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This brief series was developed in preparation for the Foresight Breakout Session of the Global Conference on Agricultural Research for Development (GCARD 2012) and the Global Foresight Hub[1]. The briefs were written to communicate to a wider audience, such as policy makers, civil society organizations, researchers, and funders. The briefs were classified into three categories: Future Studies, Regional Update, and Visioning.

What challenges is agriculture facing? Five scenarios for 2050

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"Treat the earth well: it was not given to you by your parents, it was loaned to you by your children. We do not inherit the Earth from our ancestors, we borrow it from our children." (Native American proverb)

Increasing awareness: From scenarios to major global challenges

The present and coming generations face a range of global challenges: food insecurity, health and nutrition concerns, uneven distribution of wealth and diminishing resources, climate change, environmental degradation. The challenges vary between geographical areas and nations, but many of them involve agriculture. How can we sustain and improve production of crops and livestock for a growing population in a changing climate, the consequences of which we cannot fully anticipate, while maintaining resources and preserving the global environment for future generations?

Several methods have been devised to discuss the future in a structured and scientifically organized way and to create and share pictures of the future. With a set of possible future scenarios as the starting point, our preparedness for tomorrow´s challenges will increase. In turn this can help researchers to formulate cutting-edge research ideas, and guide policy makers and funding bodies to support future oriented research.

With this in mind, researchers from different disciplines within the 'Future Agriculture' research platform at the Swedish University of Agricultural Sciences (SLU) initiated and led a foresight exercise.[2] SLU provided funding as a part of its strategic research investments (2009-2012). An expert group of researchers from several universities and research institutions was recruited for the process. Expertise was sought in agronomy, animal science, demography, economy, ecology, energy and environment, peace and development, soil science and veterinary medicine. Researchers from the Swedish Defence Research Agency (FOI) provided leadership for the scenario development.

Including the planning and reporting phases, the scenario work went on for 12 months, with three two-day workshops intertwined with literature reviews and synthesis studies.

[1]http://www.egfar.org/our-work/shaping-future-together/global-foresight-hub

[2]Future Agriculture – livestock, crops and land use is a strategic multi- and interdisciplinary research initiative in which researchers, together with industry, non-governmental organizations and other stakeholders, have developed a new research program to address the sustainable use of natural resources with emphasis on agricultural production, including farm animals, and land use.

"Morphological analysis" for scenario building

We constructed scenarios that took economic, political, technical and environmental factors into account, using the scenario development method called morphological analysis. Morphological analysis makes it possible to analyze complex and multi-dimensional problems including both quantitative and qualitative factors. It allows us to dissemble very complex problem areas into different components which are analyzed piece by piece and then combined into different scenarios. Morphological analysis leads to possible and conceivable alternative scenarios. Using a computer scenario tool developed for morphological analysis allows all the considerations made during the process of creating scenarios to be traced back to their origin. It also makes it possible to analyze connections between the different factors without having to fully understand the nature of causal relationships; however the future states of the various factors have to be compatible within each scenario. All scenarios are comparable since they are constructed from the same factors.

The factors shaping the global scenarios were: human population growth, distribution of power, economic development, climate change, natural resources, access to energy resources, development and dissemination of new technology, and consumption patterns. We then developed five contrasting and conceivable scenarios using morphological analysis. The scenarios have a time horizon of 40 years (2050). This long-term perspective was chosen in order to seek new research issues and directions within agricultural research requiring competences and structures not yet in place. It also covered the time span for the students we educate today to become professionally active.

The scenarios were called 'An overexploited world', 'A world in balance', 'Changed balance of power', 'The world awakens' and 'A fragmented world'. We first drafted these scenarios from a global perspective, as seen below. Each scenario was further developed focusing on Europe. Four of them were also later developed for sub-Saharan Africa.[3]

An overexploited world. The climate is changing dramatically, with average global temperature projected to increase by 4-5˚C (1990-2090). Population growth has exceeded the UN forecasts and the population is 11 billion. The USA dominates the political and economic scenes. The Western world is achieving strong economic development but poverty prevails in large parts of the world, where poor food security results. Energy consumption is high and there are no strong climate policies. The demand for land resources is high owing to the increased world population and use of biofuels driven by energy security concerns. The land areas being used for agricultural production and livestock grazing expands. Soil fertility, water resources and ecosystem services decline as the result of overexploitation. As a result, food security is negatively affected.

A world in balance. Population growth has been slower than the UN forecasts and we are now 8 billion. Climate change is modest due to reinforced and efficient political activities; the increase in average global temperature is projected to remain below 2˚C (1990-2090). Economic development is strong in many regions of the world. Powerful intergovernmental actors are reaching global agreements, for example about environmental issues. Rapid technological development in many sectors, including energy and agricultural, together with a wide and even distribution of new techniques, is a prerequisite of this scenario. Thus, pressure on land resources is relatively low. Soil fertility, productivity and the availability of ecosystem services are increasing. Urbanization is high, but rural areas are also flourishing as a result of the development of businesses that are not dependent on proximity to cities. Overall, global food security is likely to be relatively high in this scenario.

Changed balance of power. The global balance of power has been displaced towards India and China, where economic development is very strong. The global economy is characterized by deregulation and free trade. Global population growth has dipped below UN forecasts (8 billion in 2050), mainly due to rapid economic development in Asia slowing population growth. Political commitments regarding climate and environment are limited and global average temperature is projected to increase by 4-5˚C between 1990 and 2090. Fossil fuels (mainly coal) are readily available, and the prices are relatively low. Rapid technological development has led to new methods of production in many countries. The total agricultural land area is about the same as at present, but is being displaced towards the poles and the equator in response to climate change. The consumption of animal products has increased globally. In this scenario, global food security is relatively high but there are regional variations, with some areas where food security is low, mainly as an effect of climate change.

[3]Magnusson, U., Andersson Djurfeldt, A., Håkansson, T., Hårsmar, M., MacDermott, J., Nyberg, G., Stenström, M., Vrede, K., Wredle, E., Bengtsson, J. 2012. Critical research issues for future sub-Saharan African agriculture. Swedish University of Agricultural Sciences, Uppsala (ISBN 978-91-576-9090-6).

The world awakens. After many years of limited commitments regarding environment and climate, the global community finally agrees on efficient policies. Global average temperature is projected to increase by 2-3˚C between 1990 and 2090. The balance of power is distributed among several centers: Brazil, China, Europe, India, North America and Russia. Population reaches the UN forecast of 9 billion in 2050. Environmental and human rights organizations have a more influential role. Fossil fuels and other energy sources that do not require land resources dominate, but forceful climate policies limit emissions. Environmental ambitions are high, so the rainforests are protected from deforestation. The availability of external inputs for agriculture is low, and prices are high. After an initial decline in food security globally, strong policy measures are subsequently reversing this trend.

A fragmented world. Population growth is high and exceeds the UN forecasts (11 billion in 2050). Global average temperature is projected to increase by 4-5˚C between 1990 and 2090. Due to weak intergovernmental actors and an absence of dominant nations, power relations are unsettled and international negotiations often fail. Private companies dominate the market. Technological development is slow and the distribution of new technologies is uneven. Fossil fuels (especially coal) dominate the energy market. The high food demand increases the need for agricultural land. Water resources are scarce, and soil fertility and ecosystem services are decreasing. The consumption of animal products is low globally as a result of resource scarcity and poverty. Global food security is relatively low and varies with local, national and regional conditions.

Expertise of researchers, involvement of stakeholders

Three stakeholder workshops (each comprising 25-30 participants) followed the scenario work, bringing together representatives from the agricultural sector, governmental authorities, non-governmental organizations, and young and senior researchers. The participants represented different areas of interest and had not been involved in the outline of the scenarios. They discussed challenges, opportunities, knowledge requirements and research needs related to the scenarios. Some of the members of the team who had drawn up the scenarios analyzed and synthesized the results from these workshops at two separate working meetings. They formulated six overarching social and biophysical challenges and identified 37 issues, which laid the foundation for the Future Agriculture - Livestock, Crops and Land Use Research Program.

The six challenges where more research is needed are:

1. Reducing the environmental impact of agriculture and mitigating climate change;
2. Adapting agriculture to a changing climate;
3. Managing present and potential risks (e.g. extreme situations and pandemics, new technologies, resilience of production systems);
4. Responding to societal values and contributing to policies (e.g. different stakeholders' ethical concerns related to food production);
5. Linking agriculture and rural development (e.g. interrelation between rural development and agricultural land use, ownership, governance of natural resources);
6. Resolving conflicting goals of agriculture and land use.

Most of these are highly relevant for all scenarios. Within each challenge, six or seven more concrete research issues/questions were identified. These include:

- o What are the environmental and climate impacts of structural changes in agriculture – specialization versus integration, small scale versus large scale, and geographic localization?
- o In terms of ecosystem services, which functions do different species and biodiversity have in present and future production systems? (relates to climate change adaptation)
- o How do urban and rural areas interact through flows of natural resources, goods, energy, ideas, capital, people and means of transportation?

Shaping policies

The researchers involved in this work have been invited to give presentations at an international policy level – for example the European Union's Standing Committee on Agricultural Research and the Nordic Council of Ministers meetings – as well as

nationally (Sweden), e.g. the Ministries of Rural Affairs and Environment, and Parliamentary Committees on Education and on Environment and Agriculture. The results fed into the work concerning the Swedish Research Bill (to be presented late 2012), and to national research councils and foundations. They had also some impact on SLU's new university strategy. National representatives presented and distributed the Future Agriculture Research Program, which is based on the scenarios, at European meetings leading towards the new European Commission Research Priorities Horizon 2020.

The research program has resulted in a large proposal jointly with biotechnologists and ethicists on "Biotechnology for sustainable and competitive agriculture and food systems" that has received 12,000 USD for a 4-year period (2012-2015). Several smaller research projects have also been initiated and funded.

A scientific panel (three scientists from Denmark, Norway and Finland) and a stakeholder panel (five representatives from government authorities, non-governmental and consumer organization and the agricultural sector) conducted an assessment of the Future Agriculture Research Program in 2012. The reports that the evaluation panels submitted to the funder (SLU) will form the basis for recommendations to approve funding for a second phase (2013-2016) and provide advice on how to further develop the Future Agriculture initiative.

Lessons from a learning process

Stakeholders and the participants from the scientific community highly appreciated the approach combing socioeconomic, ethical and natural science aspects and the focus on analyses and syntheses of already available knowledge.

Everyone involved found the learning process accompanying this work very stimulating and thus put great effort into it. We also learned that the scenario development process, in particular identifying the factors shaping the scenario and their possible future states, was much more demanding and time consuming than expected. Nevertheless, we were able to reschedule and allocate additional time and resources to finalize the work. The combination of an interdisciplinary team of researchers and professional facilitators was very fruitful. The scenario development was a true interactive process where the facilitators used a computer scenario tool all through the sessions. The attempt to create a wide span of possible scenarios without appraising their value increased the creativity and flow in the workshops.

The broad representation of stakeholders in the workshops after the scenario development helped to identify more complex and interdisciplinary knowledge gaps and challenges than if an exclusively academic perspective had suggested them based on available expertise. Similarly, more long-term aspects emerged than if industry and policy sectors with more short-term concerns had dominated the scene. The outcome showed a high demand for more socioeconomic and ethical aspects within agricultural research.

The long time perspective has sometimes created a gap between researchers and representatives from the agricultural sector and industry, who face immediate challenges and huge and rapid structural changes. This was even more pronounced for those who became involved in Future Agriculture activities more recently. How to bridge these gaps still needs to be addressed. The longer time perspective used in foresights must be recognized as a complement to, not a substitute for, the short-term horizon often used in business planning and policy (e.g. based on election periods). The value of integrating foresights in stakeholder interactions (including researchers) as a dynamic tool for identifying knowledge gaps and setting research priorities cannot be underestimated.

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