Towards Agricultural Change?

A Planet for Life 2012 focuses on agriculture and its relation to development, food and the environment. At the end of the 2000s, a consensus has emerged and points to the urgent need for massive investment in the agricultural sector, which is (once again) viewed as one of the prime engines for development and food security, as well as for poverty reduction. But what exactly does this consensus cover? While the idea of investing in agriculture is gaining ground and although several countries or regions appear to be offering opportunities for investment in agricultural land, debates are going on as to which agricultural models to choose and how agricultural policies should be implemented.

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At the crossroads of the challenges posed by development, food security and the environment, the transformation of the agricultural sector is at the heart of the global stakes of sustainable development. To help steer these changes towards greater sustainability, this book makes us aware of how crucial it is to also change our representations of agriculture, change the visions that guide projects for change and the policies regulating this sector.

- Papers by leading international experts and scholars
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As we enter the Anthropocene, the question of the impact of human activities, particularly agriculture, on the planetary system becomes more acute. What are the “planetary boundaries” and how can we ensure “a safe space for humanity”?

**GLOBAL CONDITIONS FOR THE FUTURE OF AGRICULTURE IN THE “ANTHROPOCENE”**

Current global agriculture and food systems are characterized by a failure to deliver food security for all, as illustrated for example by the effects of the present price volatility, which is severely restricting access to food for the poor, while simultaneously placing an increased strain on the environment. Addressing these challenges may seem daunting for a sector that has long been considered as conventional and has only recently made a return to the centre stage. However, it is essential that such challenges are vigorously tackled given the tasks ahead for the future agricultural system. There is thus a wide and growing consensus that a major challenge in the 21st century will be to produce sufficient food of good quality, as well as sufficient amounts of feed, fibre and fuel—all in a sustainable manner. As discussed in this paper, modern agricultural practices have contributed to the dawning of the “Anthropocene”, a new historical era characterized by the fact that human intervention, and not the Earth’s natural processes, is now the main driving force behind systemic changes (such as climate change, biodiversity loss, etc.). Accepting that agriculture is at the centre of human interference in natural cycles (phosphorous, nitrogen, water, etc.), this paper points to the need for deep reforms in agriculture and food systems over the coming years if we are ever to live within planetary boundaries (Rockström et al., 2009), by acting inside a “safe operating space for humanity”.

**LIVING IN A NEW GEOLOGICAL ERA: THE ANTHROPOCENE**

It is important to consider a relatively long timeline when discussing the possible...
future conditions for agriculture – and thus humankind – i.e. from the perspective of the next 50 to 100 years. At the present moment it seems as if we are positioned in a new and rapidly changing situation for humanity at a planetary level. Within this new period, human actions appear to run the risk of taking us outside of the frames of familiarity that we have learnt to live within during the last ten thousand years (often referred to as the Holocene). During this recent era, very favourable and unusually stable conditions have prevailed, allowing humans to develop and thrive. One expression of this stability is, for example, that it has been possible to develop agriculture as a major civilization innovation.

However, strong signs now suggest that we are heading into a situation where we are about to exit this established frame of stable conditions. Nobel Prize winner Paul Crutzen and others such as Will Steffen (Crutzen and Stoermer, 2000; Crutzen, 2002; Steffen et al., 2004, 2007, 2011; Richardson et al., 2009) have drawn attention to a simultaneous set of accelerating and interconnected phenomena in terms of global environmental change during the last half century, such as the degree of growth in the world’s population, the rate of climate change, etc. The origins of these processes seem to correspond with the beginning of the industrial revolution, around the middle of the 18th century, but show a clear and remarkable escalation after World War II. This suggests that we are facing major and ongoing – but sometimes insufficiently acknowledged – structural change. In qualitative terms, especially as this period has already been in existence for at least 50 years, it seems that we may now have sufficient understanding to decide that this new era warrants a new name, for which some scholars have already suggested the “Anthropocene”. As noted above, the key characteristic of this era is that humankind is providing the dominant influence on the planet’s mechanisms. This has never before been the case in the Earth’s history.

Anthropogenic influence – or interference – has now reached such a level that none of the natural cycles – carbon, nitrogen, water, etc. – are untouched by humans. In most cases human behaviour interconnects with and impacts upon these cycles to such a degree that they cannot be regarded as independent of the human sphere. Thus humans act at the planetary level as a collective causal force, strongly setting the stage for most of the Earth’s processes. However, this increased impact that humans are having on their environment has not yet been met by a corresponding level of responsibility (nor the institutional, technical or social capacity to face the task). The best example to illustrate this emerging situation is of course the climate change challenge. The Intergovernmental Panel on Climate Change (IPCC), which started its work at the end of the 1980s, has given a step-by-step assessment of the degree to which the Panel has considered human interference to be of distinct and visible character. This has provided very important input into the political discussions on if, and how, society should intervene through major actions in terms of
mitigation and adaptation measures. The decision facing society on whether or not to take action has been dependent on the level of consensus on the dominance of human influence as a cause of the observed climate change indications. If research shows that the human element accounts for a sufficiently strong impact, amongst the consolidated explanations, then this is strong motivation to strengthen countermeasures, especially considering the risks involved with continued emissions of greenhouse gases at the current level. The outcome is then in principle in the hands of humanity.\(^1\)

The latest (fourth) IPCC assessment in 2007 clearly showed that the influence of anthropogenic factors has now become clearly visible in the empirical data (see Figure 1). This IPCC diagram presents data on temperature change for the major regions of the world, while three graphs in the lower part of Figure 1 show different forms of global aggregates of the temperature anomaly from 1900 to 2000. The lower left figure provides the global average situation. The core interest is to reflect on how the results from two different types of climate simulation models compare

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1. Recent developments in the international negotiations on climate change show that action is beginning, at many levels and through a wide array of means, although not at the scale that the IPCC indicates is necessary.

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with the actual observations. The blue band shows models that only take natural forcing into account, while the pink curve also includes anthropogenic forcing. It is clearly visible that the results from the “combined” simulation models provide the most reasonable fit to the actual data. This relationship holds true for the aggregated data and also for each of the continental graphs.

It is therefore evident that not only does the anthropogenic aspect have to be taken into account, but also that from around 1950, the anthropogenic component of climate forcing has been significantly “boosted” (without allowing for this increase, the results of simulation models are unable to fit well with the observed temperature changes). It thus seems reasonable to conclude that we are indeed emerging into a new historical era, which justifiably earns the title “Anthropocene”.

The need for decisive action by the global community to address this situation should thus no longer be in doubt. It is essential that any scenarios for 2025 and beyond should take human-induced climate forcing into account.

However, it is insufficient to focus only on climate change, since the dawn of the Anthropocene is not only characterized by the degree of human influence in one natural cycle – carbon – but in many others as well. It is also particularly important to understand how the influence differs between the various cycles. The planet is a connected and combined natural system, within which the different natural cycles interact. This interconnection can be illustrated by the transfer of material (dust, surface water runoff, etc.) from land to the oceans. These transfers are feeding biological ocean life, which in turn provides a feedback loop to climate since the biology of the sea influences its absorptive capacity of carbon dioxide. This in turn changes the climatic conditions, which influence precipitation patterns over land and sea. These interactions, at regional scales, drive feed-forward and feedback loops between different natural cycles that are complex in character and are only just beginning to be explored by researchers, leaving the possibility open for future surprises. What is sure, however, is that the human influence on these interactions is growing, including the impact from agricultural practices. Nitrogen leaching from Scandinavian agriculture into the Baltic Sea, causing eutrophication, provides one such example. Another is the role of agriculture and forestry in influencing the carbon cycle in terms of carbon dioxide capture, storage and release under the different conditions found throughout the world.

TOWARDS A SAFE SPACE FOR HUMAN OPERATION
We have looked at the major influence of humans at planetary and regional scales with regard to natural cycles. However, these impacts – and potential options for deliberate interference in the natural systems – raise questions about the potential restrictions on how far humankind can, and ought to, interfere with these natural cycles. Such considerations for a number of interrelated processes, mechanisms and resources have been addressed in terms of finding the degree to which “a safe
space for humanity” could be outlined; or in other words: to investigate what the safe boundaries of interference may be, within which the risk of the occurrence of unexpected and excessive systemic shifts remains limited. The reason for focusing attention on this issue is the potentially grave consequences that may emerge if such conditions are not respected. The causal nature of many of these processes and their impacts are not fully clear at the moment. However, these phenomena have an inherent potential to drastically change key conditions for humankind, e.g. to exert a major influence on vulnerability related to reduced food security and other safety hazards.

In the abovementioned 2009 Nature article (Rockström et al.), the authors (which included the author of this chapter) addressed the question of if, and how, it would be possible to identify “a safe operating space for humanity” considering the Earth’s interconnected features and non-linear behaviour patterns. In this study nine connected issues were investigated – including climate change. Each investigation showed a detailed risk panorama (Figure 2). In three of the nine cases, humankind now already faces serious threats (i.e. approaching a global planetary boundary), which is shown in Figure 2 as red-coloured segments. The three problematic areas (i.e. that involve a high level of threat) are climate change, the nitrogen cycle and biodiversity loss.
Agriculture and the Planetary Boundaries

The three highly problematic threat sectors all have direct linkages with agriculture. In addition, agriculture is involved in, and dependent upon, several of the other factors e.g. the phosphorus cycle, global freshwater use and land use – either directly or indirectly. Thus the world’s capacity for food generation and the possibility for long term resilience in environmental services (related to long term food production and production of renewable resources) are under scrutiny with regard to the safe operating space. The connections between climate change and agriculture were addressed by the 2007 IPCC report, not least in the discussions around the risk panorama demonstrated in Figure 3 below. This was done for different sectors under various climate change assumptions (especially with regard to temperature increase).

We see that impacts worsen rapidly for temperature increases over 2 degrees (some impacts, such as coral bleaching for example, would be dire even before a 2 degree rise), while at even higher temperature increases there is a multiplication and intensification of the negative impacts. This observation holds true for the food sector, which would face issues such as a change in the productivity of agricultural soils even at relatively “low” temperature changes. The graph thus demonstrates that the “food sector” will need to develop a distinct adaptive capacity to cope with even “small” temperature changes. In addition, regional variations must be considered.
as they may provide even stronger shifts than global mean temperatures currently indicate.

Since discussions on the potential outlook for 2050 indicate that there is a considerable risk of experiencing a global temperature rise of at least 3 degrees in half a century, it is therefore clear that agriculture (including forestry) is severely threatened by climate change within the current century. Thus, this issue clearly constitutes one of the world’s major challenges because it pertains to global food security.

Regional climate shifts will also cause shifts in ecological zones with related movements in patterns of crop preferences, but also changes in the spectrum of biological hazards that affect crop and animal species. The erratic nature of these phenomena – and the diminished stability of conditions, including eruptions of unforeseen natural hazards – seems likely to increase. The social capacity to withstand these new conditions has not yet been developed sufficiently. Thus, the combined socio-ecological system shows a strong indication that its “resilience” will be eroded.

The issues are not only related to climate change, e.g. in terms of the overall change to the carbon cycle (with its close links to whatever happens in agriculture and forestry), but also to other cycles. In addition to water conditions (in either “green”, “blue” or other forms), the nitrogen and phosphorus cycles have an integral relationship to agriculture – as does biodiversity (see Chapin et al., 2000 for example).

The connection between agriculture and the water cycle is obvious – too little or too much water is very harmful and both these aspects are connected to climate change. In the words of Wolfgang Ritter referring to the European Commission SCAR foresight reports (European Commission, 2011) in connection to the 2011 formulation of the Budapest declaration on food security: “Water is being withdrawn at increasing rates, and the ratio of irrigated areas to population is decreasing. This means that food production in the world is increasingly dependent on rain, and climate change is reducing rainfall rates in many parts of the world.”

The nitrogen (N) and phosphorus (P) cycles are also essential for agriculture. On the human modification of the N cycle the “Planetary Boundaries” article (Rockström et al., 2009) states, and references that: “Human activities now convert more N₂ from the atmosphere into reactive forms than all of the Earth’s terrestrial processes combined”. This reactive N is used as fertilizer to enhance food production, but a significant portion of it runs off and pollutes waterways and coastal areas. This problem has not been addressed at levels above the local and regional.

Phosphorus is a finite fossil mineral, mined for human use, and its use leads to increased amounts of P leaking into soils and waterways causing pollution. A major concern – highlighted in the “Planetary Boundaries” article – is the growing interaction, through human interference, of the N and P cycles, which causes eutrophication (notably algae blooms) in rivers and coastal areas, as well as anoxia (severe drops in water oxygen levels that kill aquatic life) (Zillén et al., 2008).
The rate of biodiversity loss is another associated factor strongly connected to agriculture. Loss of biodiversity “can increase the vulnerability of terrestrial and aquatic ecosystems to changes in climate and ocean acidity, thus reducing the safe boundary levels for these processes. The current and projected rates of biodiversity loss constitute the sixth major extinction event in the history of life on Earth – the first to be driven specifically by the impacts of human activities on the planet” (Chapin et al., 2000).

LIVING WITHIN PLANETARY BOUNDARIES

In a presentation by the Swedish International Agricultural Network Initiative (SIANI) it was noted that agriculture covers 40% of the Earth’s total ice-free land area. It accounts for 70% of global fresh water use and emits more greenhouse gases than any other human activity. It employs three quarters of the world’s poorest people and feeds us all. It is the key foundation of human civilization and it is also where most of our present day development problems such as poverty, hunger, environmental degradation and climate change converge. Therefore, it is immediately evident that if we are to meet these global challenges, we must certainly address agriculture. There is thus a wide and growing consensus that probably the biggest challenge in the 21st century will be to produce enough food, feed, fibre and fuel, while aiming to stay within the safe operating space defined by the interconnected environmental dimensions presented above. Innovative research will be essential to make progress on the path of sustainable development to meet the five-fold challenge of growing more food, fibre and fuel on limited land, for a global population that continues to grow and exhibits changing consumption patterns. All this has to be achieved with less energy and less usage of other scarce inputs, while at the same time improving the resilience capacity of ecosystems and exploring all possibilities for adapting to and/or controlling climate change.

It is thus apparent that we need to learn to live within the planetary boundaries, and in order to do so we will need new forms of governance, a new economic development model, a strong knowledge and education pathway and creative changes in behaviour patterns – i.e. a celebration of creativity in a diverse set of forms. All these elements, and maybe others, are needed to transform the present agricultural system and to create a new role for the sector that is more strongly based on biological resources. In other words, to create a new global economy with more reliance on biological resources and ecosystem services.

The much-needed agricultural reform must consider the combination of agriculture, agribusiness and the new bioeconomy. It must implement an approach that is based on biological, physical, chemical, geological and geographical components, but also simultaneously drawing on knowledge mobilized by expertise from social science and the humanities that could illuminate various concerns about the development aspects, and the “human dimensions” of global change. This includes the cultural context that sets an important part of the frame for these endeavors. There is also a critical need for innovation – technical, but also societal and institutional.
Underlying all this has to be an ethos of concern for the service of humankind.

At a more “operational level” the following issues can be emphasised: the connections between different policy domains must be strengthened e.g. between the food and non-food sectors; there must be greater cooperation between the agricultural, energy, industry, and health sectors; and there must be better linkages between microeconomics and macroeconomics.

With regard to research and innovation, the following aspects are very important: the institutional organisation of research must be addressed, to take into account the various balance issues in the knowledge production system in terms of, for example, timing, financing and the development of human capital and the promotion of solutions that will be of service to the next generation. The importance of trust between the various actors involved connects to the need to earn public understanding and respect for the endeavour in the midst of normative conflicts and tensions between various stakeholders. The aspects of research, innovation, transfer, education and development need to be better linked and more carefully connected to policy.

THE NEXT STEPS, WHAT TO BE ALERT FOR IN A CHANGING WORLD – AND WHAT TO DO?

That the next half-century will provide exceptional challenges for humanity is a highly probable prospect supported by several foresight and other study types, such as the IAASTD report “Agriculture at a crossroads” (2009), and the Swedish report “Future Agriculture – Livestock, Crops and Land Use. A strategic programme for research” (Swedish University of Agricultural Sciences, 2010) or more recently from the UK “The future of Food and Farming” (UK Government Office for Science, London, 2011). There is less certainty, however, on how events will proceed in terms of the capacity to develop relevant and timely solutions, and in terms of the innovative mobilization of entire societies in order to provide the necessary support for the much-needed transformations. Perhaps humanity has the ability to mobilize itself – when on the brink of very serious consequences – to provide the required capacities for innovation and social transformation in an equitable, fair and sharing manner. But there is also the potential to find ourselves – or our children – in a situation of serious conflict, where individuals withdraw to their own “backyards” and show a drastically diminished consideration for whatever happens in the rest of the world – if in the long term such a posture is indeed possible. Perhaps such a strategy is feasible for the wealthy for a limited period, but natural or social events on a scale that is currently difficult for us to perceive, are likely to remove this option eventually.

It appears that agriculture will play an increasingly important role in future, and it faces a need to adapt to a society that must rely more on biological resources. This society must establish appropriate links between urban and rural environments, or the total global development pattern will not be functional in a world where a majority of people live in urban settlements. In this regard, there may also be new challenges for agriculture, such as for example, a need for food production to expand...
geographically into areas that we would now consider to be non-rural areas, i.e. into current and future types of urban settlements. Thus agriculture may emerge as a varied activity, with technological, social and management aspects, that will diversify into a pattern of symbiotic functions that perform the necessary tasks for the survival of the global population – both rural and urban; a population that will at the same time expand towards 9 or 10 billion people by the end of this century. The changes that will take place during that time are likely to not only be in terms of the size of the world population, but will also be in the form of increased needs and demands. It remains to be seen whether by the end of the century it will be possible to meet all of these emerging demands. Recent studies indicate that it might be possible to expand the use of as yet non-mobilized capacities in, for example, land use, direction of consumption patterns, resource efficiency, reduction of waste, etc. However, it is not known whether it will be possible to realize these potential responses due to social, economic, political and cultural challenges. The final verdict has not yet been written – and it will not be possible to consolidate for a long time. Much depends on the capacity to mobilize a spirit of knowledge development and innovation, but also to create the right conditions to enable the necessary transformation of a society facing the challenges of the Anthropocene.

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