss of biosphere integrity, climate change, land-system change, and altered biogeochemical cycles (phosphorus and nitrogen) (Steffen et al. 2015). The Grand Challenge is to keep human activity within the safe operating space. According to Rockström (Rockström 2015) this is not impossible. Combinations of technical and institutional change can meet the challenge. Regarding institutional change development of global cooperation- and governance mechanisms is seen as crucial.

Another, often discussed, Grand Challenge is to produce food to the increasing world population in a sustainable way (Foley 2014, The New Climate Economy 2014). The food challenge has several dimensions. Not only is the world population expected to grow for the most part of the present century, but increasing incomes in developing countries will probably also lead to relatively increasing demand for meat ("meatification" of diets). This will put heavy pressure on the land since arable land is strictly limited. Furthermore, agriculture today is (increasingly) depending on artificial fertilizing, pesticides, insecticides, fungicides and fossil fuels. These things in combination imply that agriculture in its present forms is fundamentally unsustainable. To produce enough food in a sustainable way is becoming one of the Grand Challenges of our time.

To sum up: The examples above illustrate that the notion of Grand Challenges is becoming firmly established in the debate about long-term development. Furthermore there seems to be a wide spread belief that the Grand Challenges can be (more or less successfully) met by a set of radical and incremental institutional and technical innovations. This increases the need for research on the interconnections between innovation and development and may give innovation studies an important role in the discussion.

## The Anthropocene

All the challenges mentioned in the previous section are related to each other in different ways and they seem to be connected to an overarching "super-challenge" – the health of the biosphere in the Anthropocene. The complexity of the super-challenge is accentuated by the fact that the biosphere is an integrated subsystem of the bigger Earth System as mentioned above.

Humans have substantially affected nature for a very long time, in fact, ever since Homo erectus started to master fire (Glikson 2013). However, the Neolithic revolution led, with the cultivation of the soil, to an acceleration of humankind's interaction with the surrounding landscape and the accumulated impacts on the biosphere are enormous. The increasing environmental challenges have led to the concept of the 'Anthropocene'. In a broad sense it denotes the period since the Neolithic revolution during which Homo sapiens has become a geological force on the planetary surface comparable to volcanism, tectonism, glaciation, and weathering (Chesworth 2010, p.20). Crutzen (2002) was one of the first to define "the age of humans", but now there is already a whole literature including scientific journals dedicated to this subject. In the Anthropocene the biosphere is deeply affected by human society and almost the whole physical world we encounter is man-made – a domesticated reality in which direct experiences with nature have become rare (Vetlesen 2015).

In terms of climate and basic landscape characteristics we are now moving out of the so-called Holocene stability. This tends to make historical experiences with the relations between society and nature out-dated and largely useless. The Holocene as a whole has been remarkably stable with average global temperature staying within a range of 1°C. Only during this period the landscape has taken the form we know with different kinds of forests, grasslands, wetlands, rivers and lakes, fisheries, coral reefs, polar ice sheets, stable rainfall patterns and so on, which have been a precondition for all civilization.

Different criteria for the onset of the Anthropocene has been proposed, but there is considerable evidence that the domestication of several species of plants and animals about 10.000 years ago, which lead to agricultural development driven by social learning and to human modification of ecosystems on a global scale, marks a crucial starting point for the co-evolution of human societies and landscapes (Smith and Zeder 2013). It is also generally agreed that the scale and intensity of human impact on the landscape has accelerated since the industrial revolution and especially World War II (Angus 2015).

The Anthropocene dissolves the boundaries between nature and culture and as a consequence changes the very meaning of the notions of nature and natural environment and, hence, also the notion of sustainable development. In the debate there have been at least four different ways to react to the Anthropocene: One reaction is to say that it is already too late to prevent an ecological disaster and the best we can do is to prepare to adapt to the "end of a civilization" (Scranton 2015). The second reaction is to urge for a return to simpler forms of living supposedly more in harmony with nature. There may be some qualities in these two solutions to the Anthropocene challenge, but we doubt it and will not discuss them here.

The third approach is to embrace a new role for humanity as master and manager of the planet including the biosphere in which we all live. This way of thinking is of course not quite new. A well-known earlier example is Francis Bacon's ambition to establish *regnum hominis* on Earth by the methods of science. The argument today is that since ecosystems in the Anthropocene are already anthropogenic, i.e. hybrids of culture and nature, they should and could be planned and managed by society. Take climate change as an example. Scientists are already developing different types of "geoengineering" technologies, which, supposedly, can be used to reverse global warming (The Royal Society 2009). Carbon dioxide may be removed from the atmosphere in different ways. For example, carbon absorbing materials could be mined and spread out or tipped into the oceans and plants could systematically be grown to absorb carbon dioxide from the air. Another approach is to intercept or reflect some of the heat radiation from the sun. This might be done by spraying seawater into the air and by spraying sulfur into the stratosphere.

There are obvious problems connected to every one of these methods. Generally, the scale of the endeavors has to be quite big, which means that the costs may be very high. Furthermore, since the consequences would be global the projects have to be managed internationally. With uneven distribution of costs and benefits between countries this may

be very difficult. A third group of problems emanates from the high-risk character of the proposed technologies. We don't know for certain if it works and there may be unexpected and unwanted side-effects. Large hydrological effects (for example mega-droughts), accelerated destruction of the ozone layer, and changes of the carbon cycle have been mentioned in this connection (Nemetz 2015). The most serious risk, however, may not be technical but political: What happens if big geoengineering projects are untimely brought to an end by wars or other conflicts? If, for example, global temperature has been prevented from rising by aerosol spraying into the atmosphere while allowing greenhouse gasses to accumulate and then the reflection of heat radiation from the sun suddenly stops because of a political crisis, global temperatures may suddenly increase very fast. Nobody knows what this will lead to. In fact radical uncertainty characterizes the whole geoengineering approach. Furthermore, when the ambition is to take on "the design and management of novel ecosystems that provide valued ecoservices (e.g. carbon sequestration) yet bear little resemblance to historical landscapes" (Minteer 2012) the relations between human societies and their natural environments have changed so drastically that the very notion of sustainable development dissolves.

The fourth approach, finally, is to develop a broad spectrum, from incremental to radical, of technical and institutional innovations in order to preserve the Holocene stability. For example, if it is possible to describe planetary boundaries that define a safe operating space for humanity it may also be possible to describe and implement the innovations that can keep us within this space (Rockström et al. 2009, Rockström 2015, Steffen et al. 2015). The biggest problems to solve may not be technical but institutional and political. Rockström appears optimistic about the possibility of effective voluntary global governance to respect the planetary boundaries but the examples he gives are vague and rather empty. On the background of the present uneven global distribution of income, wealth and power this is not surprising.

Even if it is vague when it comes to institutional change and political action the planetary boundaries approach offers a way out of the deadlock situation of the "limits to growth" discourse. This discourse arrived at two types of limits: Biophysical and ethical/social limits to growth. The socio-ethical limits were neither taken seriously, nor refuted, so in a sense they are still on the agenda. The debate about biophysical limits lost momentum because it seemed abstract and negative and very long term, especially when it invoked the laws of thermodynamics as setting the limits: Low entropy is scarce and is used up in the economic process in which raw material of low entropy is transformed to high entropy waste. As long

as the deficit is paid for by the sun (as in the agrarian economy), there is no problem, but when it is paid for by vital ecosystems the privy is set on fire!

Not many people really doubted that it is impossible to go on indefinitely and in an exponentially increasing way to deplete raw materials and add pollution to the environment without destroying fundamental ecosystems and undermining the necessary material dimension of production and consumption. But it seemed unserious to rule out that innovation could cope with these problems at least for a very long time. Why can't the economic process become less and less material-intensive? Why can't waste increasingly become less dangerous and more recycled? Why can't synthetic materials substitute more and more for scarce raw materials? Why can't solar energy be utilized much more efficiently?

The notion of planetary boundaries has reintroduced the old limits to growth discussion in a much more concrete and less categorical way. The boundaries have become more specified and can to a large extent be quantified with the help of established scientific methods and existing or collectable data.

## Anthropocene Denial in Innovation and Development Research

To realize that we live in the Anthropocene doesn't necessarily mean that we accept it or want to react to it. Denial seems to accompany the Anthropocene at least in some countries and population segments. Not even supposedly objective and unbiased organizations like universities are free from a kind of Anthropocene denial.

In the field of economics, which most of the Innovation and Development community directly or indirectly belongs to, topics like sustainability, climate chance, inequality, migration and especially the relation between these are either absent in textbooks or at best granted minor appendices. After a few months students are expected to be able to explain how fiscal and/or monetary policy works by using a simple ISLM-model, but very few have any idea of the content in the UN Sustainable Development Goals and their connection to economic growth and development. Studying the relation between the economic system and the biosphere is not common among young student. This "Grand Challenge deficit" is mirrored in the relatively small volume of research at economic departments dealing with sustainability issues. This is not because of an information deficit, regarding how important planetary boundaries and the risk of transgressing them are for

humanity. It is rather a reflection of what economics traditionally sees as its main topic, i.e. what economics "is about". In the discipline of economics the main challenge remains how to achieve static and dynamic efficiency, i.e. how to allocate given resources efficiently and how to keep production and productivity growing.

Still, it is a bit puzzling, we think, that the "Great Challenge issues" are not more integrated in higher education in business and economics or, as a matter of fact, in innovation research. One reason often mentioned is the huge increase in enrollment of university students in OECD countries in recent decades. This has led to an increase in private funding of universities. Education in business and economics in most universities therefore tend to aim at jobs supporting and promoting growth and competitiveness of society and firms. In countries where universities are to a high degree publicly funded, politicians mirror this request; education should be "useful"; it should contribute to increasing economic efficiency, growth and productivity. Increasingly, higher education is considered as a factor supporting and enhancing competitiveness at all levels from firms to nation-states. A similar mechanism also holds, more broadly, for university research. Not only relative higher private funding but also demand from governments request research to support growth and productivity. As long as economic growth is the main political imperative, education and research will tend to prioritize it.

It is, however, too easy to blame the changing funding structure and the movement away from Humboldtarian universities as the only reason for the relative neglect of "Grand Challenges" in education and research. Increasing specialization in science may also play a role. When disciplines grow they tend to split up into sub-disciplines. Innovation studies are not immune to the trend in which scientific advancement is becoming increasingly specialised. Although innovation research is multidisciplinary in essence, it is now gradually aligning with logics and scientific quality criteria from mainstream economics and management studies. Anyone who frequents innovation studies conferences can observe a prevalence of papers that follow a standard formula: identifying a gap in the literature with space to make an 'original contribution', defining hypotheses based on prior literature on the same subject, testing these hypotheses statistically (almost always confirming them) and concluding the paper by reporting the result of the tests with no or little discussion of the wider implications or in which sense the results matter. In this way, innovation research is more and more driven by methods that are prioritized in high impact journals and by access to datasets, which allow for statistical analysis and marginal additions to an established research stream.

As an individual research strategy this approach has its merits. But in our view this too often leads to self-referential, method-driven research conversations rather than to a problem-driven approach attuned to addressing Grand Challenges. As innovation scholars very well know, a complex system cannot be adequately described by dividing it into subsystems. Murray Gell-Mann (2005), a Nobel Laureate in physics, more provocatively put it this way: ”People must get away from the idea that serious work is restricted to beating-to-death a well-defined problem in a narrow discipline, while broadly integrative thinking is relegated to cocktail parties. In academic life, in bureaucracies and elsewhere, the task of integration is insufficiently respected”. Too much emphasis on filling up holes in established bodies of knowledge implies that the great challenges of our time are not sufficiently confronted. Maybe Globelics Conferences and Working Papers should be more like scientific cocktail parties and less like repair shops?

Psychological and socio-psychological factors blocking for integrating grand challenges may also be important, especially those related to climate change. While most research on ‘denial’ has been on the level of individual psychology, e.g. how people develop different kinds of defense mechanism, Kari Marie Norgaard (2011) shows that from a sociological point of view denial is produced by social interactions affected by social norms. In many societies social norms urge you to be optimistic and maintain control. For many people this, from time to time, leads to feelings of fear and helplessness. The conflict between emotions and norms leads to emotion management strategies such as “don’t think too far ahead” or “focus on something you can do”. Another group of emotions is guilt and identity threats (fear of being insufficient as a person). People in the North may for example feel that they are responsible for global warming. Here (again related to climate issues) the corresponding emotional norm is to be proud (of what your country does). This contradiction leads to a strategy of perspectival selectivity: “we (my country) are not as bad as (all) other”; “we are a minor player in the game. It doesn’t matter what we do”. Although widespread in the population, Norgaard find these emotion management strategies used more frequently by educators, men and public figures. Besides the requests to deliver “useful” graduates and research, and beside the tendency to increasing specialization, we think that also teachers and faculty leaders are influenced by such socially constructed norms that lead to denial of the great challenges.

The Anthropocene denial we can observe in research and education is, of course, not limited to these realms, but, rather, a reflection of broader phenomena in society. A number of things may explain why society at large seems to lack the ability to react adequately to

the contemporary grand challenges. There are many examples of societies that have mobilized its resources to resist extreme danger for example in situations of war. But the dangers accompanying our trespassing of planetary boundaries are anonymous in character and advance rather slowly. This gives room for "landscape amnesia" (Diamond 2005, Vetlesen 2015). We tend to use the environment we grow up with as the norm against which we evaluate the environmental degradation we encounter later in life. We accept what seem to be reasonable small losses with the consequence that next generation starts from a lower baseline.

A further reason for Anthropocene denial is to fall back on false analogies to what may have worked before. One such false analogy is that since societies always have been able to solve their environmental problems before there is no reason doubt that this will be done also in the future. Technological advancements and resource substitution will be enough, and besides, there is no reason to rush into premature solutions since the environment always must be balanced against the economy. Jared Diamond (2005) shoves that this widespread belief is indeed false and gives many examples of environmentally induced collapses of societies.

Adequate responses to grand challenges may also be blocked by clashes of interest between different stakeholders and by the fact that the people who are in the strongest positions to react often are the ones who are least affected by the problem, at least in a short and medium term perspective. Furthermore standard reasons for suboptimal behavior identified in economic theory (such as free riding, prisoners' dilemma, and tragedy of the commons) may also block effective counteraction.

Finally, an important reason for inadequate response to the challenges which accompany the Anthropocene is that large groups of people tend to stick to old values, which may have been socially beneficial before but now turn into the opposite. Individual choice and maximization of consumer satisfaction at the micro level and highest possible economic growth on the macro level may have worked well as basic values supporting increasing levels of living as long as human activities didn't trespass the planetary boundaries. Now the same values tend to undermine adequate response to the grand challenges of our time. The value system in contemporary high-income countries is still underdeveloped in relation to the changes brought about by the Anthropocene. The need for an environmental ethic will be discussed in section 4 below.

One thing is why and how individuals as well as firms are pressed by both social norms and contexts of competition to disregard or even deny the great challenges of our time. Quite another thing is how and why the political system of a whole country fails to rise above the level of competing individuals and firms and meet the challenges. The responsibility to meet the great challenges is, necessarily, a political responsibility. It seems that this responsibility is avoided by national governments, that see themselves as pressed and bound by international competition and tend to pass on the problems to an, as yet non-existing, global level of decision-making.

## Environmental Ethics in the Anthropocene

The fourth way to react to the Anthropocene discussed in section 2 above (i.e. to develop a broad spectrum, from incremental to radical, of technical and institutional innovations in order to maintain the Holocene stability) lies, in our opinion, in prolongation of a learning and innovation approach to development.

However, in addition to the technical, institutional and political issues this approach also has to include ethical issues connected to the Anthropocene. When society and its natural environment become more and more intertwined and wilderness becomes increasingly scarce, new ethical issues are raised – but with a significant time lag. The American environmentalist Leopold (1949) argued that early ethics dealt exclusively with the relations between individuals. Then it gradually included relations between groups of people and cultural and political entities like nations. Leopold then observed that "there is as yet no ethics dealing with man's relation to land and to the animals and plants which grow upon it … The land ethic simply enlarges the boundaries of the community to in addition to people also include soils, waters, plants and animals, or collectively: the land" (Leopold 1949).

Leopold's land ethic may be seen as an early reaction to the Anthropocene in the sense that its sees people and societies as intertwined with and not separate from nature. According to Vetlesen (2015) the present difficulty of developing environmental ethics is related to a lack of awareness and identification of environmental problems. Vetlesen (2015) calls this a "denial of nature". Nature is becoming artificial and loses its meaning to many people: Humans do not any longer think of themselves as part of something bigger than us, but have become the masters, taking the services of nature for granted without giving anything back.

Anthropocentrism is a hallmark of the Anthropocene. Everything is seen from the perspective of humans. Nature has no value of its own. It is reduced to "natural resources".

At the same time environmental ethics is becoming more and more complex and there is now a scale of positions from pure 'anthropocentrism' to extreme 'ecocentrism' (Garner 2015). Anthropocentrism in this context means that environmental sustainability should be pursued only when it benefits humans. Ecocentrism on the other hand means that intrinsic values can be found in nature regardless of human benefits or even human presence.

To handle the proliferating and accumulating environmental problems an ethic for the Anthropocene needs to take on board at least five types of problems. First, we need environmental ethics to balance between anthropocentrism and ecocentrism in environmental policy and to define and defend animal welfare in food production. Second, since the costs and benefits of environmental change are unevenly distributed and much environmental protection has to be internationally coordinated, we need an ethic to address relations between the global prosperous and the global poor. Third, present generations of people need to engage more actively in a communication with imagined future generations. Taking up the perspective of future generations looking back at what we did to the biosphere may act as a moral constraint on present actions (Williston 2015). Fourth, the Anthropocene has developed into a situation where we have knowledge and capacity to interfere deeply with the natural environment but with unsatisfactory knowledge about the full consequences. We can't separate the workings of the socioeconomic and biophysical systems and we need an ethic to define acceptable and non-acceptable interventions in the systems (Williston 2015). Finally, we need to handle these ethical questions without preventing the innovativeness that is a precondition for keeping the systems within the planetary boundaries. The ethic for the Anthropocene needs to support creativeness and innovation as part of the solution and not as part of the problem.

Presently a narrative, which includes an imagined world of non-sentient animals, well-behaved climate change, super-resilient ecosystems, and very innovative humans, always able to solve all unexpected problems, seems to be part of the explanation for the inadequate environmental ethic for the Anthropocene. A combination of denial of nature and embracing the Anthropocene with bold geoengineering ambitions may not be a good mindset for sustainable development.

## Is the Notion of Sustainable Development Still Relevant?

There is a vast literature about sustainability and sustainable development. The notion of the Anthropocene has not yet affected this literature very much, but it is likely to do so in the future.

It is common to make a distinction between nature and culture (or society) and to see a tension between what is natural, i.e. untouched by man, and what is unnatural, i.e. interfered with by man. This is normally not seen as problematic. There are supposed to be reasonably clear and visible boundaries between nature and culture.

This is perhaps a bit astonishing on the background of the many meanings of the notion of nature. "Nature is perhaps the most complex word in the language"(Williams 1983). It can mean very different things. Sometimes it refers to the essential quality and character of something (the human nature, the nature of the bees, the nature of wood, the nature of football, etc.). Other times it refers to the material world itself, with or without human beings (as it is studied by the natural sciences). Very often it simply refers to a tract of land relatively untouched by human activity.

Especially this last meaning of nature – the parts of the world where human activities haven't significantly interfered with ecosystems or vital biogeochemical cycles like the carbon-, nitrogen- and phosphorus cycles – becomes increasingly vague as a consequence of the Anthropocene. It is a crucial aspect of the Anthropocene that the divide between the man-made world and the natural world dissolves. It is now almost impossible to find nature that is not affected by human activity. Ecosystems are anthropogenic.

Nature has been given different meanings in different cultures and historical periods. It is often ascribed specific characteristics, frequently including binary tensions and contradictions: On the one hand nature is good, pure, harmonious and balanced. On the other hand it is also vulnerable and threatened and it can be dangerous, powerful and even vengeful. Because of these double-sided characteristics we are often warned against tempering, meddling, tinkering, messing and interfering with nature. Things can get out of control and go terribly wrong when we act against a supposed natural order. More positively nature is seen not as a threat but as a challenge leading mankind to innovation and progress. In any case it is clear that nature is not just "out there" regardless of our viewpoints and attentions. It is a social construction that changes all the time accompanied by different discourses, for example a discourse of conquest, a discourse of hope and a discourse of fear (Hansen 2006).

Even if a clear dichotomy between nature and culture has never really existed it is also clear that an increasing awareness of living in the Anthropocene makes it more and more difficult to define what the term 'natural environment' means. Sustainable development is often described as including a social, an economic, and an environmental dimension, mutually reinforcing each other. Even if these dimensions are often pictured on equal footing and as equally important the Anthropocene makes it more and more obvious that they are not on the same level. For example, the environment can survive without the economy, but the economy needs the environment to survive. Without a healthy biosphere human civilization is not able to continue. If there is a substantial human influence on the life supporting systems of the biosphere the environmental dimension of sustainable development takes precedence over the economic and social dimensions. Since the Anthropocene implies that the natural environment can't be separated from human society at the same time as the human impact on the life supporting ecosystems becomes both more massive and difficult to evaluate, the alleged simplicity and sharpness of the most common notion of sustainable development (meeting the needs of the present without compromising the needs of future) goes out through the window. There is no simple trade-off between the alleged three dimensions of sustainability. The needs of the present are both vaguely described and disputed. The needs of the future are unknown and there is little agreement about what we want to sustain.

If we want to go on using the notion of sustainable development we need to acknowledge that it is an open and changing concept, and that it is hard, and perhaps not very fruitful, to find a precise and clear-cut definition. It is also necessary to explicitly introduce basic value premises in the discussion and be as clear as possible about what it is that we think needs to be sustained in sustainable development.

In an analysis of the sustainability discourse Holmes Rolston III (2015) identifies five different positions about what it is that should be sustained. The standard answer since the United Nations Conference on Environment and Development in 1987 is that development should be sustained ("*sustainable development* is development that meets the needs of the present without compromising the ability of future generations to meet their own needs") (Brundtland 1987). This definition creates an illusion of consensus: It is good to develop since it increases economic wealth and social welfare and the environment constrains that development only if a degrading environment undermines the ongoing development process. It is not difficult to agree to this and over 150 nations have endorsed sustainable development. Still, it is important to keep in mind, that in this way of thinking the economy

drives development and anything can be done to the environment as long as the economic motor is not put at risk thereby.

Very often in the economic policy discourse economic development is reduced to economic growth and sustainable development becomes *sustainable growth*. Especially in times when reasonably high employment can't be reassured economic growth seems to become an economic policy imperative. It takes precedence over everything. We can only hope that it can be green. In "green growth" growth trumps green.

The notion of sustainable development invokes the question of what is the best, or at least a reasonably good, development. Economists, or in fact any specific group of scientists, can't claim to have the answer to this question. An alternative approach is to define development as increasing capabilities and freedoms. Sen (1999) and Nussbaum (2011) have argued that development is about people's freedoms and capacities to live the lives they have reason to value. What should be sustained are the opportunities to develop our capabilities to live these lives i.e. *sustainable opportunities*.

The notion of the Anthropocene, the age of humans, has been accompanied by ideas and even claims of increasing capabilities to manage the planet. New technological capabilities should be used, not to save or preserve existing ecosystems, but to design them according to what we want them to do. We should not limit ourselves to sustain inherited landscapes. We should sustain rebuilt landscapes. Most concretely these ambitions are illustrated by the notion of geoengineering discussed above. Ambitions of planetary management and, more modestly, planetary stewardship implies that what should be sustained is the Anthropocene itself seen as the era when Man goes from just affecting the planetary systems to taking control over them – i.e. *sustaining the Anthropocene*.

## Concluding Remarks

If you (as the authors of this article) don't feel totally confident with the thought of geoengineering cowboys messing with Mother Nature, but still realize that the human impact on the planetary systems has grown relentlessly with potentially dangerous consequences for human societies, then a *sustainable biosphere* may be a reasonable guidepost for development. In the absence of capable biogeochemical planet managers human civilization depends on a healthy biosphere which can support the ecosystems, which basically support our lives. "Winds blow, rains fall, rivers flow, the sun shines,

photosynthesis takes place, carbon recycles all over the landscape. These processes have to be sustained." (Holmes Rolston III, 2015). Furthermore, a sustained biosphere is not only a basic imperative for the survival of human societies but also has values of its own, i.e. substantive values in terms of for example aesthetic experiences, biodiversity, and a sense of place and perspective.

The notion of a safe operating space within planetary boundaries referred to above is a way of connecting and combining a sustainable biosphere with development. The much too vague and ambiguous sustainable development concept may be reformulated in terms of planetary boundaries based on scientific data and methods. This means that learning, competence building and development of innovation capabilities may be placed at the centre of the sustainability discourse instead of being a side-track as now.

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