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2nd SCAR FORESIGHT EXERCISE

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FOREWORD

The financial crisis has reminded us that the world is changing quickly and dramatically. These changes are bringing pressure on a range of complex and interlinked challenges within the European economy, and particularly upon European agriculture, They range from climate change, globalisation and increasing competition, to new demands for bio-energy, environmental impacts and pressures on our natural resources, demographic changes, and advances in science and technology, amongst others.

The future of Europe and European agriculture on the world market will largely depend on its ability to cope with these challenges, which cannot be addressed simply by applying trends of the past. Therefore the Standing Committee on Agricultural Research (SCAR) started in 2006 a foresight process which was strongly encouraged by the informal meeting of the EU Council in Krems on 28-30 May 2006. Ministers felt that better coordination of research was essential to enable Europe to successfully face the profound changes that lie ahead for the agricultural sector. This foresight process aims to identify futures scenarios for European agriculture (20-30 year perspective), to be used in the identification of medium/ long term research priorities to support the developing European Knowledge-Based Bio-Economy.

As part of this process, the SCAR launched a 1st foresight exercise. The European Commission established a Foresight Expert Group (FEG) to gather and analyse information available in national, regional and international studies on eight major drivers, to use this in formulating future scenarios and to carry out an initial assessment of the implications of these for the RTD requirements of European agriculture.

The 1st foresight report from the FEG was disseminated early 2007 among relevant stakeholders and discussed at a major EU Conference "Towards future challenges of Agricultural research in Europe", Brussels, 26-27 June 2007".

Building on the conclusions of the Conference, the SCAR endorsed the principle of establishing of a foresight signalling and monitoring mechanism based on the regular surveying of on-going foresight and with the aim of providing a better understanding and insight into existing and new trends. This principle was also a key message within the Commission's Communication "Towards a coherent strategy for a European Agricultural Research Agenda" . On this basis the SCAR launched a 2nd foresight exercise. The European Commission accordingly appointed a "consultancy expert group" to conduct, under the supervision of SCAR and the European Commission (DG RTD-E), a scanning and monitoring exercise which would take into account the 1st SCAR-Foresight FEG report and also provide assessment and analysis, and alerts on critical developments and which would suggest actions on specific issues to be addressed by research in the long-term.

The results of this study are found herein and constitute the 2nd SCAR Foresight report.

The experience gained through the SCAR foresight process has shown the importance of and need for an early warning system that allows policy makers and researchers to clearly anticipate the challenges and problems that we may face in the years to come, and to suggest ways of tackling them.

The design of this mechanism will be further developed to verify the adequacy and validity of previous and emerging foresight studies, and will provide a systematic approach for identifying potential threats, opportunities and likely major future developments and their implications for the ERA agenda. It will also highlight the possible implications of such developments for the future orientation of research policy at European and Member State levels.

In this context, the SCAR Committee will decide upon the opportunity to launch a 3rd foresight exercise in the near future.

Timothy HALL
Director Biotechnologies, Agriculture, Food
DG Research European Commission

THE "CONSULTANCY EXPERT GROUP" ON FORESIGHT

1. OVERALL OBJECTIVE

The "consultancy expert group" (CEG) will conduct under the supervision of the European Commission (DG RTD-E4) and the SCAR-Working Group a scanning and monitoring exercise tacking stock of the SCAR-Foresight, to provide assessment and analysis, to alert on critical developments and to suggest actions on specific issues to be addressed by research in the long-term.

2. TERMS OF REFERENCE

Building on the reports from Foresight Expert Group (FEG), the "consultancy expert group" will carry out a two step foresight scanning and monitoring exercise, it will provide assessment and analysis and will alert on critical developments and suggest actions on 2 thematic and 2 cross-cutting fields. The thematic fields are:

- agriculture/climate change/environment/pandemic diseases
- agriculture/energy/biomass/green chemistry

The cross-cutting fields are:

- interplay with agri-policy/rural areas/food security
- interplay with agricultural knowledge systems

Based on a thorough analysis of new & relevant foresight studies the consultants shall highlight issues deserving more attention (compared to the 1st foresight exercise) in the above 2x2 matrix supported by a brief reasoning why. Advice should be given on the best ways to handle the identified issues and suggest major actions. It should create the necessary knowledge for policy generation.

The follow-up of the SCAR Foresight Exercise foresees, moreover, the set-up of two new SCAR Collaborative Working Groups on (a) agriculture and energy and (b) agriculture and climate change. The CEG should give also recommendations to these new groups which will become operable after summer 2008.

3. FOCUS OF THE WORK

- The gathering and analysis of information from previous and ongoing foresight activities, including strategic visions and research agendas of relevant European Technology Platforms, vision documents of ERA-Nets and relevant European research projects (i.e. AG 2020, FARO-EU, Eurocrop, Future-Farm, EU-Agri-Mapping and others) as well as relevant projects at international level having an impact on Europe or on European interests
- A systematic approach for identifying potential risks, opportunities and likely future developments and challenges for European agriculture and the research and innovation system supporting the sector.
- Insights into possible implications of such developments for future research policy orientation at European and Member States levels.
- A special attention should be paid to the critical European research capacity to respond to new developments.
- Preparation of an analytical document suggesting priorities and posteriorities.

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COMMENTS BY THE SCAR-WORKING GROUP ON THE 2ND FORESIGHT REPORT

Introduction

There are a variety of possible approaches to commenting on an analysis of such a width and complexity as the 2nd foresight report commissioned by SCAR.

The approach we have taken is to follow closely the lines of thought that have been developed in the foresight report, which has explored a very complex image of the future, including interpretation of the links between drivers, theme boundaries and time horizons. This has been done through discussions within the SCAR-WG (and especially through its own "subset" in this domain i.e. its foresight subgroup, SCAR-FG[1]). The main line of work has been to highlight those "conclusion lines" that seem to us to be of most interest in the 2nd Foresight report.

The criteria for pointing at particular issues relate to the degree to which they play a key role for the future climate path and in general terms the ecosystem functioning, and how they provide key messages for the agriculture sector and implications for food security. This in turn relates strongly to broader global security issues.

Seven issues have been selected because they either provide an interesting approach, they signal something new or they draw attention to the fact that things are changing faster than was expected only a few years ago when the 1st SCAR-Foresight report was published. These are:

- The *complexity* of the new challenges
- The *underestimation of the rate* of climate change
- The *vulnerability* of the food system
- The *sustainable development challenge* of agriculture and food systems
- The *research* and *innovation* needs
- The *adequacy of the Agricultural Knowledge System*
- The *governance* design

With this selection both the richness of this second foresight study and what the SCAR-WG consider to be the major issues have been highlighted.

1) The complexity of the new challenges

The Consultants of the 2nd SCAR Foresight exercise were requested to build on the 1st Foresight Report and scan relevant new foresight studies. They were asked to provide an alert on any new challenges and opportunities for agricultural research, looking at the interconnected fields of climate change, food security, rural development and agricultural knowledge systems. In order to handle the considerable number of studies (more than 100) published during the last three years, the Consultants developed an interesting approach by classifying the studies according to content (environmental, economic, social, technological and policy), time horizons, and theme boundaries (external drivers, dominant internal drivers, emerging drivers and novelties). This allowed them to deal in a very efficient way with the complexity of the task and the many interconnections between the agricultural system and other systems.

1 SCAR Foresight Group: Uno SVEDIN SE (coordinator), Wolfgang RITTER DE, Jim FLANAGAN IE, Egizio VALCESCHINI FR, Peter BESSELING NL, Mike COLLINS UK, Elie FAROULT, Mark CROPPER and Hans-Jörg Lutzeyer EC.

This integrated matrix approach highlighted potential resource pressures, e.g. phosphorous or the urgent need for research to support the delivery of more resilient and sustainable food systems. It highlighted the fact that food security is a matter of concern for both the North and the South, which cannot be addressed by approaching from a national or European perspective alone, and that the food system is influenced by a whole host of other areas of policy e.g. on the use of renewable raw materials for bio-energy or bio-fuel.

The report points to the fact that "the systemic understanding of the interconnections between important sub-systems is generally weak and the degree of interdisciplinary cooperation required to understand and to address the many cross-linkages mentioned in the report is not sufficient". In addition, it highlights the importance of a better understanding of key ecosystem components such as the functioning of the soil systems and how they might respond to environmental pressures or climatic stresses.

We fully support these views. More research is needed *to understand not only the functioning of ecosystems but also their criticality*. Such complex challenges need complex approaches, which should involve a broad range of disciplines from outside the traditional agricultural sector. A quote from Garth Morgan's book *Images of Organization* (1986, p.16) may be relevant in this context:

> "*We live in a world that is becoming increasingly complex. Unfortunately our styles of thinking rarely match this complexity".*

Complexity is closely associated with incompleteness of knowledge and information - mainly due to such things as the opaqueness of systems caused by the many interconnections and feed backs, resulting in systems dynamics including the lag-time before a problem becomes visible. All of these factors contribute to the *uncertainty* about the future especially in times of rapid changes where large fluctuations often are *early signs of systems approaching an unsustainable stage.*

This is why it is so important to have a functioning foresight monitoring and early warning mechanism in place, which is capable of identifying possible threats and likely developments as well as opportunities not only to alert but also to provide *a better evidence base for future research policy orientation and research agenda setting***.** *In this way the foresight report stresses the need for foresight mechanisms like the one under operation by SCAR.*

2) The underestimation of the rate of climate change

There is now clear evidence (IPCC4[2]) about the impact of climate change on natural ecosystems and hence agriculture and the entire food system. The report highlights the global warming issue and the difficulties we will have to hold global warming below a 2°C rise by 2050[3], while pointing to the various consequences of unabated climate change, with greenhouse gas (GHG) emissions accelerating three times faster than the IPCC4 authors anticipated in their worst case scenario just a few years ago. Other research indicates that emissions must be cut more quickly to prevent critical thresholds being crossed that could lead to runaway climate change (Lennton and Schellnhuber, 2007).

Therefore, this report sees the *main challenge for agriculture and the whole food sector as finding the right response strategies to this accelerated climate change***.** If the emissions continue unabated the risk is that current perturbations in food systems will be further exacerbated when self-reinforcing feedbacks start to "kick in" (e.g. thawing of permafrost soils and release of CH_4). Agriculture and land use change are significant contributors to GHG emissions (mainly CO_2, CH_4, N20) and agriculture is one of the first sectors to be affected by climate change. Therefore, it is *essential to reduce both the contribution of agriculture to climate change and the vulnerability of food systems* by *exploring the*

2 Intergovernmental Panel on Climate Change

3 In the light of more recent research results it seems clear that Green House Gas(GHG) emissions have already committed a global warming of 2.4°C (Ramanathan and Feng, 2008)

full range of possibilities for reducing GHG emissions and mitigating climate change effects in order to contribute to more sustainable food systems.

As pointed out in the foresight report (including its background reports), there is much scope for technological developments and innovations in the entire food chain to reduce GHG emissions and to prepare for the necessary adaptations in production systems to the expected changes. As a first step it will be particularly important *to increase land productivity, nutrient and water efficiency, stress-tolerance, disease resistance, and to maintain/improve soil fertility*. *But this has to be done in a sustainable way without further comprising natural resources.*

This line of thinking stresses the *need for a much deeper rethinking of the way food is produced, processed, retailed and purchased* (see point 4) if a "safe landing" in the face of climate change is the prime objective.

An overriding SCAR-WG comment is that the "increased speed" of climate induced challenges makes it increasingly urgent that agricultural knowledge systems in Europe are fit for purpose.

3) The vulnerability of the food system

The foresight report argues that, in the light of the many new challenges, it is not sufficient to look at the various facets of food security (availability, access and utilization) alone. Food security will be endangered by an increasing number of constraints such as shrinking water and land resources, increasing biodiversity losses and soil degradation. In addition, higher seed and fertilizer prices will make food systems more vulnerable, particularly in the light of the uncertainties of climate change.

The situation is further exacerbated by the high dependence of the entire food production, processing and retailing chain on fossil fuels. Oil output is expected to peak in the next ten to twenty years with a steady decline thereafter, while energy demand is estimated to grow by 50% by 2030, with potentially serious implications for the food supply and prices. In addition, projected population and economic growth will double the current demand for food by 2050 (FAO, 2008). The report highlights what we have known for some time, that *growing food demand alongside increasing economic and resource pressures, as well as climate change, is a tremendous challenge and one in where research will have a vital role to play.*

The foresight report raises the important question of "how to reduce the vulnerability of social, economic and ecological systems" which it considers will become a key challenge to the policy agenda in the coming years. It points to the potential for a local food crisis undermining social stability which in turn could lead to failing states and increased global insecurity. *A focus on vulnerability* should therefore take *a systems perspective* in order to pay full attention to the complexity of the various ramifications of the underlying processes. The report highlights the importance of linking the broader approach of vulnerability with the concepts of ecosystem services and sustainable development.

The SCAR-WG acknowledges the value of the proposed vulnerability concept which opens up for a wider resilience perspective beyond the "narrow" view of food security. It clearly demonstrates that the various crises since 2007 (oil, food, financial and economic) are interdependent and therefore have to be dealt with using more holistic and systemic approaches in order to prevent, or at least dampen, possible self-reinforcing feedback loops and a potential cascading sequence. The report rightly points to the fact that "dealing with vulnerability means changing attitudes to risk, privileging diversification over specialisation, adopting precautionary principles, and focusing on autonomy (as far as possible) from outside resources rather than maximizing output", and one can add to this profits (see point 4). The SCAR-WG is in full agreement with this conclusion.

4) The sustainable development challenge of agriculture and food systems

The report stresses the point that a number of important natural resources for agricultural and

food systems, such as soil, water, and biodiversity have been deteriorating over many years, slowly but steadily undermining ecosystem services and the resilience of agro-ecosystems. A number of examples are given which point to the unsustainability of conventional farming and food systems due to their high energy dependence, high water demand or their adverse environmental footprint.

World food supply is heavily dependent on fossil fuels at all stages, from planting, fertilizing, irrigating, harvesting through to processing, packaging and retailing. It is questionable whether this form of high energy dependence and the closely connected GHG emissions will be tolerable in the future under climate change conditions or whether it will be even feasible under the foreseeable scarcities of fossil fuel, phosphate, water, etc. Should the cost of oil and other agricultural inputs increase after the end of the current recession there is the potential for food prices to surge again provoking the next global "food crisis". With this and a range of other challenges in mind, the report points to the high expectations on research to bring forward the necessary technological advances and innovations to feed the 8 billion global population expected by 2030.

In addition it is important to note that the food base is extremely narrow and vulnerable to global warming. Only four crops provide about 60% of global food the FAO (2007) has recently remarked that the rate of extinction is "alarming". Plant and livestock genetic diversity is crucial in sustaining long-term productivity, with *genetically uniform systems being extremely vulnerable* not only to pests and diseases but also to "external shocks" under extreme weather conditions.

The report criticises the pre-dominant, retail-driven food model which neglects the ecological footprint, the many unpaid environmental costs of the food supply, and the overall social impacts. It therefore rightly stresses the *need to further develop low external input farming concepts which offer a significant potential to lower total GHG emissions per kg of product*. Accordingly restoring soil organic carbon as well as diversifying landscapes, farms, fields, crops and species might also help to adapt to the increasingly unpredictable weather conditions expected under global warming. At the same time promoting diversity over specialisation would improve the resilience of agro-food systems with respect to external shocks.

The SCAR-WG fully supports the need for research that will deliver more resilient and sustainable food and farming systems. In order to develop truly sustainable concepts *public research has to take a much wider perspective than market oriented private research*. New ways of sustainable landscape management will be increasingly important to ensure the vitality of rural areas that provide our essential ecosystem services. *The question can be asked whether the existing AKS in Europe are adequately organised to perform this more complex task.*

5) The research and innovation needs

Some European countries have already taken steps to build the necessary research capacity to address the emerging and longer term challenges. However this is mostly done from a national perspective leading to fragmented approaches across Europe. Much could be gained from better coordination and integrated cross-border programmes and joint efforts with the necessary "critical mass" to effectively deal with the complex challenges. What is especially lacking according to the foresight report is a *greater involvement of farmers and other resource users as well as consumers in the research efforts for both, the setting of research priorities and for the application of research*. Their involvement is critical in the innovation process, for the development of adaptations and for the acceptance of new innovations. The report indicates that public-private partnerships are expected to expand in scope and diversity over the next decades, with private interests influencing the research agenda and it expresses a concern that such a shift in focus could further weaken research activities in the public goods domain, which are important for building more sustainable farming and food systems. The report therefore suggests *"giving priority to research and innovation with clear public benefits"*. The SCAR-WG agrees with the importance of research and innovation with clear public benefits and

the importance of research activities in the domain of public goods. But it also considers that the sheer size of the research challenge requires involvement of the public and private sectors including public-private partnerships and it would not have the same undue concern about possible adverse effects of private sector involvement in research.

The report considers that some innovative developments such as *robotics* "could play a role at all scales of production" but at the same time stresses "that more systematic exploration is needed on the impact of these technologies on the structure and composition of the European farm sector, the quality of life of the farmers, on social acceptance and on rural development".

The report is very critical with respect to "*genomics*" and the need to address the consumer acceptance issue. In the case of "*functional foods*" it considers that the health claims are not yet proven and in relation to "*nanotechnology*" it points to a number of benefits, but notes that little is known about the fate and behaviour of nano-particles in the environment and the implications of this for monitoring, regulation and scientific understanding. The report also emphasizes that farmer-based participatory breeding could greatly enhance the development of varieties better adapted to a climate change world or for specific conditions.

While it is clear that progress towards a more sustainable development path is urgently needed (points 2 and 4) the SCAR-WG considers that it is less clear from the report how the necessary productivity increases or efficiency gains can be achieved without technological breakthroughs or significant progress in innovation. For example improving N use efficiency may include adjusting application rates based on precise estimation of crop needs through precision farming, by using slow- or controlled-release fertilizers or nitrification inhibitors, or by placing N fertilizer more precisely into the soil to make it more accessible to crop roots.

The report questions the potential contributions of some of the newer technologies including genomics, functional foods, nanotechnologies and robotics on safety, proven efficacy and other grounds. The SCAR-WG accepts these specific concerns with the exception of genomics where the Consultants seem to have confused the newer science of genomics with the older technology whereby GMOs are produced. The SCAR-WG does not accept the implication that the newer technologies might not have an important role in achieving sustainable production of sufficient food to feed the growing world population and in coping with climate change.

What is desperately needed is *more research into the development of systems of food production that are feasible, sustainable and profitable*. This task is similar to squaring the circle - how the growing demand for food, bio-energy and bio-fuels can be met in a world with increasing pressure on natural resources and in the face of accelerating climate change.

6) The adequacy of the Agricultural Knowledge System[4] (AKS)

The report questions whether the existing public *agricultural knowledge systems (AKS)* in Europe, which have been under-funded for years, *are adequately equipped and prepared to deal effectively with these highly dynamic changes* that demand immediate solutions, and not just in the medium to long term. It stresses the necessity of improving Europe's AKS to make them more responsive in providing integrated answers that combine ecological and social concerns with economic aspects. But in the light of the major challenges already visible it *questions whether "more of the same technical fittings"* (i.e. more fertilizer, better seeds and irrigation, etc.) *are the right approach to lead to a sustainable development path* in the longer term. "The perception that market liberalization has failed to provide food security even in rich nations has brought about a general agreement on the importance of searching for different models of agriculture and food provisioning".

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4 Remark: there are several existing definitions of a European Agriculture Knowledge System. Our point here is not to dwell on these definition issues per se.

This could of coerce be said but still what does it entail with regard to the reforms of the European Agriculture Knowledge System? In our mind the challenges earlier stated above points at a number of issues where there may emerge some consensus on the AKS and on necessary adjustments.

- the system complexity widens the field of needed competences
- the increased focus of interrelations and associated risks needs to be handled by a new vigorous effort devoted to such items. One way is to widen to collaborative efforts from the traditional AKS to a much wider realm of interests and competences.
- the institutional embedding of the AKS has to change and become much broader as the field of influence on the decisions about directions and strategies need to be broader. It is here the dialogue with society comes more strongly into the picture. There need to be new possibilities for influences from outside the current AKS that could help to formulate the new demands now based on a broader view.

7) The governance design

Some of the issues related to the governance and structure of the agricultural knowledge systems have already been addressed above. Some of the more important structural challenges are:

- the necessary adaptations/corrections to the AKS will need to be rapid to be able to cope with faster change in the future.
- the complexity of the inter-related issues seems to increase the vulnerability not only of food systems but also of political and economic systems. These challenges call for new types of knowledge mobilised through new forms of cooperation between the knowledge generating institutions such as universities, research institutes and laboratories without excluding *a priori* public-private-partnerships.
- Priority setting for research and innovation needs to include consultation and involvement of the vast stakeholder community including civil society.
- Improvement in the connection between research and policy is essential but the relationship between the two is complex. In a world of rapid change and increasing complexity this link needs to be strengthened, when agricultural related issues are concerned. The case of rural development indicates the character of relevant integration approaches.

Summary of paths for research and innovation efforts

Based on the "SCAR-WG assessment and tentative conclusions" on the 2nd foresight report, the following recommendations in relation to research and innovation can be proposed (in no particular order):

- *to further explore the full range of possibilities to reduce GHG emissions and to mitigate climate change effects associated with "the agricultural sector"*
- *to understand not only the functioning of ecosystems but also their criticality. The resilience of the combined bio- and socio/economic systems is at the heart of our ability to be able to address the challenges that we face. This has strong implications for the knowledge that needs to be generated to address issues that impact on "agriculture" but which have a much wider base than this specific sector. Therefore the systems approaches needed have to be highlighted*
- *to further develop low external input concepts which are more diversified and "greener" (the next generation of agricultural research) paving the way for alternative models that will include low input concepts, increased diversification, and a reconsideration of the way we produce, process, retail and purchase food, making sustainable development.*

- *to quickly improve the capacities of the agricultural knowledge system so that it can address the new and severe challenges in the required timescales.*

The reasons for these efforts seem clear:

The conventional agriculture has been successful in increasing productivity but this has been with a significant environmental cost that has not been sufficiently recognised. In the light of expected climate change in combination with the pressures on natural and other resources (such as oil and N-fertilizers, phosphate, land, water, soil, biodiversity) we need to rethink the way we produce, process, retail and purchase food.

In order to make progress along a sustainable development path more research into alternative models that address the double challenge of food and environmental security will be vital (including climate issues).

Innovative research is essential to meet the challenge of growing more food for a growing world population on limited land, with less energy and other scarce inputs, while at the same time improving soil fertility and ecosystems resilience capacity as well as exploring all possibilities for mitigating climate change effects. The development of the "omic" sciences, nano-technology, robotics and other technologies is an important part of meeting the challenge.

In order to achieve these multiple goals we need to improve the response capacity of the Agriculture Knowledge System by promotion of cutting-edge research to produce more with less input, and to encourage more systems oriented research to better understand key issues in terms of functioning and criticality. More investment in these types of research is needed and a better integration and coordination of research efforts have to be highlighted by establishing more cross-border programmes.

And finally: the world is not at a stand still. These efforts are mandatory and they have to be mobilised with considerable effort and with speed.

EU Commission - Standing Committee on Agricultural Research (SCAR)

The 2nd SCAR Foresight Exercise

New challenges for agricultural research: climate change, food security, rural development, agricultural knowledge systems

December 2008

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List of Acronyms

AKS	Agricultural Knowledge System
ARD	Agricultural Research and Development
BSE	Bovine Spongiform Encephalitis
EU	European Union
GHG	Greenhouse Gases
HPAI	Highly Pathogenic Avian Influenza
IPR	Intellectual Property Rights
KST	Knowledge, Science and Technology
LEISA	Low External Input and Sustainable Agriculture
LOHAS	Lifestyle of Health and Sustainability
MRLs	Maximum Residue Levels
MS	Member States of the European Union
SCAR	Standing Committee on Agricultural Research
SMEs	Small and Medium Enterprises

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EXECUTIVE SUMMARY

The 1st Foresight Panel reported at a time of more than sufficient aggregate food supply under conventional food production technologies, a presumption that climate change – though of concern – was a 'manageable' challenge, and that new and advanced science and technology would be able to deal with concerns about natural resource trends and the rising demand for meat protein. The 2nd Foresight Panel concludes from the scanned documents that, compared to the 1st Foresight exercise, the landscape has changed dramatically in three important respects:

It is now improbable that global warming will be held below or at 2°C by 2050. The world's commodity and food trading system at present is largely dependent on only three grain crops (wheat, maize, rice). These crops respond variously to moderate change in mean temperatures and GHG concentrations but yield in all three is depressed as mean temperatures rise.

Natural resource states and ecological functioning are approaching or are at tipping points in an increasing number of areas, with respect to biodiversity (fish, mammals, coral, birds, amphibians – and possibly also insect pollinators, bees in particular), water (rates of groundwater extraction, pollution/quality, physical or economic scarcity), soils (qualitative and physical condition). Recognition of these trends has increased international competition for land and water to secure the domestic food security of nations that are already, or projected to be under combined population and economic growth, heavy food importers.

Two key resources essential for the functioning of existing agricultural and food systems will approach physical or economic scarcity under current rates of, or projected expansion of 'business as usual' economic growth by mid-century: phosphorus and fossil fuel. While substitutes might over time be found for fossil fuel, phosphorus – derived from phosphate rock – has no known substitute and may be considered an absolutely limiting resource. Recognition of this is likely to drive up synthetic fertiliser prices and lead to increased competition to secure the sources of phosphate supply.

Systemic perturbations, related to the above landscape changes through positive feedbacks, have increased volatility in financial and economic spheres, with knock-on and spill-over effects on food prices, hunger, and other indices of human welfare, as well as on the costs of agri-chemical inputs. These effects have increased consciousness of the gross inequalities and militate against evolution of consensus on how to mitigate, and adapt to, climate change, conserve global public goods, and ensure progress toward food security for more of the world's people.

The perturbations appear to have increased short-term reluctance on the part of governments to address the implications of the trend data noted in (1) and (2) above, while the business sector in general appears unwilling to embark on transitions from business as usual without decisive shifts in government policy. Public opinion, on the other hand, seems to favour swift and direct re-framing of policy and action by governments so as to enable profound transitions in a climate-changing world. Financial authorities dealing with actuarial futures, insurance, and long-term investment, also are signalling quietly that the time has come for a more decisive response.

Food security and energy security and – through positive feedbacks that will drive further loss of resilience, also geopolitical instability – none the less have risen quickly up the policy agenda and are likely to continue to claim attention in the near term, with increasing urgency over time.

At the regime level, private commercial organisations are setting their own production and food standards – often above regulatory levels – and using their command of the market to influence policy, with the aim of defining the innovation space in which solutions to the challenges noted are being developed.

There seems no reason to doubt that their command of the advanced sciences, increasingly protected by proprietary IPR, could deliver solutions to yield challenges in conditions of more extreme natural resource and energy constraints , if yield were the only consideration and if 'business as usual' drivers continue unchanged.

However, the 2nd Foresight Panel notes the following: (i) the restriction of the space for innovation to the science and technology from which commercial companies can make profit does not in itself ensure increased societal resilience; (ii) the privatisation of knowledge at a time of increasing systemic instability greatly increases risk, since the free flow of knowledge, of all kinds and from all sources of expertise and experience, is one of the guarantees of survival in times of rapid and profound change; (iii) commercial companies are unlikely to take on board the monitoring and alert functions of public science, although these functions are likely to be in increasing demand; (iv) commercial companies in competitive markets have no incentive to internalise environmental and other public good costs; (v) dis-interested oversight, regulation and standard-setting would become problematic, since independent sources of expertise and experience would be attenuated (in effect, companies' command of the S&T would place them in a position of self-regulation); and (vi) both citizens and governments may baulk at the concentration of power in (an increasingly few) private hands over the fundamental basis of life and society (and at the implications of this for democratic choice and control).

At the niche level, there are everywhere in Europe and in numerous other places in the world, ongoing experiments ('novelties') and a re-development of knowledge networks that are exploring and responding to the trend data. Some of the initiatives involve formal research partners and/or public or private organisations, others are embedded in civil society networks and movements of varying scale. They are creating and testing alternatives to business as usual in agricultural and food systems. It is from these niche experiments that the profoundly creative, step-wise mitigation and adaptation potentials are emerging.

Some experiments already are beginning to influence the direction of change in regime at farm enterprise, territorial, sector, value chain, community (etc) levels. However, the institutional provisions at regime level are proving 'sticky', blocking the rate and scale of progress. For instance, the development of seed systems that offer greater resilience in a climate changing world are constrained by the dominance of a few companies in commercial seed supply, the current and emergent IPRs, TRIPS, restrictive interpretations of UPOV 1991, the DUS requirement, restrictions on so-called heritage seeds and the weak support of participatory approaches to plant breeding. Or, as the 2nd Foresight Panel notes, there is too slow a development of trans-boundary capacity to monitor and respond to new or resurgent pests and diseases in a climate-changing world, and too little investment in the underlying entomological and ecological sciences to support this function.

The slowness of institutional development is of greater concern because social trends (especially, ageing, urban growth, city lifestyles) demand a new contract between rural and urban areas and functions. What new services do the 'urban' demand of the 'rural' (e.g. flood mitigation and prevention), and what new opportunities (e.g. agri-tourism) are created for the 'rural' by the shift to the cities?

The social trends also increase the vulnerability of the population to interruptions in or break-down of food provisioning, and increases their potential exposure to pandemic diseases that may propagate quickly wherever people are concentrated, especially as populations are also highly mobile at a range of geographic scales.

At the same time, new opportunities for food provisioning may open up (such as manufactured meat protein, and algae-based biomass energy, or indeed, by means of a modernisation of urban gardening, for the production of fresh fruit and vegetables, as well as small bird, animal or fish enterprises, combined with waste/heat re-cycling). Such transitions would remove (a part of) primary production off farm land and into the cities, where consumers are concentrated, and could reduce the GHG emissions from agriculture and food systems.

The organisation of knowledge, science and technology in the EU25 is inadequate to deal with the challenges noted above in an integrated way. Capacity (both infrastructures and expertise) is uneven, within countries and between countries, and fragmented at the EU level.

There is no organised network or platform at sub-regional or EU-wide level for science to play an *integrated* alert function. Data on food, health, agriculture, forestry, landscape management, catchment management, rural, social, environment, climate, ecological, policy trends continue to be held in separate 'knowledge silos'. The data sets are often hard to integrate because they are built for different purposes, and on different technical platforms. As new questions are posed, different kinds of data are being assembled, that seek to measure what hitherto has been invisible or taken for granted. Much more decisive support seems warranted for these efforts, and a more rapid integration of these kinds of data into economic and financial decision-making.

It is not possible to make adequately informed choices among technological options on the basis of existing data on costs, price, and value.

Systemic understanding is weak, presently largely confined to specialist centres and groups who have chosen to work on systems analysis and synthesis. The degree of inter-disciplinary cooperation required to understand and address the challenges noted in this report is not sufficient. Theoretical understanding of feedbacks, knock-ons, spill-overs etc is also relatively poorly developed, especially in terms of cross-scale and inter-temporal relationships and effects in food and agricultural systems.

The withdrawal or decline in publicly funded R&D related to food and agriculture has weakened democratic oversight of the options for change, regulatory capacity, and the integration of public goods into private decision-making.

1. Introduction

1.1 Conceptual framework and general statements

Emerging consensus: there is a growing systemic problem and the costs of inaction are rising

The 1st Foresight report noted that governments could choose to do nothing in the face of negative trend data on natural resources and ecosystem functioning and of increasing GHG (greenhouse gas) emissions, or take steps to mitigate and adapt so as to reduce the vulnerability of their societies to the anticipated impacts, or begin a deep and profound transition toward new ways of managing economic activity and securing human welfare. In the intervening years the negative trends have worsened, and much faster than anticipated.

> CO2 emissions from fossil fuels increased 1.0% per year during the 1990s; their growth rate accelerated to almost 3% per year from 200 to 2005. If current trends continue, future emissions will exceed even the highest of the emission scenarios used by ICCP for simulations of future climate change. The situation is aggravated by the fact that an increasing fraction of emissions remain airborne because of a decreasing efficiency of natural sinks (particularly of the oceans). In combination, the increasing emissions result in rapidly growing atmospheric GHG concentrations.
> According to the Global Carbon Project (GCP) 2008 Report anthropogenic CO2 emissions are growing four times faster since 2000 than during the previous decade, and are above the worst case emission scenario of the IPCC. They also point to a decline in the efficiency of CO2 natural sinks (5% decline over past 50 years). Methane and nitrous oxide emissions are projected to further increase by 35 to 60% by 2030, driven by growing nitrogen fertilizer use and increased livestock production in response to growing food demand (FAO-HLG Conference on World Food Security, 2008).

2008 will be remembered. During this year, the world has witnessed an oil crisis, with exceptionally high price spikes, a food crisis, which has generated social unrest in many parts of the world, a financial crisis, which has struck the biggest banks in the world, and more recently the beginnings of what seems likely to be a deep and prolonged worldwide economic crisis, with high unemployment and falling demand. The nature of globalisation, as presently organised, means that for the first time in human history a catastrophic weakness in a part of the economy propagates across the entire world, and across socio-economic sectors.

The interdependent crises have shaken strongly the existing policy paradigms, introducing into national and international politic agendas measures that up to a few years ago would be considered unthinkable. The cascading sequence of the events has made clear that there is an essential interdependence among crises, and that problems declaring themselves in each field should be dealt with means of systemic approaches that seek to dampen positive feedback.

Let us examine the links between food, energy, climate and finance.

- Climate change is generated by emissions of greenhouse gases that in turn are largely dependent on fossil energy use (mainly coal and oil) and by methane and nitrous oxide emissions from agriculture;
- Food production, distribution and consumption depend strongly on fossil fuel energy consumption; high oil prices affect costs of production, processing, transport, conservation; at the same time, agriculture's important role in greenhouse gas (GHG) production is increasing as rising incomes drive up demand for meat proteins;
- Climate change hits agricultural productivity directly through drought, floods, pests, diseases and catastrophic events, as well as by temperature changes that affect plant productivity;
- In order to anticipate the foresighted peak in oil reserves, many governments are subsidising the production and trade of biofuels, so contributing to increased food prices;
- In order to diversify financial assets, investors are turning their attention to agricultural commodities, amplifying price increases;
- In order to safeguard their own domestic food security, countries with high populations and/or low agricultural potential are competing with small farmers in other countries for land and water by buying or contracting large tracts of land.

The emerging issue in this regard is that we are facing times of turbulence, characterized by catastrophic events, tipping points and system collapse. Theoretically, since agriculture covers some 40% of the world's land surface, agriculture offers large potential for mitigation. But mitigation by means of agriculture is currently seen as politically 'too difficult' or insufficient. Vulnerability and cross-sectoral adaptive governance are going to be key policy concepts.

The Fordist era guaranteed stability and wealth on a national basis. The neo-liberal era generated a dualism between immense accumulation of wealth in some areas and for some people, and economic, social and environmental local crises in other areas. The era we are approaching does not provide security for anyone.

> Nearly half (48%) of 12 000 respondents in a recent global survey (HSBC, 2008) of citizen opinion in 12 major economies thought that governments should play a leading role in the transition (only 25% thought that they were doing so). The majority thought that governments should be taking direct action, focusing on the big issues: investing in renewable energy, halting deforestation, conserving water, protecting ecosystems. (Instead, governments are focusing on indirect actions, such as negotiating carbon 'cap and trade' treaties). 78% favoured simple 'fair sharing' of global GHG emissions reductions, in proportion to countries' current share of global GHG. 48% nominated climate change above economic stability among their top three concerns (September-October 2008)
> *Source: HSBC 2008. The Climate Confidence Monitor 2008. HSBC Climate Partnership. London*

Dealing with vulnerability means changing attitudes to risk, privileging diversification over specialization, adopting precautionary principles, and focusing on autonomy from outside resources rather than maximizing output through exchange. Transition to adaptive governance means, among other things, much greater public support for trialogue between governments (and their technical agencies), citizens and scientists, a privileging of longer term decision-making processes, and a reduced role for private business as a driver of short term changes that are individually profitable but that lock societies into collectively

unsustainable pathways and amplify positive feedbacks. Citizen understanding of what is at stake appears in some regards to be running ahead of governments' willingness or perhaps capacity to effect rapid and deep change.

The Stern review (Stern, 2007) made clear that inaction imposes strong costs. More recent estimates indicate that the costs are rising steeply and are beginning to outweigh the benefits, even in present terms. In effect 'inaction' is the option so far followed – the many policy commitments and innumerable local initiatives seeking a transition have left the main economic drivers intact; and public policy and private business choices leave unchallenged 'business as usual' scenarios. As the 2nd Foresight scenario analyses suggest, much stronger and bolder pro-active policy would be required to achieve the transitions that now seem indicated.

The food crisis: food security concerns as an emergent driver

The food crisis has made food security a key issue in the global policy agenda. Internal food security has become also a national and EU- level affair again for Member States (MS), after decades of oversupply and repeated attempts to reduce agricultural production volumes. This attention to food security has opened policy actors' eyes to the consequences of three recent trends in agriculture and food policies: the dramatic decline in public investments in agriculture in the world, private investments that have favoured large scale specialized farming and food systems and the increasing concentration of ownership and control across the entire agri-food value chain. The perception that market liberalization has failed to provide food security even in rich nations has brought about a general agreement on the importance of searching for different models of agriculture and food provisioning.

> Family farming (and in a special way the role of women in agriculture and food systems), multi-functional agri-ecologies, and sustainable production processes are seen as key to securing the interdependent goals of 'people, planet, and profit'. Productivity, in this view, can be increased through investments in human capital, targeting (green) innovation policies to small family farmers, and re-investing public funds in advanced sciences and technologies for public good goals (The term 'common goods' is preferred here by some, to indicate that 'we are all in the same boat'). This perspective emphasises the important role of small farms, as well as innovative arrangements and forms of cooperation between farms for food security, rural development and the provision of public goods. Multi-functionality is consolidating itself as a dominant paradigm for farm management, aiming at maximizing outputs that are public utilities.

The perception of the urgency for new policy approaches is more widely shared since the 1st Foresight exercise; however, it must be considered that there remains a big gap between awareness and action. Measures that take into account jointly the interdependency of climate, energy and food issues are not easy to implement because they belong still to different areas of public administration, scientific and technical expertise, policy fields and policy networks. And there is still no adequate theoretical and methodological knowledge to address them in an integrated way.
From the analysis of the above considerations it can be stated that in the next years the agricultural and food policy agenda will be concentrated on three objectives:

- To maintain and increase the stock of global, regional and local **public goods**

- To reduce the **vulnerability** and increase the **resilience** of social, economic, ecological systems;
- To strengthen societal capacity for **anticipating** surprises, tipping points, domino effects, implying an increased support for multi-actor dialogue and innovative ways of placing science in society in interaction with other interests.

There is no consensus on the proposed remedies but a growing awareness of the 'alert function' of science

It can be said that there is much more consensus on diagnosis rather than on cure. There is an evident disagreement on aspects that have characterized the scientific and political debate in the years since the 1st Foresight exercise. As far as agriculture and food are concerned, the disagreement covers important areas such as trade, the role and impact of new technologies (especially GMOs, nanotechnologies, nutriceuticals), intellectual property rights, energy strategies (especially the extent to which production of biomass for energy should be encouraged), agri-food paradigms (organic / conventional, long chains / short chains etc.). As the debate generally has developed within sectoral boundaries, it is often easy to escape from general questions such as:

- Are there limits to growth?
- If not, how to guarantee that transition to a new technological and material base for human welfare does not lead to new inequalities and local catastrophes?
- If yes, how to implement strategies that disconnect growth, environmental degradation (etc.), and progressive loss of welfare?

The research policy agenda of the next years should be able to reduce areas of disagreement by filling knowledge gaps, and by encouraging the capacity of the research community to place science in society in ways that promote informed consensus on action.

In this regard, we start from the hypothesis that research has three purposes: a) to feed innovation aimed at producing private goods; b) to feed innovation aimed at producing public goods; c) to provide an alert function, signalling risks and dangers ahead.

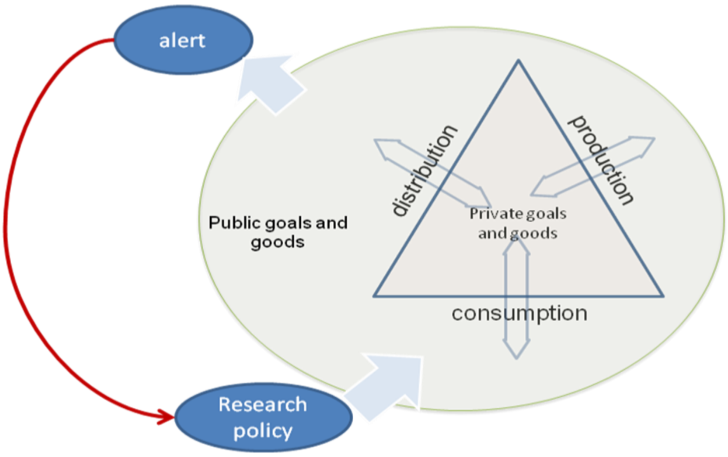

Figure 1 – Role of research and innovation

In the Figure 1 we have represented economic activities as providers of both public and private goods. These activities are classified into production, distribution and consumption, highlighting the fact that innovation can stem from any of these activities.

According to a conventional discourse, private and public goals largely coincide. As economic growth currently is taken to be the measure of welfare, innovation aimed at producing private goals should produce wealth, employment, competitiveness. But these kinds of innovation would be inappropriate in presence of market failures, for example when production of private goods produces negative public goods, or when private benefits imply public risks. Climate change could be considered, for instance, as a gross market failure. In this situation research should fill knowledge gaps that alert decision makers to risks and dangers and that may reconcile private goods with public goods.

It is increasingly the case that private goods do not coincide with public goods but the evidence for this often is not widely shared beyond specialist science circles or is hotly contested by privileged interests which benefit from challenging the evidence. The need for instruments that assess (measure) in advance the probable impacts of research, applied knowledge, and technology on the public domain and on the ecosystem services on which we all depend, has become stronger since the 1st Foresight exercise. The current and probable future trends in any case argue for a distinction to be made between types of research and innovation. For example, if the final users of research are predominantly big enterprises, it can be easily argued that the distributional effect on society will be largely favourable to these actors.
The phase of human history that we are facing requires this kind of distinction. If the priorities suggested by the analysis of the present situation are to produce and maintain local and global public goods and to reduce the vulnerability of present systems of food provisioning, it would be appropriate to give priority to research and innovation with clear public benefits.

1.2 What does the present document add to the 1st Foresight exercise?

The 2nd Foresight exercise updates the 1st (SCAR, 2007).

> The 1st Foresight exercise identified four scenarios: climate shock; energy crisis; food crisis; cooperation with nature. It pointed to declines in fossil fuel resources, land, water, biodiversity, energy availability, ecological services; and increasing world population, demand for food and feed, and climate change. It hypothesised that policy would become more focussed on global and regional responsibility for public goods, driving increased cooperation among nations, generations, and the public/private sectors. Research, technology development and training would focus on renewable energy; food, feed and water; climate and environment; communication, dissemination, and training.

Between the 1st and 2nd the most important difference is related to the trend of events that culminated in 2008, that have sorted out the 'noise' in the agenda and that have begun to focus policy and AKS more to issues that previously were considered of medium urgency.

The 1st made three recommendations: to shift to a knowledge-based bio-society; to develop new strategic frameworks for the planning and development of research; to build knowledge transfer systems that could reach all sections of society. In addition, a paramount, urgent need was identified for research that developed understanding of the key systemic linkages and feedbacks. While some progress has been made in relation to all four, it would be fair to say that the 'alert function' of science has not proven sufficiently powerful to overcome inertia or drive toward changes in direction.

It can be said that in the 2nd Foresight exercise there is thus a stronger emphasis on the drivers of policy, decisions, actions etc. In the 1st Foresight exercise the drivers were agreed at the beginning of the study. The 2nd has considered the drivers themselves to be problematic, and has taken into examination a broader set of drivers. We have given for instance much more emphasis to **policy drivers**, as the dramatic change we are experiencing puts into light problems that can be dealt with only in presence of strong public action, at international, EU, as well as national levels. In fact, our scanning exercise has shown that there are clear EU (or MS) pledges with regard to several aspects of the identified crisis, such as on food security, GHG emission cuts, millennium development goals, biofuel policies, or sustainable consumption. We have considered policy pledges such as these as drivers of the evolution of the systemic linkages in the crisis. And as coherence among policies is not only a matter of will but also implies technical and legal constraints or social and political resistance, they generate specific research questions.

We have noted that it is typically simply assumed that these pledges are coherent with existing institutional arrangements i.e. the 'rules of the game', such as trade rules or intellectual property rights regulation. Strong IPRs, for example, are claimed to be necessary to increase the rate of innovation and to reward innovative behaviour. Yet the evidence clearly indicates that so far IPRs, which are claimed by some firms as being a support to innovation, have not increased the rate of innovation: on the contrary they are closing the space for innovation, in two ways: by forcing the search for technological solutions along a narrowing pathway that excludes the options, knowledge and experience that lie outside IPR protection; and by concentration of control over which products are brought to market, for which purposes, and for whose benefit, over-whelming the engagement of wider sets of societal actors.
Current IPR provisions also set up some basic tensions. For instance, in relation to the IPRs that govern plant breeding, if you want IPRs to offer remuneration to plant breeders, you need a strong interpretation of UPOV 1991[1] i.e. interpretations that maximise Plant Variety Protection and limit farmers' privilege. If you want free circulation of farmers' seeds, then you need wide Farmers' privilege (but then it is hard to recover remuneration; thus breeding remains dependent on public research, funded by taxes). As we enter a period of rapid change more rapidly and potentially catastrophically than envisaged by the 1st Foresight, it seems more rational to seek to restore varietal diversity to farmers' fields, in order to increase resilience in the face of climate volatility, by arrangements that encourage a freer flow of biological material, data and information exchange.

As for **environmental drivers,** the trends put into evidence in the 1st Foresight have been confirmed but the sense of urgency derived from them has strengthened by the evidence of an exponential increase in the negative trends, and by the interdependent 2008 events. From the analysis of the more recent documents scanned, we observe that attention is focusing on the costs of inaction and on the need to remove the obstacles to action. In terms of policy, it can be observed that environmental drivers are still considered in isolation from rural development and agricultural issues; yet the concept of public goods and ecosystem services are increasingly linking sectors of intervention so far independent from each other. The gravity of environmental crisis forces also attention to the need to stimulate the development of new agricultural and rural paradigms.

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[1] Signature of UPOV 1991 is mandatory on entering membership of the WTO; members have a certain degree of freedom as to how they interpret its provisions in national law.

The 2nd Foresight also puts strong emphasis on **social drivers**. In fact, the current and probable future macro trends cannot any longer be ignored or under-valued. Ageing, migration, and trends in consumption affect deeply the evolution of food systems as well as rural/urban patterns. The more widely shared perception of risk, and growing appreciation of the scale of risk, makes trust one of the most important assets for societies facing rapid change. A lack of trust may amplify social concerns and turn into panic, as evidenced during the BSE crisis. Our exercise also has made clear the need to pay attention to, and to differentiate among, the impact of trends and policies on territories and on social groups. A clear example is large-scale biofuel policies, of which the impact is well documented on local communities and on gender (FAO 2008n; FAO 2008b). Another example is food policies in wealthy countries, that may create pressures on poor countries and shift production from subsistence crops to cash crops and thereby endanger the security that could be provided by local food systems. A third example is the impact of rural development measures on European countries, given that MS show strong differences in terms of administrative capacity, entrepreneurship, endowment of social and human capital. More generally, evidence drawn from the scanning exercise shows that social concerns and social analysis are often taken apart from "hard science" research and policy design.

With regard to **technological trends**, there are fields such as nanotechnologies, GMOs, nutraceuticals, nutrigenomics, that have introduced products and methods into the market but their impact on social organization has been rarely addressed, let alone their impact on the environment, risks of pandemic diseases, and on human health. The social distributional effects of new technologies are rarely taken into consideration: who benefits most from the introduction of patented technologies? How might they alter the balance between small farmers and large farmers, corporations and small and medium enterprises (SMEs)? From this observation we conclude that research should better address the linkages between science, technology and society.

Lastly, our analysis has shown that a discussion on **economic paradigms** is developing fast. In particular, it has made evident that to deal with the challenges of the next decades, economic theory and practices should look to the distribution of power, the roles of consumers and of citizens, the meaning of competitiveness and entrepreneurship in the context of sustainability, the meaning of 'resource' (this is particularly evident in the debate over endogenous versus exogenous rural development). Economic analysis also needs rapidly to bring into use valuation techniques and price data that show the true costs of economic activity so that economic policy decisions, at the level of farm enterprises, agri-business or government policy no longer externalize the natural resource, ecological or social costs of food and farming systems or of particular technologies. In addition, we note that regulatory, foresight, and investment processes and procedures at present are not able to value or do not adequately value either the risks or potential benefits of proposed options for action and technology. The danger is that continuation of false pricing will serve to amplify the positive feedbacks that are now built into food and farming systems.

2. Drivers

As part of the scanning exercise we have identified a great number of drivers. This has required a process of classification according to content, and to time horizons, and to the boundary of the theme taken into consideration. With regard to content we have classified drivers into a) environmental, b) economic, c) social, d) technological, e) policy. With regard to time and theme boundaries we have defined i) external drivers, ii) dominant internal drivers, iii) alternative/emerging drivers, and iv), probable but not yet determined drivers of transitions (high uncertainty). External drivers (**landscape**) are those whose change does not depend or depends only in part by decisions related to the object of analysis. Dominant internal drivers (**regime**) are drivers that constraint present evolution paths. Alternative/emerging drivers (**niches**) are trends with little impact on the current trends, but with the potential to be drivers of transition to new regimes, as they contribute to breaking or to replacing dominant drivers. Not yet determined drivers of transitions (**novelties**) are drivers not existing before, the evolution of which can follow very different paths.

2.1 Environmental drivers

Landscape environmental drivers

Climate change already was identified in the 1st Foresight as one of the most important drivers, with significant impact at short and in particular in the long-term perspective on agri-food prospects. The direct, predicted effects of global warning on different areas and their production possibilities and food security have been reported in several studies (FAO, 2008a,b,c,d,e,f,, etc). These figures refer to the previous "best estimates" of the projected global average, implying that if effective international action were taken, climate change could be prevented, although even with constant year 2000 emissions the "best estimate" until recently was for a further average temperature rise of 0.6 until the end of the 21st century adding to the 0.74 °C increase of the 20th century.

It is increasingly evident that unless more dramatic international action is taken to reduce global greenhouse gas emissions, holding warming to 2°C by 2050 is no longer possible. Most recent estimates indicate that global temperatures could rise by 4°C or over by the end of this century,' with increasing probabilities of runaway climate change. CO2 emissions from fossil fuels increased 1.0% per year during the 1990s, their growth rate accelerated to almost 3% per year from 200 to 2005. Recent technial estimates give no more than a 50:50 chance that global warming can be held to 2° C, assuming that GHG emissions peak by 2015, and decline by 6-8% a year from 2020 through 2040, and deliver complete de-carbonisation of economic activity by 2050 (Liverman, 2008). Giving ourselves higher odds would mean accepting steeper annual cuts.

If current trends continue, future emissions will exceed even the highest of the emission scenarios used by ICCP for simulations of future climate change. The situation is aggravated by the fact that an increasing fraction of emissions remain airborne due to a decreasing efficiency of natural sinks (particularly of the oceans) and result in rapidly growing atmospheric CO2 concentrations.

'Do nothing' is no longer an option while modest pro-active change would expose European populations to an unacceptable degree of vulnerability. The longer the process of change is delayed the greater the risk of catastrophic impacts, the weaker the resilience , and the higher the costs of adaptation. As the odds lengthen for above 2 °C warming, adaptation strategies will no longer be sufficient.

So, we face a global material situation of increasing physical and economic water constraints, increasing land competition, rising GHG emissions, and projected demand for food that requires that cereal outputs increase by 50% and meat outputs by 85% by 2030, with high probability of additional stress imposed by biofuels, pandemic diseases, food safety hazards, and a whole array of knock-on and spill-over effects that ratchet up the feedbacks. A 2°C temperature rise would cause a decline in yields of irrigated wheat (as presently constructed) ranging from 37 – 58% (Brown, 2008)

Developing countries are likely to suffer most in the near to medium term from the direct effects of climate change. The range of countries that seem likely to experience production declines in the near to medium term include Morocco, Australia, Zimbabwe, Venezuela, Chile, Greece, India.

Rain-fed agriculture, which covers 96% of all cultivated land in sub-Saharan Africa, will be particularly hard hit. By the 2020s, yield from rain-fed agriculture in some African countries could be reduced by as much as 50%. By the 2080s, land unsuitable for rain-fed agriculture in sub-Saharan Africa due to climate, soil or terrain constraints may increase by 30 to 60 million hectares. Crop yields in tropical regions are likely to decline even for small increases in temperature (IPCC 2007).

South Africa is SSA's largest economy. Regional climate models predict declining rainfall across southern Africa. Water resources in the Republic of South Africa already are fully used; thus the dilution effect is not any more possible and pollution is accumulating. There are increasing problems of toxic algae. Settlements in the republic are located on watershed divides (because that's where minerals are upthrust), and water already has to be pumped to where people, industries, and agriculture are located. Maize, a staple food, will become an increasingly risky crop. Although the country has perhaps the most sophisticated water legislation in the world, technical and organisational capacity to implement its provisions is weak and scientific infrastructure to address the new challenges is lacking (Turton, 2008).

Overall, in the medium to longer term, the production-depressing effects of climate change are likely to outweigh any production-boosting effects, with production shifting somewhat unpredictably from developing to developed countries, and from southern to more northern latitudes. What is more difficult to foresee are the secondary economic and production effects in Europe, as the vulnerability to climate change varies widely across regions and sectors. Mountainous regions, coastal zones, low lying deltas, Mediterranean and Arctic regions are the most vulnerable.

Agricultural growing seasons are becoming longer, especially in the North. This may favour introduction of some new crops but crop yields will be more variable because of projected increases in extreme weather events and presently unknowable pest and disease responses. The rate of change may make it impossible for many (plant, insect, bird, animal, tree, fish) species to adapt, decreasing agri-biodiversity, with presently unknowable effects. Soils will become more susceptible to erosion & negative off-site effects will increase.

Soil water retention capacity will decline, affected by rising temperatures and land management; desertification trends in some parts of Southern Europe are irreversible. Increasing water demand for agriculture, especially in the Mediterranean region, will increase the unsustainable competition for water with tourism and household uses. The growing season of forests is changing with an increased risk of forest fires in southern Europe. Unpredictable changes in disease vectors and pests will significantly impact human and animal health (EAA-press release, 2008). Pörtner and Farrell (2008) indicate that all species have a very narrow temperature-dependent performance window which determines their ability to grow, breed or forage; increasing temperatures causes narrower thermal windows for these functions. The IPCC (IPCC 2007) report predicts that a rise in temperature of 1°C would put up to 30% of all species at risk of extinction. Of particular concern are the wild relatives of major crops; and 16-22% of the wild relatives of 3 staple crops of the poor (peanuts, cowpea and potato) are threatened by extinction by 2050 (FAO, 2008i).

Reactive nitrogen depositions (nitrogen oxides, ammoniac) Atmospheric deposition currently accounts for roughly 12% of the reactive nitrogen gases entering terrestrial and coastal marine ecosystems globally, although in some regions, atmospheric deposition accounts for a higher percentage (Millennium ecosystem, assessment, 2005). Such gases, often transported over long distances, are mainly ammoniac (NH3), which comes as emissions from livestock manure/slurry as well as synthetic N-fertilisers and nitrogen oxides (NO and NO2, mainly from combustion of fossil fuels.) These emissions impact ecosystems negatively, especially those that have been developed under low-nutrient conditions such as flower-rich

meadows, but also forests and moor land. This may result in so-called "critical loads", which reduce biodiversity and lead to imbalances in the ecosystem (change of species, acidification, less stress tolerance of plants, higher N2O emissions with secondary effects on the formation of ground level ozone and/or secondary aerosols) (OFEV et OFAG, 2008). These critical loads were defined already in the Göteborg protocol 1999, and were fixed in conventions by UNECE. For most of ecosystems the critical load is around 5-25 N per kg/ha/year (UNECE, 2005). In many areas in Europe N-depositions are significantly above these critical loads already. Policy measures already adopted aim to reduce these loads. For example, for Switzerland it is recommended to reduce emissions by 50 % (to max. 10kg N/ha/year) (BAFU, 2008).

Water users face dwindling supplies and growing demand; that means more competition for a resource with no substitute! In some studies this is indicated as an even more serious problem than peak oil or peak phosphorus. Water is being withdrawn from groundwater at increasing rates, and the ratio irrigated areas / 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 water exploitation index (WEI) decreased in 17 EEA countries between 1990 and 2002, representing a considerable decrease in total water abstraction. But nearly half of Europe's population still lives in water-stressed countries. In Europe there are eight countries that can be considered water-stressed (Germany, England and Wales, Italy, Malta, Belgium, Spain, Bulgaria and Cyprus), representing 46% of Europe's population. In Cyprus the WEI exceeds 40 %[2].

Changes in the large-scale hydrological cycles mean that a vast water deficit is emerging, barely perceived by policy actors. Glaciers feeding rivers during dry seasons are melting; a serious problem is slowly building up in China, India, Bangladesh and South American countries; hydrologically inter-dependent drought and falling water tables are already a problem in the USA, southern and central Europe, in many parts of Africa and Australia. Water management remains reliant on institutions for managing water use functions, with only meagre progress toward creation of institutions for the management of hydrological cycles, catchments and river basins.

High probability consequences include increasing water scarcity, leading to insecurity in food supply (farmers losing to cities), further exacerbated by growing competition for water between agriculture, public water supply, industry and energy plants (Brown 2008, Bates et al. 2008). Further surface sealing as a result of continued infrastructure development and urban expansion, and increased precipitation intensity and variability, are projected to increase the risks of flooding and drought in many areas, further contributing to agricultural risks.

We note that, as areas shift from hydrological surplus to deficit, the 'dilution' capacity of water is reduced. Agri-chemicals will concentrate, nutrients will concentrate, concentration in turn leading to management challenges that will throw up radically new questions and make considerable additional demands on science and technology. Higher water temperatures are projected to affect water quality and exacerbate many forms of water pollution (eg. sediments, nutrients, pathogens, pesticides, salts) (Bates et al, 2008). And there is an urgent need to save water and increase water efficiency in all economic sectors. At present only about 45% of irrigation water reaches the crop, which as a consequence means that more crop is needed per drop of water (SIWI, 2008).

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[2] http://themes.eea.europa.eu/IMS/ISpecs/ISpecification20041007131848/IAssessment1116497549252/view_content

Soils are sources of concern as well. The global crop land availability is in decline as a result of population growth, soil degradation, soil losses and soil sealing, shrinking water resources, salt water intrusion into coastal aquifers, as well as rising temperatures that are leading to falling land productivity. The competition for land among agriculture, urban and industrial settlements will continue and will diminish in Europe the good agricultural land mainly around mega-cities. As an example the surface area of soil covered with an impermeable material (sealing) represents around 9% of the total area in Member States. Between 1990 and 2000, the sealed area in EU15 increased by 6% and the demand for both new construction and transport infrastructures because of increased urban sprawl continues to rise (EU Commission, 2006a). In contrast there are still large areas in Central and Eastern Europe where the soils are under-exploited because of legal uncertainties concerning land ownership. Competition for land of good quality is increasing, with an increasing number of countries seeking to ensure their own food security by purchasing or leasing land in other countries.

Biodiversity The loss of biodiversity, in particular of species and of genetic biodiversity, is still ongoing despite the measures and incentives provided on a range of levels (global, EU, national, regional). The Millennium Ecosystem Assessment 2005 reports: "The number of species on the planet is declining. Over the past few hundred years, humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history (*medium certainty*). Some 10–30% of mammal, bird, and amphibian species are currently threatened with extinction (*medium to high certainty*). Freshwater ecosystems tend to have the highest proportion of species threatened with extinction. Genetic diversity has declined globally, particularly among cultivated species."

Even advanced genomics is dependent ultimately on freely circulating genetic diversity in the wild as a feedstock. Existing forms of agriculture are critically dependent on maintaining capacity in-field to respond to climate surprises and shifts in biological relationships. The extreme narrowing of the global food system's reliance on a limited range of crop and animal species is of particular concern in this regard. Institutional constraints – such as DUS requirements – hinder the re-introduction of modern composite-cross or population-based seeds back into modern farming.

Loss of agri-biodiversity is associated with a range of causal factors, including destruction and fragmentation of habitats and the increasing use of land for non-agricultural purposes, emissions, agricultural intensification, etc. (Millenium Ecosistem Assessment, 2005). **Global energy demand i**s likely to continue grow steadily at least for the next decades. In a business as usual scenario, global primary energy demand is expected to increase by 50% between now and 2030; over 70% of this increase comes from developing countries, led by China and India. The primary driver of this surge in energy demand is GDP growth; population growth also drives energy demand, though not as much as GDP. The oil and gas import dependence is expected to increase, with increasing probability over time of disruption and price shocks. Concern about the world's energy security is growing.

Oil is forecast to reach peak consumption by 2020 or 2030, depending on pessimistic or optimistic scenarios. The robustness of the estimates has been questioned but current industry expectations are that by 2050 oil consumption will be lower that consumption in 2000 (141 EJ/year) in a 'pessimistic' scenario , and slightly higher in an 'optimistic' scenario. The food chain currently is largely dependent on **non-renewable fossil fuel energy**, and mainly on oil. The size of energy reserves (melting of the Arctic ice cap

may substantially increase the availability of reserves; coal gasification and related technologies may be used to exploit still abundant coal reserves)[3], and the depletion rate, but especially the global warming effects of continued reliance on fossil fuels, will affect strongly food production, distribution and consumption.

To sum up external environmental drivers are increasingly important for food production. Shortage of water, soils, energy, phosphorous will make food systems more vulnerable, especially in face of a growing food demand (Brown 2008, FAO 2008g). We are consuming the resources that underpin our existence much too fast – faster than they can be replenished. Yet our demands continue to escalate. The rate of growth in population is declining steeply but consumption continues to grow – and for at least a fifth of the world's population, needs to grow in order to life the poor out of misery. Yet our global footprint even now exceeds the world's capacity to regenerate, by an estimated 30 per cent. If our demands on the planet continue at the same rate, by the mid-2030s we will need the equivalent of two planets to maintain our lifestyles (WWF, 2008).

Regime environmental drivers

Agriculture and food contribute significantly to carbon emissions, energy consumption, biodiversity and erosion. Among the activities of modern food chains, that have an impact on environment, we can list: production methods; choice of species and varieties to be sold; transport distance and mode, efficiency and scale of energy use; packaging intensity and waste prevention and management practices; GHG emissions and air pollution linked to conservation and preparation; packaging and organic waste (OECD 2002, ETP-Food for Life 2008). Global food chains focus on a few species and varieties that are processed and sold globally, and with standardised characteristics, so marginalizing local species and diverse traits that, not having a market, tend to disappear. Loss of agri-biodiversity makes food systems more vulnerable to climate change, and because in general 'global varieties' depend strongly on external inputs (McInthyre et al, 2008).

Forests are changing in extent, composition and productivity, with large forested areas experiencing increasing degradation or destruction. Global net loss in forest cover is offset in some regions (including Europe) by re-afforestation. Penalties for forest destruction have had only weak effect on rates or extent of loss; more recent experimentation with incentives to reward forest users for 'destruction foregone', for sustainable forest management, and for exploitation of traditional non-timber forest products, require more time to evaluate. New opportunities for sustainable forest management are opening up in terms of carbon credits, bio-fuel markets and – especially in the tropics – for domestication and market development of wild or new non-timber forest products. In an increasing number of areas modern agro-forestry systems are offering new ways to reward multi-functional agriculture. The commercialisation of 2nd generation biofuels may offer new opportunities for multi-functional land use in currently marginal forest areas.

Agriculture is affected by climate change; but as the world's largest industry agriculture itself contributes significantly to greenhouse gas emissions (currently estimated by the IPCC at about 60% of anthropogenic methane and about 50% of nitrous oxide). In most European countries the most significant greenhouse gas

[3] For 21st century, there is still a huge amount of coal available, and it is quite feasible to convert coal into fuel. But it will generate CO2 emissions. Therefore the limit is given by the global warming problems rather than by oil reserves depletion.

contributions from agriculture are methane and N2O (nitrous oxide). Globally the contribution of methane and nitrous oxide emissions is projected to further increase, driven by growing nitrogen fertilizer use and increased livestock production in response to growing food demand.[4] There is no clear picture of the rate of change or pattern of net greenhouse gas emissions from agriculture in developing countries. In some areas methane production is still rising due to higher livestock densities. Several other factors also influence the greenhouse gas emissions such as the feeding regime, manure/slurry storage and application, use of artificial N-fertilisers and measures for soil protection (conservation and minimum tillage), use of fossil fuels in agriculture, scale of paddy cultivation, forest clearance or the use of moor land soils for arable crops, etc. (BAFU, 2008). All these accelerated processes are interacting with each other and the inter-action poses a big challenges to research and policy. A much more interdisciplinary approach would beneeded to tackle them.

Reactive nitrogen gases (nitrogen oxides, ammoniac) Agriculture is also contributing to the formation of reactive nitrogen gases. In some areas in middle Europe ca. 10 % of nitrogen oxides and more than 90 % of ammoniac is generated from inappropriate storage and use of nitrogen rich fertilisers and manure/slurry (timing, too high losses in the air due to slurry distribution systems). These practices typically arise from a lack of knowledge and lack of better (more expensive) equipment. The situation has not much improved in the last years (WHO/Europe, 2006).

Soil productivity and degradation On a world-wide level, the rate of growth in grain land productivity has been declining since 1990, from a 2.1% annual increase per decade, to 1.2% in 2000. It is expected to decrease further to 0.7% by 2010 i.e below projected rates of population growth (FAO 2008). Some authors, like Montgomery (2007) in his book "Dirt", mention that the loss of soil productivity, in particular through erosion, is running at about per 1mm a year, whereas the natural soil formation is about 0.02 mm/year; to compensate this loss would require 50 years. Although the generalisation of this figure has been questioned, the estimate is valid for many areas, also in Europe, that in the last years have been intensively cultivated.

Over the last few decades, there has been a significant increase in soil degradation processes. These processes are likely to further accelerate if nothing is done to protect soil. The European Commission has identified in its 2006 Soil Strategy (EU Commission, 2006a) several major threats, which seem likely to remain important, especially the following:

Erosion: 115 million ha (12% of Europe's total land area) are affected by water erosion and 42 million ha are affected by wind erosion, 2% of which are severely affected (Van-Camp L. et al., 2004).

This is mainly in arable land areas, related to a diversity of factors like soil tillage, rainfall, type of soil, type of crop, rotation (soil coverage) and cultivating systems. In several regions erosion programmes (e.g. with reduced soil tillage and rotations with more cover crops and leys) have started, but in many areas many soils are still affected strongly by soil erosion.

Organic matter decline: Around 45% of soils in Europe have low or very low organic matter content (0-2% organic carbon) and 45% have a medium content (2-6% organic carbon). Organic matter decline is an issue in particular in Southern Europe but parts of France, the United Kingdom, Germany, The Netherlands and Sweden are also concerned. This decline has a high relevance as it also diminishes the CO2 sink capacity of the humus in the soil. The intensification of arable production (shorter rotations, no or little return of

[4] FAO-High Level Conference on World Food Security: the challenges of climate change and bioenergy (Rome, 3-5 June 2008).

organic materials, too deep ploughing, too intensive tillage, etc.) will accelerate this process in the future despite some soil conservation programmes.
Compaction: estimates of risk areas vary between 36% and 32% of European sub-soils being very vulnerable and 18% moderately so, in particular in regions with more rainfall and heavier soils. The increasing use of heavy machinery might raise the risks of compaction, although now more and more better wheels are used.
Salinisation: around 3.8 million ha in Europe are affected by the accumulation of soluble salts. The most affected areas are Campania in Italy, the Ebro Valley in Spain and the Great Alföld in Hungary.
Landslides tend to occur more frequently in areas with clayey sub-soil, steep slopes, intense and abundant precipitation and land abandonment, such as the Alpine and the Mediterranean regions. Again this trend is accelerated by the intensification of pasture use.
Contamination: approximately 3.5 million sites may be potentially contaminated. 0.5 million sites are expected to be really contaminated and need remediation. Considered as risky substances are heavy metals (like copper in pesticides and also in some feed, cadmium in P-fertilisers, etc.) as well as other persistent organic contaminants such as PCB, dioxins, etc. Little is known about the long term impact on human health, including disruption of endocrine systems and foetal development, the accumulation in the food chain, and complex interaction among and with pesticide residues.
Costs of soil degradation: Erosion, organic matter decline, salinisation, landslides and contamination might be costing the EU up to €38 billion annually. As the costs of the other threats could not be assessed, the real costs of soil degradation are likely to exceed this estimate. The majority of these costs are borne by society [5] rather than by the polluter.

Water and agriculture (nitrates, phosphates, pesticides, antibiotics, etc.). As many lakes and rivers and the sea coasts are surrounded by agriculture, farming practices play an important role in maintaining the water quality and the landscape. In the Millennium Ecosystem Assessment 2005 it is reported that, “Globally, water quality is declining, although in most industrial purification countries pathogen and organic pollution of surface waters has and waste decreased over the last 20 years. Nitrate concentration has grown rapidly in the last 30 years. The capacity of ecosystems to purify such wastes is limited, as evidenced by widespread reports of inland waterway pollution. Loss of wetlands has further decreased the ability of ecosystems to filter and decompose wastes.”

One of the key concerns in many areas is a too high ***nitrate content in drinking and in ground water*** as a result of intensive agricultural practises, in particular related to arable and vegetable cropping systems and partially also intensive fertilised leys and meadows. The leaching of nitrates in the groundwater and in rivers can lead to a negative impact on the coastal areas. E.g. the river Rhine carries 25-30 % of the nitrogen released into the North Sea, which can result in oxygen scarcity and as a result in strong algae growth disturbing negatively the fauna and flora. If this nutrient load would be reduced by 50 %, the ecological state of the coastal areas could be improved by 25-30% (Prasuhn & Sieber 2005).

The European Groundwater Directive demands reversal of the upward trends in pollutants in groundwater. It is however difficult to provide sound proof of a declining trend because of uncertainties about the length of time taken for movement of the groundwater that is being sampled in the monitoring wells. However ,

[5] EU-COM Rapid Press release: Questions and answers on the Thematic Strategy on soil protection. MEMO/06/341.http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/06/341&format=HTML&aged=0&language=EN&guiLanguage=en

the monitoring networks in the EU indicate that "about 20% of groundwater bodies suffers nitrate concentrations over 50 mg/l, and 40% over 25 mg/l. Nitrogen from agricultural sources accounts for between 50 and 80% of the nitrates entering Europe's water. High nitrates concentration in groundwater deteriorates water quality inducing economic and ecological problems. Excessive amounts of nitrates in water can also generate eutrophication and are negative for human health (Peña-Haro et al. 2008)"

Beside the eutrophication with nitrate there are still many lakes in Europe affected by a high eutrophication by ***phosphates.*** Whereas in the past this was mainly casused by non-agricultural sources (washing detergents), today the main cause of phosphate accumulation in lakes is from high animal stocking densities with inappropriate application of farmyard manure/slurry, which lead to surface losses of phosphates into lakes, particularly in areas with high rainfall and with high phosphate reserves in the soil. This can lead to a higher biomass production in lakes, resulting in oxygen scarcity with multiple negative impacts on the aquatic ecosystems such as formation of toxic substances, fish dying etc. Although the nutrient load has reduced over the last years because of farm adaptation measures as well as the application of technical solutions like aeration of lakes, the problem for several lakes is still not solved (BAFU, 2008).

The ***contamination with pesticides*** in surface water, ground water and partly in drinking water, in particular after heavy rainfalls, is another problem area. In many countries studies show significant traces of these pesticides in the water. As there is no European wide complete monitoring of the use of pesticides it is difficult to get a clear picture of the contamination. However, recent studies show that certain pest and disease agents and by-products and/or metabolites of pesticides already have had a negative impact on water organisms below a concentration of 0,1 µg active substance, and this has to be taken into account.[6] Potential effects of human health of low level contamination with pesticides need to be studied.

Little is known about the ***pollution with veterinary medicines***, e.g. antibiotics, which find their way through slurry during rainy periods into the rivers or lakes, and their impact on the ecosystems in soil and water (OFAG, 2008).
Agriculture in future also can expect to experience surface water flooding from rainfall events that are increasing in intensity and frequency. These events heighten the risks that pollutants will be carried where they are not wanted. However, the development of 'ecosystem service payments' may offer some farmers additional income, with fields designated as spaces for temporary flood management.

Biodiversity and farming practises: Agriculture has a particular responsibility for biodiversity, as farming practices have a strong impact on the species and habitat diversity, on the genetic diversity within species and for functional diversity. Strong drivers which have contributed to the loss of biodiversity are linked to intensification: higher mineral fertilisation, high pesticides and herbicide use, new mowing techniques of grassland, intensification of number of mowing per year, high stocking densities (with a lot of nutrients and slurry), etc. In many areas this intensification is predicted to continue. Although in the EU and in many countries all kind of efforts have been made to stop this decline, under a variety of programmes and special incentives, the most recent OECD environmental outlook (OECD, 2008a) states: "If no new policies are introduced, the conversion of natural land to agricultural use will continue to be a key driver of biodiversity

[6] Common Position (EC) No 3/2008 of 20 December 2007.

loss. A considerable number of today's known animal and plant species are likely to be extinct, largely due to expanding infrastructure and agriculture, as well as climate change."

One of the biggest challenge is the risk of the loss of endangered species. In some countries special payments for rare traditional breeds and old varieties/crops have been introduced, but it is not likely that the trend of biodiversity loss has been really stopped on a large scale nor that it will be in the near to medium term.

Pesticide use Currently there are over 600 active pesticide substances on the EU market. In September 2008 In the EU, a new Regulation[7] came into force which lays down revised rules for pesticide residues. The new Regulation covers all agricultural products intended for food or animal feed. Maximum Residue Levels (MRLs) for 315 fresh products are listed, and these MRLs also apply to the same products after processing, adjusted to take account of dilution or concentration during the process. For each year the EU Commission reports on pesticide residues. The last public report of 2005 (EU Commission, 2007) indicates no significant reduction of pesticide residues for the period 1996-2005 (taking into account better detecting analysis in the laboratories).

Overall 54.3 % of the 62500 samples (mainly fresh products and cereals) did not have residues, whereas 41.0 % had residues below or equal to the MRLs. Differences are reported between the different product groups and import or export products. 4.7 % were above the MRLs. Currently worldwide more than 500 species of insects, mites, and spiders have developed some level of pesticide resistance. This has created an issue around the EU pesticide regulation 91/414, because the agri-chemistry industry argues for maintaining as many synthetic pesticides as possible in order to avoid resistance problems, whereas from a toxicological point of view several categories of active ingredients currently on the market have proven negative impacts on health and the environment.
The contribution of GM crops to reduction of the use of synthetic chemicals in crop protection has been mixed.

After 30 years' promotion, 2 traits in 4 GM crops in 6 countries account for 95 % of the area sown. The IAASTD (2008) findings on the contribution of GM crops to crop protection include:

- Robust evidence of resurgence of non-target & secondary pests
- Mixed evidence for reduction in synthetic insecticide use (dependent on cropping system)
- Robust evidence that Integrated Pest Management achieves steeper reductions.

The Millennium Ecosystem Assessment assumes that the modification of ecosystems can both increase or decrease the risk of particular diseases and pests, but that with an intensification of production also more pesticides will be used. Comparable resistance problems are known also for pesticides. An important role is played in crop protection by the breeding of more resistant or tolerant varieties. It remains unclear if in

[7] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005.

future the breeding of tolerant or resistant GM-crops, as proposed by the Technology Platform "Plants for the future" (ETP, 2007), will reduce significantly the use of synthetic pesticides.

Fertilizer efficiency: Between 1950 and 1990, world grain yield per hectare climbed by 2.1 percent a year, ensuring rapid growth in the world grain harvest. From 1990 to 2007, however, yield per hectare rose only 1.2 percent annually. This is partly because the yield response to the additional application of fertilizer is diminishing and partly because irrigation water supplies are limited. (Brown, 2008). Recent assessments (see, for example, White and Cordell, 2008) of the declining availability of phosphorus fertilisers, derived from phosphate rock, signal that the era of cheap fertilisers is ending. 2007-2008 saw a 700% increase in the price of phosphate rock, from US$50 to US$350 tonne in 14 months. Absent discovery and commercialisation of alternatives, declining stocks are likely within the next thirty years to give rise to increasing resource competition.

Pandemic pest and diseases in animal and plant production The movement of plant pests, animal diseases and invasive alien aquatic organisms across physical and political boundaries threatens food security in new ways in a climate-changing world. The higher mobility of people and globalisation of commodity and food trade increase the risks. Global public concern is growing across all countries and regions about the treats to human health in particular; the threats to food security are less well perceived. Countries are allocating relatively small but growing resources to detect, limit the spread, and improve the control of trans-boundary pests and diseases such as avian influenza, foot-and-mouth disease and locusts. Animal and plant health services and activities are, albeit slowly, developing greater capacity for cooperation and for regional and global risk management, early warning and control (FAO, 2008e)

In the ***livestock sector*** the development of diseases which were unknown a decade ago have appeared – SARS is an example – while others, such as foot and mouth disease, bluetongue and avian flu, have recently presented new challenges, reminding us that they remain very serious risks. The pattern of research funding is not well-matched to either existing or potential new patterns of disease, being concentrated on routine health threats that arise in intensive modern livestock (dairy, poultry) industries, rather than on the diseases that affect the animals and poultry on which the much larger number of small producers and poor consumers depend (IAASTD, 2008).

In a UN financed research report on "Industrial Livestock Production and Global Health Risks" (Otte et al., 2007) it is noted that the recent emergence of contagious human diseases from animals, such as Nipah in 1999, SARS in 2002 and the current epidemic of Highly Pathogenic Avian Influenza (HPAI), which has so far caused the death of nearly 200 people, have heightened public awareness of the potential linkages between wild animals, livestock production and global public health. The risk of disease transmission from animals to humans is likely to increase in future, as a result of human and livestock population growth, dramatic changes in livestock production, the emergence of worldwide agro-food networks, and a significant increase in mobility of people and goods as well as by the climate change.

One of the main concerns that arises is that the ***concentration of food animal production*** and the unregulated 'evolution' of densely populated livestock production areas not only result in major environmental burdens, but also generate significant animal and public health risks. Globally, pig and poultry production are the fastest growing and industrializing livestock sub-sectors with annual production growth rates of 2.6 and 3.7 percent over the past decade. In industrialized countries, the vast majority of

chickens and turkeys are now produced in houses in which between 15,000 and 50,000 birds are kept throughout their lifespan. Increasingly, quail, pigs and cattle are also raised under similar conditions of high density. The consolidation of poultry and pig production for reasons of competitive advantage has also affected the geography of food animal populations. Over the past 60 years, the geographic distribution of both pig and poultry production are increasingly concentrated in particular locations which are often geographically coincident. With the geographical concentration of pig and poultry production, there has been an associated increase in global trade and movement of pig and poultry meat products, which over the past decade has increased at an average annual rate of 4.0 and 5.3 percent, respectively Animal slaughter operations have also become concentrated, leading to larger average distances for transport to slaughter. Investigations in relation to the recent HPAI outbreak in the UK revealed that links in poultry production within one enterprise between facilities located in the UK and in Hungary involved movement of hatching eggs, birds and poultry products four times before the final product reached retail.

Recent experience has shown that disease containment in these areas is extremely difficult, and in the case of outbreaks can result in the ethically rather questionable destruction of millions of healthy birds. Reports of HPAI (highly pathogenic avian influenza) epidemics have increased over the past 10 years, with nearly as many minor and major epidemics having been recorded worldwide since 1997 as over the preceding 40 years. Moreover, the extent of the more recent epidemics has dramatically increased. The HPAI epidemics in Italy, the Netherlands and Canada have shown that in densely populated poultry production zones the control of HPAI poses a substantial challenge, even for high quality animal health services.

An unrecognized aspect of industrial food animal production concerns ***worker exposures to zoonotic diseases***. Human exposure to ‘silently’ circulating avian influenza is just as likely (or unlikely) to lead to emergence of a potentially pandemic strain as exposure to HPAI.

Cl***imate change has an important impact on transboundary pest and diseases*** both for plant production and animal production. Climate change will result in a higher probability of entry, establishment and spread of vector-borne diseases of animals, parasites of animals with free-living life stages, and pests of plants, diseases of fish and invasive alien aquatic species for the following reasons. The emergence of animal and plant pests and diseases and invasive alien aquatic species rarely can be foreseen, and lack of reliable data will make projections of the potential spread of such animal and plant pests and diseases and invasive alien aquatic species highly unreliable. Changes in rainfall, very complex to foresee, will have a major impact on outbreak and plague patterns of migratory plant pest species, in particular on locust species which are totally dependent on moisture and temperature. The scanning of documents showed, that there is clear evidence that climate change is altering the distribution, incidence and intensity of animal and plant pests and diseases such as Bluetongue, a sheep disease that is moving north into more temperate zones of Europe (FAO, 2008e).

Climate driven emergence of new ***plant pests and diseases*** is of concern, for instance, a new strain of wheat stem rust is threatening major wheat producing countries. It is estimated by FAO that 80% of all wheat varieties planted in Asia and Africa are susceptible to this new virulent wheat fungus; the fungus is spreading rapidly mostly by wind and could seriously lower wheat production (possible losses are estimated at 60 million t which is more than the entire annual US wheat production). This could lead to increased wheat prices and local or regional food shortages (FAO, 2008 o).

While drivers of ***plant pest*** *c*hange include increases in temperature, variability in rainfall intensity and distribution, change in seasonality, drought, CO2 concentration in the atmosphere and extreme events (e.g. hurricanes, storms), intrinsic pest characteristics (e.g. diapause, number of generations, minimum, maximum and optimum growth temperature of fungi, interaction with the host) and intrinsic ecosystem characteristics (e.g. monoculture, biodiversity) also affect change. Emerging pests are often plant pests of related species known as "new encounter" pests, which come into contact with new hosts that do not necessarily have an appropriate level of resistance, or are plant pests introduced without their biological control agents (in particular, insect pests, nematodes and weeds). (FAO, 2008e)

Climate change may also result in new **transmission modalities and different host species.** Animal disease distribution that will be strongly influenced by climate change includes bluetongue and Rift Valley fever as well as tick-borne diseases. The effects of climate change on internal parasites (gastro-intestinal parasites and liver fluke) may include changes in the distribution of the parasites and the intermediate hosts. In areas that become wetter, these will become of greater importance. Changes wrought by climate change on livestock infectious disease burdens may be extremely complex. Apart from the effects on pathogens, hosts, vectors and epidemiology, there may be other indirect effects on the abundance or distribution of the vectors' competitors, predators and parasites. Diseases caused by arthropod-borne viruses (arboviruses) include a large number of arthropod vector-borne (mosquitoes, midges, ticks, fleas, sand flies, etc.) that are often zoonotic, predominantly RNA viruses, that can cause haemorrhagic fevers or encephalitis in humans. They mostly spill over from natural reservoirs such as bats, birds, and rodents or other wild mammals. Emerging arbovirus disease complexes (particularly those in evolutionary flux) are by far the most important (climate change is only one factor altering disease ecologies). This group includes dozens of relevant disease complexes, which may be broken down into at least half a dozen subgroups, of which a number are chiefly animal diseases, others are of mixed animal and public health concern, while a third consists of mainly human diseases with an animal health dimension (FAO, 2008e).

In the EU Action Plan on Animal Health and the **EU Animal Health Strateg**y 2007 (EU Commission, 2007)) it is emphasized that animal health is of increasing concern. This concern stems from the public health and food safety aspects of animal health but also from the economic costs that animal disease outbreaks can trigger and the animal welfare considerations, including the implications for disease control. Therefore the EU has considered in its action plan, the EU animal health framework, the prioritisation of prevention and surveillance measures and research. Furthermore the European Technology Platform for Global Animal Health's strategic research agenda has a strong focus on animal health issues such as the prioritisation of animal diseases/infections, regulatory issues and research needs (ETP, 2007). Implementation will pose numerous as yet unresolved challenges.

Niche environmental drivers

Because agriculture can offer solutions to climate change, this sector is beginning to be regarded as a strategic asset (Hart, 2006).

Agriculture is a major provider of environmental services, although these services are generally unrecognised and unremunerated (sequestering carbon, managing watersheds, and preserving biodiversity) (World Bank, 2007). One of the major challenges that the new rural–urban context faces is increasing society's acknowledgment and willingness to pay for the sustainable provision of ecosystem services. The problem is how to convince households, cities, food and farming industries and farm enterprises of the need to pay for something that until recently was taken for granted and usually free.

The development and implementation of **new agricultural production/distribution/consumption visions** (The Soil Association 2007; International Commission on the Future of Food, 2008) could change consistently the rate of emissions of greenhouse gases, in some cases reversing the carbon/energy balance. However, appropriate drivers of such reversals are not currently in prospect.

More efficient use of resources and inputs Low external input sustainable farming system (LEISA) and further advancements in the scientifically-informed development of organic farming systems show strong socio-technical possibilities and potential for reducing energy use.
Examples include: the optimal use of legumes in the rotation or as green manure, and in integrated intercropping systems. Nitrogen leaching rates in organic arable fields are reduced by 35% to 65% when compared with conventional fields (various European and US studies). In a 30-year field experiment in Switzerland, the active ingredients of sprayed pesticides in the organic arable crop rotation were only 10% that of the identical integrated and conventional crop rotations (in the organic crop rotation, copper, plant extracts or biocontrol agents were used, while in the integrated and conventional crop rotation herbicides and pesticides in compliance with IPM standards were used (IFOAM and ISOFAR, 2008).

Further development of organic and low external input farming concepts A ban on use of nitrogen from fossil fuels and its replacement by leguminous and organic nitrogen could reduce GHG emissions considerably. For some crops and livestock products such as cereals, grass-clover and milk this would result in a lower total emission of greenhouse gases (GHG) per kg product in organic compared with conventional systems; for other crops with relatively low yields such as organic potatoes, however, the organic system needs further improvement to reduce energy use and GHG emission per kg of product (Halberg, 2008). Organic farming techniques such as shallow ploughing, recycling of livestock manure onto arable cropland, composting techniques, integration of green manure, catch crops and cover crops, agroforestry and alley farming as well as diversified crop sequences all reduce soil erosion considerably and lead to increased formation of soil humus. This often results in considerable annual carbon gains (between 40 kg and 2000 kg of C per hectare.

A big mitigation potential has been shown in conservation tillage measures. The IPCC (2000) estimated that conservation tillage can sequester 0.1–1.3 tonnes C ha-1 y-1 globally, and feasibly could be adopted on up to 60 percent of arable lands. These benefits accrue only if conservation tillage continues: a return to intensive tillage or mould-board ploughing can negate or offset any gains and restore the sequestered C.

Higher soil organic matter content as well as greater diversity at landscape, farm, field, crop and species level might help organic and LEISA farmers to adapt more effectively to increasingly unpredictable weather conditions both locally and globally (IFOAM and ISOFAR, 2008). Soil carbon sequestration could be even further increased when cover crops are used in combination with conservation tillage (FAO, 2006).

Similar results with regard to carbon sequestration have been reported from organic farming, as organic practices have evolved since the early years of the twentieth century. Organic farming increases soil organic carbon content. Additional benefits are reported such as reversing of land degradation, increasing soil fertility and health. Trials of maize and soybean reported in Vasilikiotis (2001) demonstrated that organic systems can achieve yields comparable to conventional intensive systems, while also improving longterm soil fertility and drought resistance (FAO, 2006). In a long-term US study of Agricultural Research Service (ARS) from 1994 to 2002 (Teasdale, 2007), a comparison was made between light-tillage organic corn,

soybean and wheat with the same crops grown with no-till plus pesticides and synthetic fertilizers. In a follow-up three-year study with corn with no-till practices on all plots, the organic plots were shown to have had more carbon and nitrogen and to yield 18 percent more corn than the other plots did.

Local and regional biodiversity programmes

The introduction of ecosystem service support system on regional and local level, in some countries also under Natura 2000 programmes, have contributed to an improvement of biodiversity, although not for all species. In particular the improvement of ecological quality of habitats and their inter-linkages between each other through specific support systems through specific payments systems is promising.

Disruptive environmental drivers

Acceleration of climate change

A stronger acceleration of the climate change in combination with a rising demand and higher costs for water and fertilisers will make agriculture and food systems more vulnerable and will impact poor consumers everywhere. The most immediate, direct and strongest impacts will be experienced by small farmers in poor regions and by the estimated 850 million already hungry consumers (FAO, 2008a). Recent FAO estimates are that the 2008 price spikes drove an additional 40 million into hunger; the MDG goal of reducing hunger by a half by 2020 no longer seems an achievable prospect.

The climatic impacts could lead to a dramatic scarcity of freshwater in some regions. This crisis may in turn fuel existing internal or interstate conflicts and social conflict and heighten competition among different users of the scarce water resources. In certain circumstances the conflict could culminate in violent clashes. The same conflict constellations as drivers of international destabilization can be caused by other climate change related impacts like food scarcity, storm and flood and migration (including their linkages).

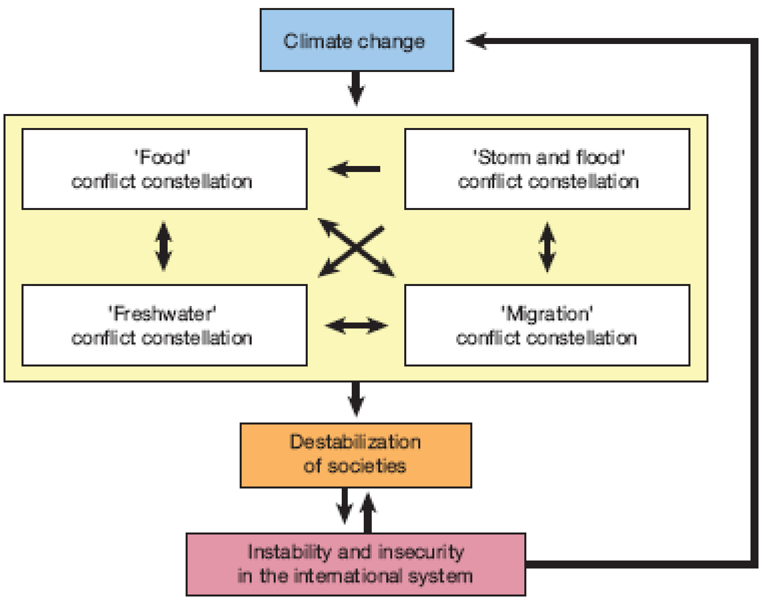

Figure 2 - Conflict constellations as drivers of international destabilization. Source: WBGU, 2008[25]

Broad resistance to herbicides in major crops

There are a growing number of cases of herbicide resistance. The first case of herbicide resistance in weeds was identified in 1964. Currently there are recorded more than 150 resistant grass and broadleaf weed

biotypes in about 50 countries world-wide. In a recent publication on weed science[8] the number of resistant weeds was listed as 323 resistant biotypes and 187 species. Researchers and industry groups like the "Herbicide Resistance Action committee" and other groups in Europe, are trying to develop recommendations to reduce the risks of herbicide resistance.[9] However, it remains unsure if these strategies will be successful, when in reality, because of the commercial power of a few world-wide companies, 80 % of the GM cropped area is designed to be tolerant or resistant to glyphosate. Glyphosate resistance in weeds is a problem that is unique to GM cropped areas and it is a problem that is growing rather rapidly. A study by Iowa State University (Micheal, Owen & Zelaya, 2005) concludes "It is clearly documented in studies that the widespread adoption of herbicide-resistant cultivars, particularly glyphosate-resistant crops, has dramatically impacted weed communities. Weed populations shift to naturally resistant species, species with inherent biological characteristics that make the populations difficult to manage (eg. delayed emergence), and the evolution of herbicide-resistant biotypes are real, as are the immediate economic issues attributable to the adoption of herbicide-resistant crops and the concomitant use of the herbicide. The speed at which these changes have occurred has caused significant concern. However, given the level of selection pressure that these crop production systems impart on the agro-ecosystem, it is not surprising that the changes in the weed communities have occurred as rapidly as demonstrated. These trends, weed shifts, tolerance and evolved resistance, are not predicted to slow in the immediate future".

Ecologists warn therefore that this strong dependency on a cultivation system based on one active herbicide substance should be drastically changed in order to reduce the risk of large scale resistance break-down that would significantly affect food security.

Widespread pandemic diseases and resistance against antibiotics

One of the disruptive environmental drivers might be the occurrence of widespread pandemic diseases associated with climate change, in combination with more industralized and centralized livestock systems and globalised trade. In many countries and areas biosecurity measures and disease monitoring are underdeveloped or non-existant. There is a growing risk of accelerated and uncontrollable spread of pandemic diseases in particular at the interface of people, domestic animals and wildlife. Although WHO, FAO, OIE (World Organisation for animal health) and also the EU in their Animal Health Strategy put a much higher emphasis on the prevention and international cooperation between governmental agencies and organisations, some researchers question if this is effective enough. As it was written in a report by the Wildlife Conservation Society, New York (Cook, 2005) the problem is that "internationally no agency is responsible for, or capable of, monitoring and preventing the myriad diseases that can now cross the borders between countries and species. More specifically, no organization has the mandate to pursue policies based on a simple but critically important concept: That the health of people, animals, and the environment in which we all live are inextricably linked."

Although modern industralised farm practices maximize food production, they also make livestock more susceptible to illness. Infection spreads quickly through crowded animal pens, and growing antibiotic resistance makes fighting disease more difficult. Many farms now routinely mix antibiotics with animal feed to avoid transmitting illnesses, and selective breeding for specific traits often predisposes animals to

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[8] http://www.weedscience.org/In.asp

[9] http://www.pestresistance.com/Home/tabid/121/Default.aspx

conditions requiring repeated antibiotic treatment. Such increased antibiotic use is helping to create dangerous drug-resistant superbugs that may endanger both animals and humans (Cook, 2005).

In Europe on January 1, 2006, the European Union banned the feeding of all antibiotics and related drugs to livestock for growth promotion purposes. Until now there is no clear data that indicate that the antibiotic resistance problems will be significantly reduced in the future, although several research projects and surveillance programmes have been put in place (De la Mata, 2008). Experts propose more coordinated actions both in the policy field and in research because resistance is currently outrunning antibacterial research and development, leading to a high risk situation that needs addressing urgently; (2). The lasting ability to treat infections of any new antibacterials, and hence their health impact, will be greatly reduced if factors leading to development of resistance are not contained by the time they reach the market; and (3) there is no guarantee that that these drugs will be discovered, nor developed in time (ETAG, 2006).

Environmental drivers: summary

The 2nd Foresight panel notes that there is **no organised body or procedure for continuous monitoring** of the environmental drivers and trends noted above, at national, EU or global levels, nor a **platform** that would enable science to play its alert function (in a way comparable to the successive IPCC reports). Very considerable sums of money are being mobilised in the name of food security, technological innovation and nature protection yet the data on the systemic interactions between agriculture, natural resources and ecological functioning and human health are not readily available to support the investments made or promised nor to allow decision-makers to decide appropriately among the range of options. Table 1 summarises the 2nd Foresight Panel's analysis of environmental drivers.

Table 1 Environment drivers

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Interlinkage with other drivers	Research needs
landscape	Climate change	up to 4° celsius in the most favourable scenario	acceleration due to synergies among drivers			methods for local impact and enhanced understanding of people's responses
landscape	reactive nitrogen deposition	Steady		Trespassing the critical load	Climate change; agric models	Impact on ecosystems
landscape	Water	decreasing rate irrigated areas / population; increasing withdrawal rate		large scale drought; water wars	agricultural models; use for non agricultural purposes	Sustainable use and governance of water and watersheds
landscape	Soils	loss of farmland and natural soils	rates of loss of non urban land	collapse of existing rural-urban compacts	urban development	System biology applied to soils
landscape	Biodiversity	Declining number of species		collapse of local agri-food systems	food production	Successful biodiversity concepts, tools and policies
landscape	oil reserves	peak by 2020-2030	impact of new technologies and saving habits	catastrophic local events due to shortage	food production; biofuels; food prices	Sustainable consumption and distribution systems
regime	agriculture and greenhouse emissions	relevant impact; not clear if it is decreasing; reactive nitrogen gas have improved in some areas	impact of Kyoto measures; diffusion of low impact techniques		Agric. models; food and agric policies	Adaptation measures
regime	agriculture and soil degradation	erosion, contamination, loss of organic matter	Impact of different tillage systems and high crop inputs		Water, fertiliser use Pesticide use	Appropriate soil care and nutrient management; application of system biology to agric practices
regime	Agriculture and water quality	water quality is declining	impact of specific policy measures		agric models; food and agric policies, Fertiliser use	Appropriate soil care and nutrient management; application of system biology to

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Interlinkage with other drivers	Research needs
					Pesticide use	agric practices
regime	Agriculture and biodiversity	transformation of natural land into agricultural land is increasing		loss of species essential to agri-food systems	Pesticide use Fertiliser use (intensity) Structural changes	Biodiversity based business; enhanced understanding agri-ecosystems
niche	agriculture and envt services	increasing when paid	are they becoming part of routine practices?			Understanding business models and intervention philosophies to improve environmental services
niche	New agric visions	proceeding slowly	will they become mainstream? To what extent research can help them to become mainstream		technology drivers; values prevailing in societies	Supporting emerging of new agric visions
niche	Resource-efficient agriculture (LEISA)	Increasing	when will they scale up?	catastrophic events may stimulate their growth	resource depletion	Supporting LEISA, Further development organic farming concepts
niche	Local biodiversity programmes	Increasing	when will they integrate agricultural activities?		urban development	Eco-eco approaches

2.2 Economic drivers

Landscape economic drivers

The **economic crisis** that burst loose this year is interpreted by the 2nd Foresight Panel not as a 'normal crisis' but as a systemic perturbation with deep roots. Current OECD estimates are that the GDP for the OECD countries as a whole will fall 0.3 percent year-on-year in 2009 before recovering slightly to grow by 1.5 percent in 2010. The average unemployment rate in the OECD area, estimated at 5.9 percent this year, is forecast to climb to 6.9 percent next year and reach 7.2 percent in 2010. Macroeconomic trends affect the vulnerability of food systems, as stagnation or recession impact on incomes; also income distribution affects food security, financial trends affect commodity prices and exchange rates and therefore terms of trade[10].

The outcome of political debates about 'restoration' or 're-design' of global economic and financial architectures will determine the future economic landscape. In any event, a global shift in the balance of economic power is likely in the near to medium term, reflected in an accompanying shift in decision-making powers. It is unclear whether such a shift would signal greater attention in global and regional economic policy to global public goods, climate change, and ecological functioning.

Energy prices are one of the causes of increasing food prices, and of increasing vulnerability of food systems. In 2008, oil prices reached a peak of 140 US$/barrel; the average price in the preceding two years had been below 70 $ and currently is hovering around US$50. The volatility is in itself damaging, creating uncertainty in investment planning, and affecting most those least able to adjust to the rapidity of change.

There is a clear link between food prices and oil prices. The reason is that the present agricultural production, trade, processing, distributions and retail systems, and fossil fuels, are tightly coupled systems, and this is an important driver of the vulnerability of food provisioning (DEFRA, 2008). There is at present no alternative energy source for commercial agriculture and food systems. Productive farm systems less dependent on fossil fuels, and coupled to localised food provisioning, are operating within the EU but they have attracted relatively little policy attention and are routinely challenged by vested interests.

Regime economic drivers

During the last two years the agri-food sector has been hit by a shock of huge proportions, that has made the 'food crisis' emerge as a global agenda item and triggering calls for action both in the short term – to mitigate the impact of the crisis - and in the mid to long term to get at the roots of the crisis. Events have shown also that the food crisis is closely linked to the energy and environmental and financial crises.

Food prices increased sharply in 2008, and the FAO food price index (1998-2000=100) broke the threshold of 200 for the first time. Prices since have fallen off the peak but there is conviction among experts that the average levels will stay above the past average (OECD-FAO, 2008), and that there will be increasing price volatility.

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[10] Tumbling coffee prices are prompting some exporting countries to stockpile the bean in an attempt to push prices higher as the global financial crisis makes it harder for traders to secure credit to buy inventories. Coffee exporters in Indonesia, the world's largest producer, in November threatened to halt shipments until prices recover and said they were seeking government help to address the crisis (http://www.ft.com/cms/s/0/943e09de-9a08-11dd-960e-000077b07658.html).

Among the causes, the following are frequently cited: adverse weather conditions (see climate change); support to biofuels (especially in the USA and in Brazil; wheat, maize and vegetable oil prices are likely to increase respectively by 5%, 7% and 19%) (International Commission for the future of Food 2008, Mitchell 2008, EU Commission 2005); increasing demand, both for food and fuel as well as for industrial purposes, in emerging countries (notably China and India) (OECD-FAO, 2008), caused by both population growth and nutritional transitions (shift to protein rich diets and processed and packaged food) (Brown, 2008); speculation on commodity markets (Fisher Boel, 2008);and reduction of food stocks (IFPRI[11]; DEFRA, 2008)

Global consumption of food has increased. In China, the volume consumed has more than doubled for almost all food types from 1990. In India and in Brazil the increase has been between 10% and 70% (according to different types of food). According to FAO [FAO, 2008d] projected population and socio-economic growth will double current food demand by 2050. To meet this challenge, cereal yields need to increase by 40%, net irrigation water requirements by 40-50%, and 100-200 million ha of additional land may be needed.

Between 2004 and 2006, **global food spending** grew by 16 percent, from US$5.5 trillion to 6.4 trillion (IFPRI, 2008). At world level, average per capita consumption of food has increased, on average from 2280 Kcal/day per capita to 2800 kcal/day. However, there are strong **inequalities** in access to food. Developed countries consume more than 3000 kcalories/day (well above the necessary intake) and developing countries consume on average 2500Kcal/day. Africa is well below this level, at 2200 Kcal/day. Despite improvement in relative terms, from 1991 to 2001 the number of undernourished people in the world has increased from 770 to 820 millions[12]; FAO estimates are that the 2008 food crisis pushed an additional 40 million into hunger.

The **structure of the food system** has changed, with the growing power of international corporations. The dominance of food retailers is growing particularly fast[13]. Between 2004 and 2006, sales of food retailers have increased of about 40%, while food processors and traders' sales grew by about 13% and agricultural input industry 8% (IFPRI, 2007). Food retailers have been able to anchor producers, processors and distributors into global commodity chains under their command through procurement and by means of safety and quality standards set by the private sector. While belonging to a global commodity chain can open big opportunities for some producers, such standards create high barriers to entry into the market for small producers.

The **food industry** deals with an increasingly limited range of raw food inputs, which is transformed to meet an increasingly diversified demand. While emerging countries represent a huge market for mature products, product innovation is directed increasingly towards health, taste and ethical concerns in more mature markets. Among the highest rates of growth are found 'food minus', that is, products that do not contain substances potentially harmful for health (fats, chemical residues, salt), and 'food plus', that is, products enriched with substances claimed to be beneficial for health (omega3, vitamins, pro-biotics and

[11] Effects of food prices: http://www.ifpri.org/pubs/fpr/pr19.pdf

[12] Source: UN mdg, http://mdgs.un.org/unsd/mdg/

[13] For the most recent data and analysis, see Farnworth, Jiggins and Thomas. Eds. 2009. Creating Food Futures. Trade, Ethics and the Environment. Gower Publishing Ltd. Aldershot, U.K.

prebiotics[14]). There is also a growing attention to organic food and to specialty food with a clear geographical origin. The domestication of wild and semi-wild foodstuffs, and the commercialisation of local or traditional foods and animal species represents a huge potential growth area but it is unclear how this might be realised, given the current structure and interests of the food industry, and if local small scale producers, traders and enterprises would be able to benefit (IAASTD, 2008).

Food waste In the developing world, up to 40% of food harvested can be lost before it is consumed because of inadequacies in procurement, food processing, storage and transport. In Europe, evidence shows that consumers throw away considerable amounts of food that could be eaten, up to 30% of all food purchased (EU Commission, 2006).

Fertiliser market and prices As reported in the current FAO Outlook on the World fertilizer market (FAO, 2008m), the high commodity prices experienced over recent years led to increased production and correspondingly greater fertilizer consumption, reflected in tight markets and higher fertilizer prices at the start of the outlook period. At global level it is anticipated that in the near term there is an ample supply of all three major fertilizer nutrients. Supplies of nitrogen and phosphate are forecast to grow while those of potash are likely to remain more or less stable. Experts expect that the growing demand of fertilisers will mean that prices remain high. In 2008, for example urea, a type of granular nitrogen fertilizer, jumped to $505 a ton from $273 a ton in 2007. Manufacturers are scrambling to increase supply. At least 50 plants to make nitrogen fertilizer are under construction, many in the Middle East where natural gas is abundant, and phosphorous and potassium mines are being expanded. But these projects are expensive and time-consuming, and supplies are expected to remain tight for the coming year[15].

Phosphorous peak The current FAO outlook does not mention that phosphorous reserves are limited. The Global Phosphorus Research Initiative (GPRI) notes that phosphate rock is a non-renewable resource that takes 10-15 million years to form from seabed to uplift and weathering. Current known reserves are likely to be depleted in 50-100 years. Phosphate rock reserves are geographically highly concentrated, and thus access is under control of a small number of countries, including China, Morocco (which controls Western Sahara's reserves), and the USA. The USA has approximately 25 years of physical reserves remaining; economic access is likely to peak well before the physical resource is exhausted. China recently has imposed a 135% export tariff on phosphates to secure its domestic fertilizer supply, which in effect has halted most exports. Western Europe and India are totally dependent on imports. Like oil and other natural resources, the rate of production of economically available phosphate reserves will eventually reach a peak, followed by a steep decline and subsequent ongoing decline of output. An analysis based on industry data shows the global peak P is expected to occur around 2034. While oil and other non-renewable natural resources can be substituted by other sources, phosphorus has no substitute in food production.

The price of phosphate rock rose in 2007-2008 by 700% over 14 months. While demand continues to increase, the cost of mining phosphate rock is increasing due to transport costs, in addition to a decline in quality and greater expense of extraction, refinement and environmental management The expansion of

[14] Prebiotics are non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon, and thus improves host health. Probiotics are Live microorganisms which when administered in adequate amounts confer a health benefit on the host.
[15] Shortages Threaten Farmers' Key Tool: Fertilizer. *The New York Times*. April 30, 2008

crop-based bio-fuels is increasing the demand and hence price of phosphate rock; intensive crop-based bio-fuel production is increasing fertilizer runoff (and hence pollution).

It can be assumed that in particular small farmers in poor regions will be affected by higher fertiliser prices, as stated in a an article in the Guardian in August 2008[16] "A global fertiliser crisis caused by high oil prices and the US rush to biofuel crops is reducing the harvests of the world's poorest farmers and could lead to millions more people going hungry, according to the UN and global food analysts. Optimism that soaring food commodity prices could lift millions of developing country farmers out of poverty and lead to more food being grown have been dashed, says the UN. This is because small farmers either consume their own crop or have no access to global markets to take advantage of the higher food prices."

Farm labour market One scenario, developed for the agricultural machine industry AET (ETP&AET, 2006), assumes that farm consolidation drives a higher need for non-family farm workers and that seasonal workers will have growing importance in EU 25. The depopulation of rural areas might lead to a farm labour shortage of a peculiar kind. The analysis offered by the scenario, when read alongside the other documents scanned by the 2nd Foresight, sets up a paradox. The interdependent crises of 2008 are driving up unemployment in the cities; the structure and interests of highly industrialised agriculture have driven skilled, permanent labour out of farming; yet there is an increasing demand for temporary, seasonal, unskilled, low wage labour in farming, a demand that city dwellers, even if unemployed, do not want to satisfy. The result is an increase in social tensions in both sectors. In consequence, leading farmers are investing in robotics, high-tech machines, complex production processes and strict production regulations that require skilled labour to operate and maintain. Skilled labour increases farm wage costs and the costs of training (ETP&AET, 2006).

[16] Soaring fertiliser prices threaten world's poorest farmers vom 12.08.08 http://www.guardian.co.uk/environment/2008/aug/12/biofuels.food

Source:

Niche economic drivers

High value markets, often linked with regional marketing projects, give opportunity for farmers to go for more sustainable production with less inputs and lower dependency on dominant market actors. Furthermore, economic demand for organic products is still considerable and growing (IFOAM and ISOFAR, 2008). In many countries the stronger demand for more authentic and more local food allows farmers to reduce the use of inputs and to convert to organic or LEISA farming systems.

As a countertendency to the trend toward concentration and homogenisation, **alternative food chains** (based on sustainable patterns of production, distribution and consumption) are emerging everywhere, but especially in industrialised countries (BIB). They have developed profitable market niches, that continue to expand and, to some extent, to move into the commercial mainstream. However, their current niche status means that alternative food chains are not seen by policy and dominant market actors as offering ways forward into the future. Yet they represent a source of diversity that may help the system to resist shocks in the near future. In recent years more, and more direct links, between consumers and farmers have been developed, e.g. with farmers markets and community supported agriculture, increasing the social resilience of food provisioning.

Table 2 summarises the 2nd Foresight Panel's analysis of economic drivers.

Table 2 Economic drivers

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Interlinkage with other drivers	Research needs
landscape	Global economy trends	In 2008 we have entered into a structural crisis, according to many observers	Capacity of the States to enact appropriate measures to counter the crisis	Collapse of the system; wars	Unemployed back to agriculture; changing consumption patterns	Effects of economic trends on food security and urban rural relations
landscape	Energy prices	High volatility; price will depend on oil reserves and economic trends		Local shortages turning in system collapse	CO2 emissions, industrial agricultural model	Effects of energy process on global food systems and food security
regime	Agr-ifood patterns: production, trade, distribution, consumption, waste	Increasing impact on the environment			Climate change (via energy consumption), biodiversity (via standardisation of eating habits), pollution (packaging and waste)	Transition mechanisms and costs
regime	Alternative agri-food visions	Spreading	Are they economically realistic?		Agricultural knowledge systems	Giving alternative visions a critical mass
regime	Food prices	Structural trend to stand at a higher level		Collapse of local food systems	Food production and consumption	Monitoring systems for food prices; safety belts
regime	Fertiliser market and prices	Supply is forecasted to grow; prices will remain high; nitrogen production plans under construction	Strong dependency on oil: how supply will be affected by oil shortage?	Global fertilser crisis (high prices) impact mainly small farmers	Agricultural models, oil prices	Reduced input agriculture
regime	Farm labour market	Increasing demand for non-family farm workers and seasonal workers		Concentration of migrants in rural areas; social tensions;	Migration flows; prevailing models of agriculture; ag prices; agri-policies	Social integration, access to land
regime	Food waste	40% of food harvested lost before eating			Food security; consumption models	Reshaping food consumption and distribution patterns
niche	Alternative food chains	Trend to growth	Which role for AFN? Just niches or will they scale up?		Food production and consumption models	Overcoming barriers to scaling up
niche	High value market segments	Growth	How will they evolve with the economic crisis)		Global economic and social trends	High value segments as incubators of green innovation

2.3 Social drivers

Landscape social drivers

Total world population was around 6.5 billion in 2005 and is projected to be 9 billion by 2050. By 2005 the **urban population** has overtaken rural population, reaching a 51% share of the global total. From 1975 to 2015 the number of people in urban areas is projected to more than double and the number of mega-cities to increase[17].

According to the 2006 Revision of World Population Prospects[18], by 2045 the number of **older persons in the world** (those aged 60 years or over) will likely surpass, for the first time in human history, the number of children (i.e. persons under age 15 years). This crossover is the consequence of the long term reductions in fertility and mortality.

Together, these social transitions represent unprecedented changes in people's – and societies' – relationship to food and farming. A rapidly decreasing proportion of the world's population handle raw food or are aware of even basic facts about how food is produced and transformed. The political power of farmers has been transformed as their numbers decline and as the power of food and agri-chemical industries increase.

The number of **international migrants** is increasing. In 2005 the estimated number was about 190 million; in 2000 it was estimated to be about 176 million[19]. In Europe, the official number in 2005 was 64 115 850[20].

Inequality also is increasing. The OECD's report Growing Unequal (OECD 2008h), concludes that the economic growth of recent decades has benefited the rich more than the poor. In some countries, such as Canada, Finland, Germany, Italy, Norway and the United States, the gap increased also between the rich and the middle-class[21]. According to the OECD report, a key driver of income inequality has been the number of low-skilled and poorly educated who are out of work; this driver is likely to become even more significant in the near term. More people living alone or in single-parent households also have contributed to the trend toward greater social inequality. Some groups in society until 2008 have done better than others. Those around retirement age have seen the biggest increases in incomes over the past 20 years, and pensioner poverty has fallen in many countries. The 2008 crises have brought this transition to an abrupt halt and pensioner poverty is likely to rapidly increase in the near to medium term. In contrast, child poverty has increased[22]; and is likely to worsen in the near to medium term.

Needs and expectations of EU citizens are quickly evolving. What rural areas will be in the future in Europe mostly depends on what European society demands of these territories. Environmental, social or economic priorities also will determine the objectives of agricultural and rural policies.

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[17] http://maps.grida.no/go/graphic/urban_population_status_and_trends

[18] http://www.un.org/esa/population/publications/wpp2006/FS_ageing.pdf

[19] http://esa.un.org/migration/p2k0data.asp

[20] http://esa.un.org/migration/p2k0data.asp

[21] http://www.oecd.org/document/25/0,3343,en_2649_33933_41530009_1_1_1_1,00.html

[22] (The OECD defines poor as someone living in a household with less than half the median income, adjusted for family size.)

Regime social drivers

Continuing improvement of human and social capital are crucial for rural development (World Bank 2007, OECD 2006, EU-COM502 2006). Unevenness in these aspects is the main determinant of differential development performance, and can represent an insurmountable obstacle for individuals and communities wherever there is a lack of investment in human and social capital. A little noted but well-documented side-effect is that they are also fundamental for compliance, implementation and effectiveness of policies.

The social drivers for food production and consumption are mainly related to purchasing and consumption patterns, as sketched below.

Nutritional transitions are evident in emerging economies and in the top segments of least developed countries. Nutritional transitions bring a shift from traditional diets to diets high in protein, with larger reliance on heavily processed and packaged foods, based on long distance transportation.

Another relevant trend, also related to nutritional transitions, is **obesity**. Currently more than 1 billion adults are overweight - and at least 300 million of them are clinically obese. Current obesity levels range from below 5% in China, Japan and certain African nations, to over 75% in urban Samoa. But even in relatively low prevalence countries like China, rates are almost 20% in some cities (WHO, 2008). It is widely assumed that the nutritional transition, allied to more sedentary lifestyles, is driving obesity but this claim is robustly disputed by food industry interests.

In Europe**, food consumption patterns** increasingly are diversified, following an increasing diversification of lifestyles and social fragmentation. Producers and retailers are responding to this increased diversity in consumption patterns by differentiating their products and services and adapting them to well-defined segments of consumers. As largely known, segmenting consumers is a way to perform effective and efficient marketing strategies by focusing on common characteristics within the group. Segmentation is still related basically to age, sex and income but, at the same time, values, culture and lifestyles increasingly are taken into consideration by the food industry.

One of the big trends in the food industry is related to the need of consumers to reduce the time dedicated to food preparation, to which the industry has responded with catering services and **convenience** food. This trend is accompanied by a household-level loss of food preparation and cooking skills and a de-structuring of the social context of eating, with an increasing individualization of consumption. This trend is relevant to sustainability because it makes a high energy demand to get convenience meals and foodstuffs to the point of sale though it significantly reduces energy consumption in home-based food storage, preparation and cooking.

There is increasing evidence of growth in the number of **disadvantaged consumers** in the EU25 (EU Commission 2007c , NCC 2007, Hitchman et al. 2002). As put into evidence in a British study (NCC 2007), disadvantaged consumers have less choice; as customers they are less attractive to providers and have little consumer power. As the food system is increasingly centred on big grocery stores, low income and reduced mobility (not having a car) can be the cause of inadequate access to nutritious food. As it has emerged during the recent food price inflation, there are social groups whose capacity to access quality food, once taken for granted, is put into discussion.

Another important driver is **social concern** over the penetration of **new technologies** into food provisioning. Eurobarometer has been carrying out surveys on consumers' attitudes towards new food technologies. The most recent one, on **animal cloning**[23] , has revealed that a) the long-term effects of animal cloning on nature were unknown (84%); b) animal cloning might lead to human cloning (77%); c) animal cloning was morally wrong (61%); and d), cloning might decrease the genetic diversity within livestock populations (63%). Negative attitudes towards **agricultural GMOs** amongst European citizens are well documented[24]. Surveys in the US, in Switzerland, in Germany on **nanotechnologies** show the similar concerns[25]. ETP 2007; ETP, 2008) address the problem of consumers' suspicion of new food technologies, and of the interests that lie behind their promotion. The EU Agrimapping (2007) addresses the problem of a better communication between food industry and consumers[26].

New but as yet marginal trends and changes in the food supply chain also are conditioning the evolution and the importance of the agri-food sector in rural areas. Among these trends, which we examine below, the following can be highlighted: 1) reconnection of local supply chains; 2) local labelling and 3) food quality assurance schemes.

Niche social drivers

New actors are emerging in rural areas and are taking a leading role in the future and evolution of these territories. The movement of skilled professionals into rural lifestyle properties with high ICT connectivity, new or different patterns of demand, and the development of new links between rural and urban areas, have a similar influence. So, rural economies are proving rather vulnerable to migration patterns, planning regulations, and institutional developments (World Bank 2007, EU Council, 2008, OECD 2008).

Diversity in lifestyles provides room for emerging 'niches' that, despite their relatively small economic size, are markets where new consumption patterns and new products are tested and consolidated into well defined food chains. Organic farming, fair trade, high value low quantity products such as Slow Food praesidia have for a long time relied on specific groups of consumers to develop their activity. These niches are progressively growing as awareness of the environmental crisis, health concerns and ethical attitudes to consumption grow. It can be seen as a counter-trend to globalisation and industrial consolidation, which results in more and more standardized products with no regional identity (or terroir - the term used in France to designate a unique area of origin), and un-connected to a typical taste preference. In Britain, ethical food sales rose from £1 billion to £5.4 billions between 1999 and 2005 (DEFRA, 2008). Marketing practitioners have identified so called LOHAS (lifestyle of health and sustainability) as a niche market with growing potential in the food, services, housing, transportation, energy, tourism sectors[27]. Deliberate policy action to switch public food procurement (for meals served in hospitals, schools, prisons, army barracks

[23] http://ec.europa.eu/public_opinion/flash/fl_238_en.pdf

[24] http://ec.europa.eu/public_opinion/archives/ebs/ebs_244b_sum_en.pdf

[25] http://www.nanowerk.com/news/newsid=1579.php; http://www.azonano.com/News.asp?NewsID=3484; http://www.nanolawreport.com/2007/03/articles/new-european-public-perception-survey/

[26] "The logic and understanding of consumers may differ considerably from that of experts and when ignored this discrepancy may lead to misperception, misunderstanding and ultimately distrust and thereby hamper the effective communication to realise desired behavioural changes" (ETP on Food for Life).

[27] http://www.lohas.com/about.html

etc) to organic production and fair trade outlets (e.g. national policy, Sweden; Cornish Food Trust, U.K.) is moving niche drivers further into mainstream practice in some EU countries.

Younger people who become involved in agriculture can change the panorama of rural areas in the future, in three dimensions: economic, social and environmental. The future contribution of agriculture to rural development is widely seen as depending on the degree of involvement of young people in this activity.

Disruptive social drivers

It remains unclear what stronger (official or uncontrolled) in- migration into Europe might have on the ecological and economic performance of agriculture. It might increase the pool of cheap labour for some horticulture farms, for instance. Table 3 summarises the disruptive drivers identified in the scanned documents.

Table 3: Analysis of social drivers

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs
landscape	Changing dominant values	Increasing interracial conflicts; tendency to closure	Clash of civilizations or a new global order?	New political initiatives changing the landscape	Global political trends	Peace studies
landscape	World population	9 billion in 2050; urban population has trespassed the 50% threshold; by 2045 the number of older people will trespass the number of under 15	Will demographic transition and production peaks coincide?	Collapse of urban organization	Food production and consumption; urban rural relationships	Future studies not only on demography but also on related resource use
landscape	Migration flows	Increasing	Effectiveness of integration policies	Xenophobic reactions / migrants as a key resource	Climate change; global economic trends; effectiveness of dev policies	Integration policies
landscape	Income distribution	Growing income inequality		Radicalisation¬ of social unrest	Global economic trends; policies	Effects of inequality on vulnerability of agri-food systems
regime	Consumption quantities and patterns	Nutrition transition; increasing consumption, growing inequalities; diversification of patterns	Changing consumption patterns or increasing divide between rich and poor?	Crisis producing a sudden change of attitudes		Motivations and constraints of consumption
regime	Social concerns over new technologies	Still strong	Will technology innovation take fully into account health and environmental risks?	Panics linked to outbreaks	Risk policies; communication policy; technology developments	impact assessment in society
regime	Diversity in lifestyles	Emerging niches of consumption	Will be able to counter dominant		Consumption; social concerns	

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs
			trends to adopting unsustainable patterns?			
regime	Human and social capital in rural areas	Variability from area to area	Will urban policies erode endowment of human and social capital in rural areas?		Rural land; economic trends; migration flows;	
regime	Demographic trends in rural areas	Ageing of rural population; depopulation; counterurbanization; migration of extra UE	Will urban and rural policies revert the trend to aging?		Agricultural entrepreneurship	Urban and rural policies; land markets and land policy
regime	Non agricultural economic activity	Increasing non agricultural activity in lively rural economies	Will agricultural and non agricultural integrate?		Urban development; general economic trends	Multifunctional¬ diversified agriculture based rural business

2.4 Technology drivers

Landscape technology drivers

The 1st Foresight exercise provided a detailed account of technologies that were thought likely to affect agriculture and food in the future that can be summarised as follows:

> Technology advancements in food will be characterized by the increasing **convergence** between bio, nano and info technologies. According to Roco and Bainbridge [1] there exists a "material unity" so that all matter – life and non-life – is indistinguishable and can be seamlessly integrated.
>
> The productivity of agriculture will be enhanced through appropriate applications of advanced technology and management techniques for farms, resources and land that do not harm the environment (OECD, 2008). In the context of sustainable development, the development of advanced technologies will increase the scale of economic activity that can be accommodated within the requirement that critical natural capital be sustained. New technologies and techniques will alleviate environmental and economic pressures and solve public good dilemmas.

Industry ambitions to change landscape drivers in these directions have increased. Proprietary confidentiality makes it hard to assess the validity of these claims, or their impacts. As and when industry brings them into practice, there will be an urgent need to develop new monitoring, regulatory and standard-setting procedures and competencies, that can offer dis-interested science-based guidance to policy actors and citizens.

Summary of current situation Europe is the home-base for some of the world's largest food retail, agri-chemical and advanced biotechnology companies, and together they command significant research budgets and globally recognised scientific excellence (IAASTD, 2008). Most MS have research groups recognised as outstanding in their field and a few countries (e.g. France) have maintained large publicly financed research capacity in food, agriculture and the environment, of exceptional depth and scope. An increasing number of countries, especially to the north of Europe, in recent years have taken steps to build capacity (human resources and infrastructures) that address the emerging and longer term challenges but in general the knowledge infrastructure is uneven within countries and fragmented at European level (Agri-mapping). EU funding has stimulated the growth of networked science across Europe (e.g. ETP, 2007 and 2008), and beyond, as well as advances in integration across disciplines and among different kinds of expertise. None the less, the contribution of farmers and other resources users, as well as of consumers and citizens, as knowledge actors continues to be under-valued, although - as catchment management experience shows – their involvement is critical to the development of adaptations that work at local levels and impossible to achieve without their collaboration. Public-private partnerships (see, for example, Blaauw et al. 2008 that deals with collaboration on biomass developments between the Dutch Ministry of agriculture and the Dutch chemical industry) are now common and seem likely to expand in scope and diversity over the next decades. Europe's long history of collaboration on agricultural research for development (ARD) also continues, with significant strategic development in 2008 (Challenge Programme – CGIAR; and EIARD, Dec. 2008) of the short and longer term prospects for continued investment in ARD in a rapidly changing world. The R&D funded, supplied by or commissioned for civil society groups (e.g. Birdlife

International; PAN Europe), as well as by farmers and others seeking new values in food and farming (as in the development of a research agenda for organic agriculture – see, for instance, IFOAM and ISOFAR, 2008) are also well-established and are becoming increasingly important niche drivers of (even mainstream) AKST.

The development of the ICT (Information and communication Technology) will continue to have a strong impact on the food and farming sector, accelerating and facilitating the wider spread of other (converging) technologies.

Innovation in the non-agricultural industrial sector (e.g. the car industry, automatisation, robotics) will influence strongly also machine technology in agriculture and food provisioning, and the distribution systems in the food sector.

Regime technology drivers

Genomics will increase the potential to design new animals, fish and plants and to modify their genetic character. The so far unproven claim is that this will deliver better harvests, resistance against pests and diseases, drought resistance, salt resistance and so on. The industry claims that genomics will be able to deliver these products in a much faster way than evolutionary biotechnologies or classical breeding techniques, and that the new design capacity can 'do it better'. What is not widely realised is that the 'faster' claim is dependent on the continuation of outputs from 'classical breeding' and ecologies evolving 'in the wild', and the 'better' claim is unproven – genetic engineering remains a hit and miss affair and virtually nothing at present is known about the effects of changing the context of a gene's position in a biological structure. Classical breeding, allied to other branches of advanced modern biotechnology, ICTs and robotics, in the near to medium term continues to offer a more resilient and effective way forward for certain classes of problem in breeding (IAASTD, 2008).

Genomics is one of the major drivers for investments in food and farming at present but the public benefits, dis-benefits, and risks will take time to emerge, and perhaps will not emerge at all under present IPR constraints that have led to extreme concentration of control over advanced biotechnology and removed the under-lying evidence from public domain scrutiny. At present, after 30 years' of promotion, 2 traits in 4 GM crops in 6 countries account for 95% of the sown area.

Acceptance by citizens and consumers ("mixed feelings") is one of the questions that need to be resolved if genomics is to serve the public welfare in the EU25. There is growing interest in applications that may assist in the monitoring and diagnosis of health and environmental impacts of evolving farm and food system practices and in food safety. There is also a pressing need for governments to consider how to open up proprietary control of the sciences and data, and in the development of marketable applications, to a much wider, and more competitive, set of actors. On the scientific side, the development of capacity for modelling in genetic and metabolic engineering, as well as improved mathematical models, are mentioned as major challenges. Proteomics is a second major field in development, that is likely to raise similar challenges to genomics (1st Foresight exercise).

Functional food is any fresh or processed food that claims to have a health-promoting and/or disease-preventing properties beyond the basic nutritional function of supplying nutrients, although there is no consensus on an exact definition of the term. This is an emerging field in food science. Such foods usually are accompanied by health claims for marketing purposes, for example, a certain "cereal is a significant source of fibre. Studies have shown that an increased amount of fibre in one's diet can decrease the risk of

certain types of cancer in individuals." The general category includes processed food or foods fortified with health-promoting additives, like "vitamin-enriched" products. Fermented foods with live cultures are considered as functional foods with probiotic benefits[28].

Innovative developments by the agricultural machine industry The AET, representing the agricultural machine industry, expects that agricultural machinery will be a key industrial sector in the 21st century, and will allow higher energetic efficiency and GHG reduction. It is expected also to contribute to higher labour and economic efficiency through improved automation technology. The AET indicates in its strategic research agenda (ETP&AET, 2006) a number of important technological trends, which might have a strong impact on the environmental performance of farming. Developments in robotics, coupled to in-field and per animal sensors, will allow for targeted precision agriculture, reducing the amount of inputs applied, leaching and emissions, labour and management costs. Robotics in principle could play a role at all scales of production, and in organic and niche systems as well as in industrialized systems.

Machinery is being developed for crop and animal production with new functionalities, changing power transmissions, with higher levels of automation / machine intelligence, sensors to support integrated application management (ITC supported), GPS, precision farming, better ergonomics. This trend will allow energy savings and reduced GHG emissions. However, more systematic exploration is needed of the impact of these technologies on the structure and composition of the European farm sector, quality of life of the farmers, on social acceptance, and rural development.

Niche technology drivers

Nutrigenomics – The use of genomics to investigate the dietary and genetic interactions involved in health or disease, is a term often used interchangeably with nutritional genomics. This term implies that other portions of the genome play a role in the genetic response to a nutrient (even if researchers cannot assess the total genome)[29]. Nutrigenomics has been associated with the idea of personalized nutrition based on genotype. While there is an expectation that nutrigenomics ultimately might enable personalised dietary advice, it is a science still in its infancy and its contribution to public health over the next decades is thought to be minor[30].

Green technology development increasingly will be strongly encouraged by governments' pledge to reduce GHG emissions. Biodiversity-based organic (more broadly, agri-ecological) farming is still a niche, but it has a strong potential to grow in the next years under these incentives.

A handful of food and nutrition products containing invisible **nano-scale additives** are already commercially available. Nano-tech is already in widespread use in advanced agri-chemicals and in agri-chemical application systems. There is at present no EU-wide regulation of nanotechnology – practically speaking, nanotechnology is unregulated.

Hundreds of companies are conducting research and development (R&D) on the use of nanotech to engineer, process, package and deliver food and nutrients to our shopping baskets and our plates. Among them are giant food and beverage corporations, as well as tiny nanotech start-ups (ETC-Group, 2004).

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[28] http://en.wikipedia.org/wiki/Functional_food

[29] http://nutrigenomics.ucdavis.edu/nutrigenomics/index.cfm?objectid=C8F72120-65B3-C1E7-087EFD5BA2DDC012

[30] http://en.wikipedia.org/wiki/Nutrigenomics

These advancements are characterized by an increasing contestation[31], centred on the social, environmental and economic risks inherent in hasty and unmonitored applications. The public policy goals of decreasing the vulnerability and increasing the resilience of food and farming is thought more likely to lie in the diversification of innovation trajectories[32] (ETC-Group, 2004) rather than in undue focus on the nano-tech innovation space.

Systems biology is a biology-based inter-disciplinary study field that focuses on the systematic study of complex interactions in biological systems, using the perspective of integration instead of reduction to study them. Particularly from year 2000 onwards, the term is used widely in the biosciences, and in a variety of contexts. Because scientific practice in the modernisation of food and farming systems in the past fifty years has favoured reductionism, one of the goals of systems biology is to discover new emergent properties that may arise from the systemic view used by this discipline, in order to understand better the entirety of processes that happen in biological system hierarchies[33] and in their relations with their environments.

Minimal and careful processing technologies are used more often by innovative SME-processors, replacing the use of additives, which are of concern of many European consumers (Schmid, Beck & Kretzschmar, 2005). This implies the replacement of additives (with E-numbers) by functional ingredients with interesting properties or/and or with “smart but gentle” physical methods. These techniques are often applied in organic food but also other high quality foods, which claim to be authentic and want to maintain the flavours, bioactive compounds or the structure of the raw material (IFOAM and ISOFAR, 2008).

Appropriate farm machinery Many SME and also farmers have developed innovative machinery (e.g for non-chemical weed control or for minimum tillage). These help to reduce the use of energy or inputs and might prove to be interesting to industry as the impacts of climate change intensify.

Farmer-based participatory breeding. Participatory breeding, which relies on an alliance between modern breeding techniques (including molecular-markers) and traditional knowledge, are contributing significantly to development of varieties that are better adapted to a climate-changing world, or adapted to niche localities and soils, to particular consumer preferences and to speciality markets, with high acceptance in the population and among farmers. These efforts also contribute to diversity when allied to conservation in use of ‘heritage seeds’ in food cultures of high value. When combined with marketing activities for traditional breeds, these efforts also can contribute to the diversity of consumption. However, farmer-based participatory breeding lacks support both within scientific establishments – that increasingly are focussed on genomics and other high tech sciences – and by the currently dominant market interests.

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[31] In Europe, a report of the EU commission warns that while CT applications offer “an opportunity to solve societal problems, to benefit individuals, and to generate wealth,” they also pose “threats to culture and tradition, to human integrity and autonomy, perhaps to political and economic stability”. ETC Group, a Washington-based NGO, refers to converging technologies as BANG, an acronym derived from Bits, Atoms, Neurons and Genes, the basic units of transformative technologies. According to the ETC group, BANG will allow human security and health – even cultural and genetic diversity – to be firmly in the hands of a **convergent technocracy**.

[32] Explain what are technology trajectories

[33] http://en.wikipedia.org/wiki/Systems_biology accessed 19 October 2008

Disruptive technological drivers

Nanotechnology – even more than genomics – is thought to be a potentially highly disruptive driver. The application of nanotechnology is still limited in agricultural production compared to the claimed potential range of applications. The ongoing debate about the potential benefits and negative impacts rely on only a few reports that hazard an assessment, based on rather scanty objective evidence: they conclude that more consideration should be given to the long-term impacts (Miller and Senjen, 2008, ETC Group 2004, EPA 2007). A summary of potential benefits and negative impacts within the organic food and farming sector has been elaborated by Speiser in 2008.[34]

Potential benefits: Nanot-echnological packaging materials may improve shelf life, by maintaining a more adequate atmosphere or through antimicrobial properties. Nano-coated surfaces may improve the hygiene of processing equipment, by rendering the surfaces water- or dirt-repellent, antimicrobial, or scratch-proof. Disinfection agents, veterinary drugs, plant protection products, and fertilizers are said to be more effective when formulated as nano-particles, offering improvements in animal or plant health, product quality, or shelf life; or nano-particles can lead to quantitative or qualitative reductions in the use of inputs.

Potential negative impacts*:* Little is known about the human health hazards of nano-particles. The few available studies indicate that nano-particles can be taken up from the air, from food and drink, or through the skin, that they are highly mobile in the human body, penetrate cell membranes, and thus can be found in various tissues, including the brain. Even less is known about the fate and behaviour of nano-particles in the environment. It can be assumed that many of them disperse rapidly through water and air, and along the food chain. Depending on their reactivity, they may have diverse environmental effects. Many nano-particles will finally aggregate to larger particles, which reverse their specific nano-scale properties. These potential negative impacts urgently need to be addressed by both general and specific legislation, since product release is far out-running monitoring, regulation and scientific understanding.

Table 4 summarises the drivers related to technology.

[34] Speiser, B. (2008). Nanoparticles in Organic Production? Issues and opinions. 16 IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008. http://www.agrimodena.it/OWC_Proceedings/Modules/GMOs/Speiser_proc_GMO.doc.pdf

Table 4– Analysis of technology drivers

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs for environment and sustainability
regime	Genetics	Strong advancements in genomics and proteomics. Until now only few new varieties have been produced	Helpfulness in supporting breeding techniques Uncertain cost development	Robustness of products in face of climate changes Irreversible biological impacts	Intellectual property regimes	Development of monitoring & research to support regulation
niche	Appropriate farm machinery	Fast development of ICT supported automatisation and robotics	if will find applications. Time is needed for development of process control systems, power transmission, application in multi-functional agriculture, etc.			
niche	Farmer based participatory breeding concepts	Increasing trend in support of organic markets, heritage seed systems, biodiversity conservation and multi-functional agric				Contribution to resilience in seed system mnt.
niche	Nanotechnology	[?] A growing range of applications in agriculture and food systems	Unknown negative impact on health and environment	Irreversible contamination of the environment	Legislation	Devt of Monitoring & research needed to support regulation
niche	Functional food	Growing	It may have an impact on nutritional patterns	Health impacts		As above
niche	Nutrigenomics	On its beginnings	It may have an impact on nutritional patterns and on food habits	Increasing food anxiety	Social drivers	As above

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs for environment and sustainability
niche	Systems biology		It may revert many technology trends and research paths		Agricultural knowledge systems	
niche	Minimal and careful processing technologies	On its beginning			Food consumption patterns	

2.5 Policy drivers

Landscape policy drivers

The coherence between European policies is crucial for the future of rural areas. Emerging or strengthening socio-economic trends and new approaches to rural development need integrated policy responses and policy coherence (OECD, 2008b). For rural areas of developing countries there is also need of coherence of developed countries' policies (EU Commission, 2005).

In the first **Kyoto Protocol** the industrial countries, including the EU, agreed to lower the emission of greenhouse gases by 8% in the period from 2008-2012. In addition to Co2 reductions, reductions in methane, N2O and some other synthetic gases (HFC, PFC, etc.) were foreseen. Negotiations of further reductions within the EU25, and globally, after 2012, are ongoing (BAFU, 2008). While there has been some progress toward these goals, it has been uneven and insufficient.

The European Commission recently issued a communication on the EU's commitments to addressing **climate change**[35]. It states that "since the revised Emission Trading System will only cover less than half of the GHG emissions, an EU framework is needed for national commitments to cover the remaining emissions – covering areas like buildings, transport, agriculture, waste and industrial plants falling under the threshold for inclusion in the ETS. The target for these sectors would be a 10% reduction in emissions from 2005 levels, with specific targets for each Member State. Absent changes in patterns and rates of economic growth, policy drivers may prove insufficient to achieve the rapidity and scale of reduction that now seems necessary. Trend data indicate that global temperature have a strong and increasing probability of reaching 2°C warming b the middle of this century; thereafter, there is increasing probability that run-away warming might occur.

In principle, there is something of a global consensus on the need to open trade on a multilateral basis. The development trade round (Doha) has endorsed the concern regarding the negative effects of 'pre-mature' trade liberalisation on the agriculture and rural development of poor countries and the working document has accepted the need for special and differential treatment and non-reciprocal access for developing countries. There is an increasing consensus on the need to set up a more appropriate framework to make trade a tool for sustainable and equitable development (Sachs & Santarius, 2007; FAO 2004), and to compensate the losers from opening markets. However, multilateral negotiations on the Doha round have slowed substantially and bilateral agreements have increased, from 89 in 2000 to 159 in 2007.

In 2001, EU Heads of State and government agreed to "halt" the **decline of biodiversity** (in the EU) by 2010. In 2002, the Convention on Biodiversity (CBD)[36] adopted a strategic plan which aims to "significantly reduce" the rate of biodiversity loss by 2010 . This target was endorsed by the world's leaders at the World Summit on Sustainable Development (WSSD) that took place later in 2002 in Johannesburg. WSSD also recognized the CBD as the key international body to promote the achievement of the 2010 target. The EU is strongly committed to further strengthening the CBD as the key international instrument for achieving the

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[35] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – 20 20 by 2020 - Europe's climate change opportunity {COM(2008) 13 final} {COM(2008) 16 final} {COM(2008) 17 final} {COM(2008) 18 final} {COM(2008) 19 final} /* COM/2008/0030 final

[36] http://www.cbd.int/

2010 target and to making sure that it is effectively implemented. The EC Biodiversity Strategy and Action Plans, and the new Commission on Biodiversity Communication, outline how the CBD is to be implemented by the EU. However, trend data indicate continuing high rates and widening geographic scales of loss of biodiversity in reptiles, fish, birds, and large mammals. The '**biodiversity crash'** is unprecedented in human history, and matches the last collapse in deep geological time, with unforeseeable consequences for agriculture and food security.

Regime policy drivers

Agri-policies offer keys to the renewed engagement of developed countries with the issue of food security. In a recent speech, Marianne Fisher-Boel stated that in future, farmers "must show why, without some kind of safety net for farmers, the future of our food supply is at risk; They must show why it costs money to care for the land and to farm in line with other environmental imperatives. Above all, they must show that the CAP gives value for money"[37]. The prospect offered in this speech is of an agricultural policy oriented to competitive markets, with a reduced budget, yet that provides a safety net for farmers unable to survive in the market, and demands an increased focus on management of production risks, fighting climate change, more efficient management of water, making the most of the opportunities offered by bioenergy and the preservation of biodiversity.

A**gri-energy policies**, and especially those related to biofuels, will be increasingly influential. The (perceived) impact of biofuel policies on the 2007-2008 food price spikes (EU Commission, 2005) urges in-depth studies on biofuels to ensure that production and use of 1st, 2nd and 3rd generation biofuels is sustainable and takes into account natural resource sustainability and ecosystem functioning, as well as the need to achieve and maintain global food security. The EU has pledged to implement its target, established in the biofuels action plan (10% of fuel coming from biofuels by 2020[38]), and to introduce certification schemes for the sustainability of biofuels[39]. A study commissioned by the EU Commission projects total demand for biofuels to be 34.6 mtoe in 2020, of which 6.4 mtoe will be covered by imports. About 15 % or 17.5 mio ha of the arable land within the EU25 will be needed for the production of biofuels in the EU. In 2020, 59 mt of cereals or 19 % of total consumption in the EU and 30.4 mio t of oilseeds or 47 % of total EU consumption will be used for biofuels. The impact on prices is expected be small in the case of cereals (an increase by 3 to 6%), and moderate for oilseeds (plus 8-15 %).

Another important driver will be the **reform of CAP**. "The European Commission wants to modernise, simplify and streamline the Common Agricultural Policy and remove remaining restrictions on farmers to help them respond to growing demand for food. The so-called CAP Health Check will further break the link between direct payments and production and thus allow farmers to follow market signals to the greatest possible extent".[40] However it remains unclear how the EU wants to deal with the conflicts of promoting a

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[37] "Agriculture in the future: a challenge for European young farmers" (CEJA [European Council of Young Farmers] seminar, Annecy, 21/09/2008)

[38] Commission of the European Communities Brussels, 10.1.2007 Com(2006) 848 Final Communication From The Commission To The Council And The European Parliament Renewable Energy Road Map Renewable energies in the 21st century: building a more sustainable future {SEC(2006) 1719}{SEC(2006) 1720}{SEC(2007) 12}

[39] Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources {COM(2008) 30 final} {SEC(2008) 57} {SEC(2008) 85} /* COM/2008/0019 final - COD 2008/0016 */

[40] "Health Check" of the Common Agricultural Policy. http://ec.europa.eu/agriculture/healthcheck/index_en.htm

high production on one hand, and at the same time to take sufficient care of public goods that cannot be delivered by the market.

The adoption of **integrated pest management** as the preferred crop protection standard within the EU (final approval pending, Dec 2008), and **pesticide regulation** (approved 2008) also will drive farming practices. In September 2008 In the EU, a new Regulation[41] came into force which lays down revised rules for pesticide residues.

The 2nd Foresight panel notes that the 2008 **food crisis** triggered an acceleration of the debate over food and has facilitated links between policies once anchored to narrow sectoral interests. It has put into evidence that food security is a matter of global security, as underlined by Angela Merkel in her letter to the G8 ahead of the summit in Japan in mid 2008. The crisis could "threaten democratisation, destabilise countries and lead to international security problems," Merkel wrote, according to the German newsmagazine *Der Spiegel*[42]. The G8 summit in Hokkaido (G8, 2008) concluded with an affirmation that "We are deeply concerned that the steep rise in global food prices coupled with availability problems in a number of developing countries is threatening global food security. … We have taken additional steps to assist those suffering from food insecurity or hunger, and today renew our commitment to address this multifaceted and structural crisis".

In several FAO documents from 2008 the different dimensions of the food crisis have highlighted. World food demand is expected to grow due to an absolute population growth (+ 3 billion by 2050) and an estimated 3-4 billion climbing the food chain, eating more grain intensive livestock products (some 37% of world grain harvest is used to produce animal protein); by 2050 global farm animal production is expected to double from present levels. The number of hungry and malnourished people in DCs has turned upwards again reaching 830 million as in 2003 (FAO, June 2008). World food stocks have plummeted to lowest level since 1980s (about a 12 week stock for wheat and rice and another 8 weeks for maize) (FAO, April 2008).

A series of recent official documents produced by international organizations and agreed by member states have made similar, very clear statements with regard to the short, medium and long term action to be taken. The declaration issued after the FAO summit in Rome in 2008[43], (FAO, 2008b) concludes: "We firmly resolve to use all means to alleviate the suffering caused by the current crisis, to stimulate food production and to increase investment in agriculture, to address obstacles to food access and to use the planet's resources sustainably for present and future generations." The declaration also states that the current crisis has highlighted the fragility of the world's food systems and their vulnerability to shocks. Medium and long term measures suggested are: a) fully embrace a people-centred policy framework supportive of the poor... b) increase the resilience of present food systems to challenges posed by climate change. In this context, 'maintaining biodiversity is key to sustaining future production performance'. c) to definitively step up investments in science and technology for food and agriculture; d) continue efforts to liberalize international trade in agriculture (EU Commission, 2005). The strong dependency of food security on so many inter-acting factors is often not sufficiently understood or stated.

[41] Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005.

[42] (http://www.dw-world.de/dw/article/0,2144,3462743,00.html)

[43] Declaration of the high-level conference on world food security: the challenges of climate change and bioenergy. http://www.fao.org/fileadmin/user_upload/foodclimate/HLCdocs/declaration-E.pdf

The EU has engaged to promote the integration of international development objectives, where appropriate, into its research and development policies and innovation policies [44]). The EU also has engaged to support more strongly the delivery of **international public goods** contributing to food security. AS far as research and technology are concerned, the EU pledges to *support pro-poor and demand-driven agricultural research and technology and improve its outreach and dissemination*[45].

The food crisis has also put into evidence the need to avoid national strategies that seek to ensure domestic food security by securing farmland overseas. China, Russia, Arab Emirates, South Korea and others none the less are leading the rush toward '**food colonialism'**. This trend carries high danger of increasing instability, prompting fierce competition for land, water and livelihoods, and of displacing already vulnerable populations from the means of subsistence.

Because of the **diversification of rural economies**, rural non-farm activities are likely to become critical for development, internationally and within the EU (World Bank, 2007). However, despite diversification of activities, agriculture is likely to remain the mainstay of rural livelihoods for the majority of rural residents well into the mid-century. In this context, improvement to the **competitiveness of small producers** will become a key policy concern (World Bank, 2007). Policy effectiveness in this area requires stronger and better-targeted investments in development of market access, and effort to ensure that new market opportunities – such as carbon trades – are available also to small producers and rural communities within the EU25 and in developing countries. However, because in part of differential historical trajectories and natural resource endowments, territorially divergent trends are thought likely to intensify and will demand differentiated policy responses. European policy can affect these trends by the way it balances local development opportunity and regional infrastructures and services.

Niche policy drivers

Incentives for low-external input/organic agriculture on local or regional level

Some regions and communities have special support programmes for low-external input and/or organic agriculture, e.g. in nitrate-sensitive areas. Some towns have reoriented their public procurement for hospitals or schools to local/regional and organic products (e.g. Vienna, Kopenhagen).

Since the Rio Declaration many governments have pledged to pursue **sustainable consumption and production (SCP)**. Governments at the Johannesburg Summit in 2002 called for the development of a 10-year framework of programmes (also called 'the Marrakesh process') in support of regional and national initiatives to accelerate the shift towards SCP patterns. Food is a SCP priority for Africa and Europe[46]. (Initiatives include sustainable production and consumption policies, labelling, sustainable consumption, climate change mitigation and adaptation).

[44] Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee of 12 April 2005 - Policy Coherence for Development - Accelerating progress towards attaining the Millennium Development Goals [COM(2005) 134 final - not published in the Official Journal]. http://europa.eu/scadplus/leg/en/lvb/r12534.htm

[45] Communication 'Advancing the *Food Security* Agenda to Achieve the MDGs' and EU FSTP Action plan

[46] http://esa.un.org/marrakechprocess/pdf/10YFPBackgroundDoc.pdf

The European Union is currently in a process of adopting actions to promote the **consumption of fruits and vegetables**: "In light of the dramatic increase in obesity amongst schoolchildren […] to come forward with a proposal for a school fruit scheme as soon as possible based on an impact assessment of the benefits, practicability and administrative costs involved."[47]. Consumers are especially concerned about pesticide residues when eating fruits and vegetables. Therefore, quality standards have become very high and the threshold for pesticide residues tend towards zero. Some public institutions are promoting organic food for schools (IFOAM and ISOFAR, 2008).

Probable but not determined drivers of transition

The uncertainty about the strength of policy drivers is related mostly to the relation between official discourses and the real implementation of policies. We might interpret policy drivers as arenas for confrontation between forces with different interests. The outcomes of the struggle will depend on the inter-play of the forces involved. The systemic uncertainties noted so far imply that the prevailing balance of interests is becoming unstable, dominated by the increasing strength of private sector actors, to the cost of collective welfare and the public good, and with increasing dangers of confrontation with citizen and consumer interests. Policy drivers have proven so far to be entirely inadequate to halt or reverse negative trends in hunger, nutrition, natural resources, ecological functioning, and bio-diversity. Gross market failures, represented most notably by climate change, seem unlikely to be mitigated by reliance on the same market mechanisms that have generated the problem. Although the changing landscape offers strong potential opportunities for effecting transitions toward longer term sustainability and toward better-integrated policy goals, the 2008 events appear to be shifting political priorities toward resolution of shorter- term economic and financial issues.

The EU MS and Commission seem convinced that the MDGs still can be attained in all regions of the world, provided that concerted action is taken immediately and in a sustained way until 2015 (EU Council, 2008). The involvement of the private sector in these efforts is considered to be determinant of the results actually achieved. The 2nd Foresight panel, on the basis of the documents scanned, is sceptical that the expectation will be fulfilled.

The development of common accounts that appropriately value natural resources and ecological functions, and internalise the true cost of economic activity, would substantially assist governments, citizens, those determining science and technology policies, businesses and investors to plan for sustainability and the longer term. New regime drivers, such as a carbon tax, would create a more rational framework for decision-making in a climate-changing world. The use of different criteria than those offered by standard economic models to differentiate rural areas could alter the future of these territories in ways that integrated social, economic and environmental sustainability. A (partial) re-nationalisation of CAP would introduce a new institutional context for the development of the agrarian sector and rural areas. Increased competition in access to and development of the new sciences and advanced biotechnology would open up the innovation space, as would greater support for multi-actor assessment of KST options in food and farming.
Table 5 summarises the Panel's analysis of policy drivers.

[47] Commission Staff Working Document, (Com2008) 442, (Sec2008) 2225

Table 5 - Analysis of policy drivers

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs
Landscape	Kyoto protocol	Agreement to lower the emission of greenhouse gases with 8% in the period from 2008-2012	Effectiveness of the adaptation measures; political will to carry on with the pledge during economic crisis	Increasing probability of runaway climate change	Innovation policy; capacity to enforce measures; economic policies; market management; energy policies	Link between adaptation measures and available capacities
Landscape	MDG	Slow progress on some goals; trend to reversal in others (eg food security)	Will dev policies be effective enough to reach the goals	Failure likely to be associated with geo-political instability & drive lack of agreement on how to address global policy challenges	Global economic trends; dev policies levels; trade policies	Effectiveness of implementation
regime	CAP reform	CAP Health Check will further break the link between direct payments and production	how to deal with the conflicts between competitiveness and public goods		Agricultural models; trade policies; land policies	New models of competitiveness; gap objectives/outcomes
regime	Rural policies	Differentiated territorial impact of rural policies	How to link rural policies with regional policies		Land policies; regional policies; social drivers	Barriers to integration rural/urban/regional/land policies
regime	Doha round agreements	Liberalization on multilateral bases	Will multilateral approaches survive?	Trade agreements break down in face of the next food price spike	Food security, rural development policies; competitiveness of farms and agri-food systems	The relationship between liberalization and food security: instruments to avoid negative impacts
regime	Agri-energy policies	10% of fuel coming from biofuels by 2020 and certification schemes for sustainability of biofuels	Energy efficiency; competition fuel/food; social and environmental impact	3rd generation biofuels relieve fossil fuel energy constraints	Food prices; Oil prices;	Sustainable biofuel technologies and production/distribution models

Category	Drivers	Trends	Uncertainties	Surprises, tipping points	Inter-linkage with other drivers	Research needs
Niche	Sustainable consumption and production	Agreement to sustain innovative initiatives	Degree of priority given to the issue in times of economic crisis	Crisis may stimulate attention on new consumption patterns; water constraints may force paradigmatic transitions	Agriculture and food models	Barriers to sustainable consumption
Niche	New form of service provision: co-production, local economies	In some countries experiments of new forms of service providing based on co-production have emerged	Will these form gain a critical mass to represent an alternative form?	Economic & ecological crises may boost these forms	Institutional arrangements; dominant values in society	Technical, legislative, organizational and social aspects of new forms

3. Main messages from sub-theme analysis

The analysis carried out of the sub-theme documents has put into evidence some key messages, from which priorities and research needs can be identified.

3.1 Climate change, agri-environment, agricultural innovation

a) Climate change and fossil fuel management are key challenges for agriculture in the next years.

The main challenge for agriculture and the whole food sector is to find the right responses and strategies to the challenge of a much faster rate of climate change (FAO, 2008a/b/c/d/e/f, AEA 2007, EEA, 2007). Farmers and pastoralists can play an important role in reducing global emissions by planting trees, reducing tillage, increasing soil cover, improving grassland management, altering forage and animal breeds and using fertilizer more efficiently 9among other measures). By maintaining higher levels of carbon in the soil – a process known as "soil carbon sequestration" – farmers can help reduce carbon dioxide levels in the air, enhance the soil's resilience and boost crop yields (FAO, 2008d). Payment mechanisms need to be found, that penalise producers for practices known to contribute to the negative trends, and reward them generously for adoption of resource-conserving, biodiversity-enhancing, and water-and energy-efficient practices and technologies.

Climate change affects species either directly via temperature or CO2 or indirectly through dis-equilibrating effects on food webs or other factors such as new pathogens or pests on evolutionary processes in the decades to come. Especially the combined long-term effects of the latter have to be better understood. Research is needed to cope with global warming in those regions where food surpluses could be generated, and with the impacts on the poor where need will be greatest.

As the climate in Europe is forecast to become warmer and weather conditions less reliable, a first priority is the development and implementation of ***adaptation strategies***. In the short-term changing varieties and planting times can help to reduce negative impacts in annual cropping systems (e.g. alternative crops, drought- or heat-tolerant varieties, altered timing of cropping activities). With perennial crops adaptation strategies have to take a much longer perspective (introduction or development of suitable varieties or changes in land-use patterns; new breeding goals to utilise the entire vegetation period or multi-cropping options)(Ritter, 2008).

> The scale of agriculture and food systems means that although their impact is huge, there is large scope for change. Major reductions in impact could be achieved at reasonable cost by near-term transitions.

'Adaptation' can be understood in two ways. The conventional science understanding is that it is a synonym for 'fitness', a metaphor for something 'suited to' its environment. This usage implies the possibility of a high degree of informational certainty, design, and control. But there is another usage, more akin to the realisation that the old pair of shoes, left at the back of the cupboard, have stiffened and one's feet have altered shape. The shoes no longer 'fit' because they have not co-evolved. Adaptation in this latter sense implies that understanding, practice, technology and policy are co-dependent. There is irreducible

informational uncertainty; the 'design turn' focuses on shaping the process of co-learning; and the ambition of 'control' gives way to 'managing'.
Only a handful of the studies scanned in this exercise reveal any appreciation of adaptation as a process of shared learning, as the zone of uncertainty increases in a climate-changing world. Or of the need for design effort that turns to the design of 'systems of (societal) learning' for resilience in a carbon-constrained, climate-changing world.
Adaptation in the second sense also implies the following. 'Foresight' turns away from (merely) expert-based insight, extrapolations from history, and (scenario) modelling that focuses on the middle of the risk curve. It seeks to discern where and how societies can build capacity to reduce vulnerability to high risk events at the tails of estimates of the risks of new technologies, policies or 'surprises'.
Only a handful of the scanned documents take up these issues. In the Panel's view, they are likely to command steeply increasing attention in the coming years.
The FAO Report on "*Livestock's long shadow*" (2006) and the UNFCC-Report 2008 "*Challenges and opportunities for mitigation in the agricultural sector*" describe the following main ***mitigation measures***: carbon sequestration; reducing deforestation by agricultural intensification and agro-forestry; restoring soil organic carbon to cultivated soils; reversing soil organic carbon losses from degraded pastures; reducing CH4 emissions from enteric fermentation through improved efficiency and diets; and mitigating CH4 emissions through improved manure management and biogas. Other technical options for mitigating N2O emissions and NH3 volatilisation include a range of Interesting systems for carbon sequestration such as advanced conservation tillage and organic farming approaches.

b) Biodiversity is a key resource for agriculture and for climate change mitigation

The links between climate change impacts and agriculture are still largely unexplored. Biodiversity has an enormous potential as an agricultural resource and this needs to be valued in payments mechanisms.

More biodiversity/nature conservation areas can in many areas reduce the vulnerability of the land uses and reduces greenhouse emissions. They can facilitate the migration of species. Measures, which increase the carbon content in the soil, contribute to species diversity, improve the C-sink and the water retention, the nutrient cycling. Such measures both contribute to mitigation and adaptation to climate change. Research should look more at such synergies and their their successful monitoring and integration in policies.

The realisation of the potential however throws up a major challenge: to find a balance between increasing land productivity in a sustainable way and reversing the loss in biodiversity. Still not enough is known, for instance, about the systemic acts of continuing enlargement of the fodder inputs to Western Europe's (and other countries') livestock industries if this comes at the expense of tropical and sub-tropical rainforests in South America and a related decline in biodiversity. Such costs in the future have to be taken into account when assessing the long-term sustainability of globally inter-dependent farming systems.
In the shorter term biodiversity can be addressed by both more targeted measures for specific endangered organisms (genetic diversity) and by more rapid adoption of production methods that contribute to conservation of a high level of general biodiversity (agronomic and biological diversity), e.g. such as organic or LEISA approaches to production.

Over the longer term, technically, socially and economically feasible concepts for optimal combination of soil conservation, habitat management, nature conservation and eco-functional intensification need to be developed and adopted on landscape and regional scales.. They can build on the tacit knowledge of the

farmers and other land users who have long historical experience of systemic interactions in their localities, as well as taking into account the needs of civil society. Various schemes for financial incentives that reward users for landscape management as yet have to be assessed with regard to effectiveness and cost-efficiency in specific contexts, and merit further development.

Another difficulty lies in the domain of ***water***; current usage and management are driving toward food shortages. Reducing the use of water, in particular for irrigation, and improving water quality by avoidance of contamination, offer two immediate challenges. In the short term, the combination of water saving measures and cultivation methods that contribute to the water retention capacity of soils (e.g. with improvement of the humus content and quality), offer promise. Over the longer term, breeding for greater water efficiency and drought tolerance might be promising strategies (ETP, 2007). It remains uncertain how new varieties, however they are developed, might react or adapt in a climate-changing world (IFOAM, 2008).

New farmer-based breeding practices are interesting, as paying greater attention to local adaptation, nutrient-efficiency and biodiversity. This strategy appears the more important in so far as the potential for further yield increases by means of insect-resistance and herbicide-tolerance seems to have reached physiological limits in the major grain crops. Fertilisation efficiency s likely to be improved by innovative application technology (especially for farmyard manure and slurry, and in precision farming), better utilisation of leguminous plants in balanced rotations , as well as by the optimalisation of recycling nutrients within the farm as well as on a local or regional level. Modern forms of cooperation might allow the development of less-labour intensive mixed farming systems (IFOAM, 2008). It also seems likely that the long run quality of urban sewage sludge could be improved in such a way that it could become an important source of nutrients (in particular to address the phosphorous peak) if sufficient focussed research is dedicated to this option. In sensitive agro-ecological areas, such as groundwater protected areas or soils with high organic matter content, where a stabilization and the avoidance of carbon and nitrogen losses can be achieved only by special conservation measures, targeted research on fertility management would be required to assess, for example, the contribution of agro-forestry.

c) The choice of patterns of interaction between markets, technologies, and policies will affect in a substantial way the environmental, social, economic sustainability of farming systems.

Forced trade-offs, unintended consequences, and tipping points already have occurred and appear to be increasing in frequency in all agricultural regions. They call for more adequate governance of ago-ecological resources, effective warning systems, and integrated social and environmental assessments of technology options.

These challenges demand not only a good understanding of the interactions among drivers but also a more aware appreciation that adaptation requires choice among ‘food and farming paradigms’. We illustrate this point with the ***example of pandemic diseases.***

> Assessment is in its infancy of the impacts of the interactions among climate change, international trade and intensification/industrialisation of livestock systems, and pests, diseases and invasive alien aquatic species. There is little understanding of the consequences of movements of animal and plant pests and diseases. Greater resilience (reduced risk exposure) would require procedures for preparedness orchestrated across national boundaries, maintenance of expertise, improved and more rapid diagnostic tools, and forecasting models. Investment to strengthen capacity in all these areas

would contribute reducing vulnerability to surprise. The study of the causes and risks of emerging diseases involves basic sciences (including climate change science, taxonomy, modeling, population ecology and epidemiology) (FAO 2008).

Capacity development thus demands better integration among scientific disciplines to create the expertise to bring about a drastic reduction in and better regulation of trade in wildlife and more sustainable livestock industries. This in turn would require a shift in understanding of who is the relevant 'cognitive community'. A broader, more inclusive appreciation of the relevant knowledge actors, and the imagination to find ways of engaging these actors in problem-definition and problem-solving will be needed if effective adaptation in a complex world is to be realised (Cook, 2005).

Large livestock systems with high animal densities have proven vulnerable to diseases. Although decentralised systems also experience serious disease outbreaks, an alert monitoring system can ensure that these outbreaks are contained and eliminated, with far less social, economic and welfare costs than in concentrated industries. Food safety problems with international consequence have occurred, such as the recall of export products from supermarket shelves or the large scale, ethically problematic slaughter of thousands of animals (as in the Foot and Mouth disaster) lead to extremely high costs, which until now not have been taken into account in cost calculations or in technology assessments, nor have those responsible had to pay for the effects. Research urgently needs to deliver more resilient systems.

d) There is an emerging consensus on the need to adopt new, sustainable agricultural models

Despite this consensus, different paradigms claim to have the solution to the challenges of the next and following decades. One yet-to-be-realised paradigm is focused on mobilising science and technology to increase resilience to shocks, reduction of dependence on external resources (and on fossil fuels in particular), open-source exchange of information and biological materials, and a strong involvement of farmers and other societal actors in co-researching the ways forward. Another, commercially dominant paradigm, relies on industry-led technological innovations, on markets, and on proprietary knowledge.

3.2 Agri-policies and rural development

a) There is a need for a new rural-urban compact

"The traditional rural–urban compact, now almost ten thousand years old, whereby the countryside sent products and people to the city in exchange for the city's products, services and governance is not working anymore. The rural population is increasingly marginalized and natural environments are increasingly destroyed. A new rural–urban compact needs to arise where cities acknowledge and pay for environmental sustainability. In this new rural– urban compact there would be more employment opportunities and more income coming to the rural areas, and the cities would benefit from a sustainable supply of rural products and ecosystem services provided by restored rural environments" (Gutman, 2007)

b) The mission of agriculture in the new rural-urban compact is going to change: it will have to provide a balanced set of ecosystem services, including food and food security, fibre, energy, carbon storage, biodiversity conservation, water purification, soil maintenance.

The concept of multi-functionality is undergoing transformation, from a 'positive' concept into a 'normative' concept, in recognition of the integrated, systemic nature of the challenges we face. If it is true that agriculture in general performs joint functions of which many have the characteristics of public

goods[48], it is more and more clear that the choice of different agricultural models shifts the balance between private goods and public goods (see recent OECD on multi-functionality). Yet the 2nd Foresight Panel notes that efforts were made to exclude comparative assessment of the multi-functional contribution of different food and farming models in the recent IAASTD and language on multi-functionality was challenged in the inter-governmental negotiation of the IAASTD's findings. The transition towards new understanding clearly will be hard fought; high quality, dis-interested KST is needed that can inform and guide the transition.

b) Urban-rural compacts should be managed with new management philosophies

The vitality of rural areas depends increasingly on their capacity to ensure a sufficient flow of public goods. Drivers that threaten sustainable urban-rural compacts are both internal drivers (agriculture, deforestation, abandonment, over-exploitation, hyper-specialization, consumption of renewable resources, …); and external drivers (urban sprawl, energy prices, urban water consumption). New management approaches to mitigation and adaptation would need to link closely urban and rural strategies. "Promoting integrated rural development poses numerous policy and governance challenges. They would require a less "defensive" approach to rural policy and stronger coordination across sectors, across levels of government, and between public and private actors (OECD, 2006)". They would also require a new focus on 'places'' rather than 'sectors' and an emphasis on investments rather than subsidies (OECD, 2006).

c) Strong differences in terms of performance and characteristics exist between urban-rural compacts

Peri-urban and integrated rural areas face increasing urban pressure. They are subject to immigration flows, increasing daily mobility, consumption of resources (water, land). Strategies to defend these areas range from quantitative constraints (northern Europe) to qualitative constraints (agri-environmental schemes and focused rural development incentives to agriculture (organic, non-productive investments, down the chain). For the most **remote rural areas**, the major degradation driver is abandonment, which produces social desertification, land degradation, lack of maintenance of the territory, and loss of employment opportunities.

d) Awareness of the diversity of rural problems calls for more context-dependent strategies

RD policies typically do not address the specificity of problems of rural areas. For example, according to the criteria used, peri-urban rural areas do not fall under RD policies because their administrative boundaries include towns. The result is that they do not benefit from RD support, so that their functions are weakened and they lack defence (economic, social, administrative) against urban sprawl. For integrated rural areas, often the problem is to avoid the crisis generated by success of rural development strategies. Scaling up of rural development initiatives on the other hand could generate pressures on natural resources (overgrazing of local breeds, water resources dedicated to agri-tourism, land prices increase due to demand for second houses).

3.3 Bioenergies

To some degree, non-fossil biomass energy sources including bioenergy and biofuels actually depend on an underlying fossil fuel economy. Therefore, all sectors of the economy will be affected by emerging fossil fuel problems, including important agricultural inputs, processing of food and feed, its transport and trade.

[48] OECD has established a framework for analyzing non-commodity outputs of agricultural activities. The first concept is **jointness**, or the extent to which the intended agricultural product and the incidental non-commodity outputs of agricultural activity are linked. The second concept is related to the nature of public good of the non-commodity output. In this case may be that the market does not provide the right signal to stimulate production of public goods.

Due to this wide-ranging impact a number of complex research problems have to be solved in an integrated way:

What role can renewable resources play to substitute for growing oil and energy demands? Especially the problem of 'energy returned over energy invested' has to be solved. It is questionable whether countries like Brazil will be in a position in future to export large quantities of bioethanol since its population is projected to reach 233 million by 2050 with fast-growing domestic food, fodder, fibre, and fuel needs. And clearing more land would have serious consequences for biodiversity, for soil degradation and for inland rainfall patterns (forest clearing can jeopardize the recycling of rainfall in the interior regions).

Research has to answer the question how the growing demand for food, bio-energy and bio-fuel can be met simultaneously in a world with shrinking water and land resources, increasing soil degradation and rising temperatures all impacting on land productivity (Ritter, 2008).

a) Public support for biofuels is based on a multiplicity of policy objectives.

In general, declared objectives for support to biofuels oscillate between a) reducing dependency on fossil fuels; b) reducing greenhouse gases; c) supporting agricultural diversification. Prioritisation of these policy objectives varies by country, over time, and between different departments of government. With increased concerns about climate change, however, the reduction of greenhouse gas emissions can be counted among the prime reasons to support development of 2nd and 3rd generation biofuel production and use.

b) Support to biofuels is perceived to be one of the most important causes of the recent food prices hike.

Many studies now recognize 1st generation biofuels production as a major driver of food prices. The IMF estimated that the increased demand for biofuels accounted for 70 % of the increase in maize prices and 40 % of the increase in soybean prices experienced in 2007-2008 (Lipsky, May 8, 2008; Collins, 2008) estimated that about 60 % of the increase in maize prices from 2006 to 2008 might have been caused by in the increase in maize used in ethanol. Rosegrant et al. (2008), calculated the long-term impact on weighted cereal prices of the acceleration in biofuel production from 2000 to 2007 to be 30% in real terms.

c) Apart from the price effects, existing support to biofuels might have important implications for global land use.

According to the OECD (2008d), new legislation recently enacted (USA) or currently discussed (EU) is likely to accelerate the expansion of land under biofuel crops, particularly in Latin America and large parts of Africa. While on one hand this may provide additional income opportunities to generally poor rural populations it bears the risk of significant and barely reversible environmental damages and further loss of food security. The downside risks might include substantial freeing of greenhouse gases, but also the loss of biodiversity and the risk of runoff of nutrients and pesticides.

d) There are clear links between biofuels and food security.

According to FAO (2008l), with rising oil prices, low-income countries that are both food and energy importers are currently facing redoubled balance-of-payment pressures. Moreover, as world commodity markets become more integrated and changes in food prices on international markets affect domestic markets, biofuel production in one country has important effects on food security in other countries

e) The development of large-scale biofuel chains could harm vulnerability of local food systems

Recent reports from the FAO show increasing concern that large-scale production-distribution patterns of biofuels could increase the vulnerability of local food systems. The growing global demand for liquid

biofuels, combined with the high land requirement that characterizes the production of such fuels, might put pressure on the so-called “marginal” lands, providing an incentive to convert part of these lands, which may be perceived as less important and of less ‘use’, to biofuels production.

f) Most production chains for biofuels show costs per unit of fuel energy significantly above those for the fossil fuels they aim to substitute.

Despite the important increase in crude oil prices and hence in the costs for gasoline and fossil diesel, the cost disadvantage of biofuels has widened over the past 2 years as agricultural commodity prices and feedstock costs increased. In consequence the hope for better economic viability of biofuels with higher crude oil prices has not been realised, and 1st generation biofuels in most countries remain highly dependent on public support.

g) Once available on a commercial scale, second-generation biofuels may help to reduce the competition between food and feed production on the one hand and energy production on the other.

This is particularly promising when biomass can be derived from wastes such as used cooking oils or urban wastes, or where residues from agricultural or forest production (such as straw or forest residues) are used. Care needs to be taken, however, that the supply of organic matter and nutrients to the soil is not overly reduced, and that soil fertility and ability of the soil to provide other ecological services (such as providing fauna habitat, water purification etc.) are maintained.

h) The impact of biofuels may depend on the way it enters into broader production/use systems

Local energy security strategies and rural development efforts have underpinned recent interest in the cultivation of biofuel feedstocks as part of rural development projects. High oil prices and scarce access to electricity in many rural areas have sparked interest for instance in *jatropha* as a basis for local energy supply. Appropriate policy incentives can promote inclusion of small-scale operations on an economically viable basis.

i) Additional research is needed to better understand the environmental and social risks related to land use changes resulting from biofuels expansion.

This research needs to be of an interdisciplinary nature to capture the interrelationships between economic, social and environmental effects. Empirical evidence gives some indication as to the potential magnitude of such problems, but clearly remains at too aggregate a level to provide detailed answers. It should be clear, however, that the problem of land use changes is related not only to biofuels produced in sensitive areas themselves as indirect land use changes can create quite similar negative effects.

j) An international consensus on biofuels is needed

According to a document issued by FAO at the High Level Conference of World Food Security (FAO, 2008b), there is urgent need for an international consensus on biofuel sustainability, including knock-on and spill-over effects on food security. Governments may wish to consider the following five areas for action:

- safeguard mechanisms for food security,
- sustainability principles,
- research and development, knowledge exchange and capacity building,
- trade measures and financing options,
- methodologies for measuring and monitoring biofuel impacts.

3.4 Food

a) The recent food crisis has revealed a strong interdependence between energy, environment, food, financial drivers, and between choices in the North and in the South of the world

During the last two years the agri-food sector has been hit by a shock of huge proportions. The 'food crisis' has emerged as a global agenda item and calls for action both in the short term – to mitigate the impact of the crisis - and in the mid to long term to get at the roots of the crisis, have proliferated. The food crisis has triggered an acceleration of the debate over food and has facilitated links between policies once anchored to narrow sectoral interests.

Food policies implicate not only agriculture but also health, environment, energy, although very different approaches exist in the way that these may be integrated. The dominant productivist paradigm of the 20th century, in the light of more recent concerns for health and environment, is giving way to consideration of a range of other paradigms. The 2nd Foresight Panel identifies three different paradigms in the documents scanned.. The first, based on 'life sciences', incorporates health and environment concerns as market opportunities in industry-oriented biological research (functional foods, gene therapy and nutrigenomics). This paradigm considers nutrition to be an individual activity, enjoyed by the informed consumer as an autonomous agent. It accepts the market as a main integration mechanism and focuses more on cure of a presumed deficit rather than on prevention. At the opposite end of the spectrum stand policy analysts who advocate a strong subordination of agricultural activities to sustainability, and who stress the non-market functions of agriculture (such as amenities and ecological services): we could call this position post-productive agriculture. Third, the paradigm that takes into account the inter-dependency between the health of people and the environment puts consumers at the centre of the system. It considers nutrition as a social activity, and advocates a balanced governance of the food system. It focuses on prevention rather than on cure.

As far as development policies are concerned, the EU has engaged to promote the integration of development objectives, where appropriate, into its food research, technology development and innovation policies[49]. The EU also has engaged to support the delivery of **international public goods** contributing to food security, and pledges to *support pro-poor and demand-driven agricultural research and technology and improve its outreach and dissemination*[50].

b) Vulnerability of food systems, and therefore food security, has emerged as a common issue both in the North and in the South, although with different modes of expression

Broadly defined as "a situation existing when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life[51]", food security goes much beyond the mere availability of food (FAO 2008c; DEFRA 2008; Ericksen 2008). An updated food security model should take into account access, distribution, utilization, nutrition and quality, safety.

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[49] Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee of 12 April 2005 - Policy Coherence for Development - Accelerating progress towards attaining the Millennium Development Goals [COM(2005) 134 final - not published in the Official Journal]. http://europa.eu/scadplus/leg/en/lvb/r12534.htm

[50] (Communication 'Advancing the *Food Security* Agenda to Achieve the MDGs' and EU FSTP Action plan)

[51] FAO (1996) Rome declaration on world food security and world food summit plan for action.

The issue of vulnerability brings food security into consideration in a different way than in the past. First of all, it makes us understand that food security is a matter both for the North and for the South, and cannot be dealt with only by looking at national concerns. Attempts to secure food or renewable energy at national level, whether by means of protectionist measures or unconstrained free trade (Sachs and Santarius, 2007), by investments overseas, the command of powerful food chains (DEFRA[d66]), or subsidies to biofuels (Doornbosch and Steenblik 2007, EMPA 2007, FAO 2008l), can dramatically impact global food security, and by consequence also global security. If on the one hand export restrictions during the food prices crisis exacerbated the crisis itself, making food less available for import dependent countries, it is clear that without safeguard mechanisms for trade poor countries would be extremely vulnerable to external shocks (Sachs and Santarius, 2007). A unified and cooperative approach implies that a new balance between multilateral and national instruments should be found, especially on trade matters (Sachs and Santarius, 2007), and by the provision of a sufficient level of support to small scale farmers and by means of policies aiming at increasing national self-sufficiency (Nourrirlemonde.org, 2008) to the extent possible within the limits of sustainability.

c) Food consumption and production trends are among the clearest indicators of limits to growth

After two decades during which agricultural policies in the EU were devoted to decreasing production surpluses, a focus on quality, and the provision of goods and services beyond merely food, fooder and fibre production, the issue of 'who will feed the world' (Nourrirlemonde.org, 2008) has emerged again with strength. In a speech to the Italian parliament in September 2008 the director-general of the FAO said that "*we must mobilize US$30 billion dollars a year in order to double food production so as to feed a world population of nine billion in 2050*".

However, there is clear evidence that the question 'who will feed the world?' has to take into account both production and consumption as dependent variables. To the question 'how many people can the earth support?' Lester Brown answers: ' The correct question is: at what level of food consumption?'. According to Lester Brown, in fact, In the US, where annual consumption of grain as food and feed averages some 800 kg per person, a modest reduction in the consumption of meat, milk and eggs could easily cut grain use per person by 100 kg. People living high on the food chain, such as Americans or Canadians, can improve their health by moving down the food chain (Brown, 2008) as well as free up food stocks for all those who are hungry, without any further recourse to yield-stimulating technologies.

More elaborated supply and demand projections are needed, which take account of the scarcity of water and soil as well as climate and temperature changes. Meaningful projections require not only inputs from economists but also from other disciplines (such as agronomists, meteorologists, or hydrologists). This is in part a research problem; but it also offers an organisational challenge to European knowledge infrastructures.

d) To deal with limits to growth, system innovation should affect both production and consumption patterns

Based on the understanding that values, education and information lie at the basis of consumption patterns when choice is unconstrained, there is a large area of intervention possible in Europe, to create aware consumers-citizens, through disseminating information on the sustainability of their consumption choices. There is a growing number of consumers willing to pursue sustainable patterns of consumption but who lack the necessary means to do so. Information, education, and development of the retail infrastructure, are the most important tools for realising this potential. Indicators such as water, carbon

and energy footprints, food miles, seasonality, are already being used as communication tools by retailers and others to orient consumer choice, develop market share, and to activate a societal as well as individual learning processes. However, education and information are not sufficient by themselves to drive significant change. Constraints to sustainable consumption depend importantly on the everyday structures of life (distance between home-workplace, food provision structures, food choice and cooking skills, etc.). Thus change in consumption routines is not easy or costless and typically requires organisational, planning, and/or technological investments. Understanding consumption in its different socio-technical contexts is one of the keys for designing innovation policies that support sustainable production and consumption - changing the socio-technical context can drive change in the whole system of provision.

More research and knowledge is needed to show and document the consequences of unsustainable consumption styles (in particular the high proportion of animal products) and needs for action, e.g. with the ecological footprint approach (WWF, 2008) or with other assessment methods, which are understandable by civil society and consumers. On the long-term the external costs of different food systems should have been researched and their policy implications should be documented.

Furthermore purchasing behaviour of food for example plays an important role whether developments follow one direction or another (link between food purchasing behaviour increasing concentration in the food processing and retailing sector and the pressure put on primary production to deliver a certain product at a certain price). More research is needed to better understand the possible long-term impacts.

3.5 Agricultural Knowledge Systems

a) The fundamental structural and systemic shifts that have occurred in external drivers have been insufficiently absorbed and internalised within the conventional AKS regime.

Rather than being drivers of systemic innovation, the remaining publicly funded AKSs appear to be locked into old paradigms based on linear approaches and conventional assumptions. AKS infrastructures in the 20th century were largely created as public systems connected with the green revolution paradigm[52] Over the years, as they have been to an increasing extent privatised, there has been a progressive dis-investment by public authorities in AKST. Many countries among the EU25 have dismantled to a considerable extent the basis for dis-interested science and public good training and advisory services, as well as the mechanisms that supported longer term public good AKST and applied and adaptive research. Privatisation of AKST has favoured short term problem solving, and the interests of private commercial actors. Other MS retain public capacity to a varying degree, ranging from continued excellence in depth and scope (e.g. France) to increasing budgetary difficulties in maintaining historic knowledge infrastructures.

By far the largest part of the data evidencing the increasing vulnerability of food and farming systems, food insecurity, and adverse environmental trends has been generated by disciplines and typically by research groups that lie outside conventional AKSs. AKST infrastructures at European level are not organised at the moment to provide adequate capacity (infrastructures and expertise) to integrate agricultural, health, food, climate change and environmental knowledge, science and technologies, and there is a lack of instruments and trained personnel to assess in an integrated way the relevance and the urgency of issues such as climate change impacts and mitigation potential in food and farming. AKSs policies also lack the data and feedback to sufficiently address farmers' motivations to follow new innovation paths. Only a few countries, such as Ireland, have elaborated a systematic review of the kinds of education, training, organisational and institutional developments that would be required to fulfil the promise of a sustainable knowledge-based bio-economy (TEAGASC, 2008).

b) Renewed political attention to the effectiveness, relevance and scale of Europe's AKSs seems merited.

While old models of AKS have entered into crisis, policies relating to agricultural innovation are fragmented, dividing expertise and funding among a multiplicity of programs, organisations and specialist expertise, often competing in ways that promote confusion rather than efficiency. Although a few countries have been experimenting with 'innovation networks' (e.g. Netherlands) in expectation that these might drive integrated adaptations, AKS policy in general has been unable to support transitions in food, farming and rural development in a sufficiently powerful way because of the fragmentation. At the moment the EU does not have a system to monitor the evolution of AKS infrastructures, nor specific innovations, across Europe, so it misses crucial data necessary for designing and evaluating AKS policy formation and implementation.

c) Redefinition of AKSs is needed.

AKS are evolving toward networked forms of organisation (multiple actors, multiple relations and exchanges, multiple focus). However, dis-investment and privatisation have made less clear who is in control of knowledge creation, the distribution and exchange of information, or education and training of

[52] See In-sight project conceptual framework: http://www.insightproject.net/files/IN-SIGHT_WP1_final.pdf

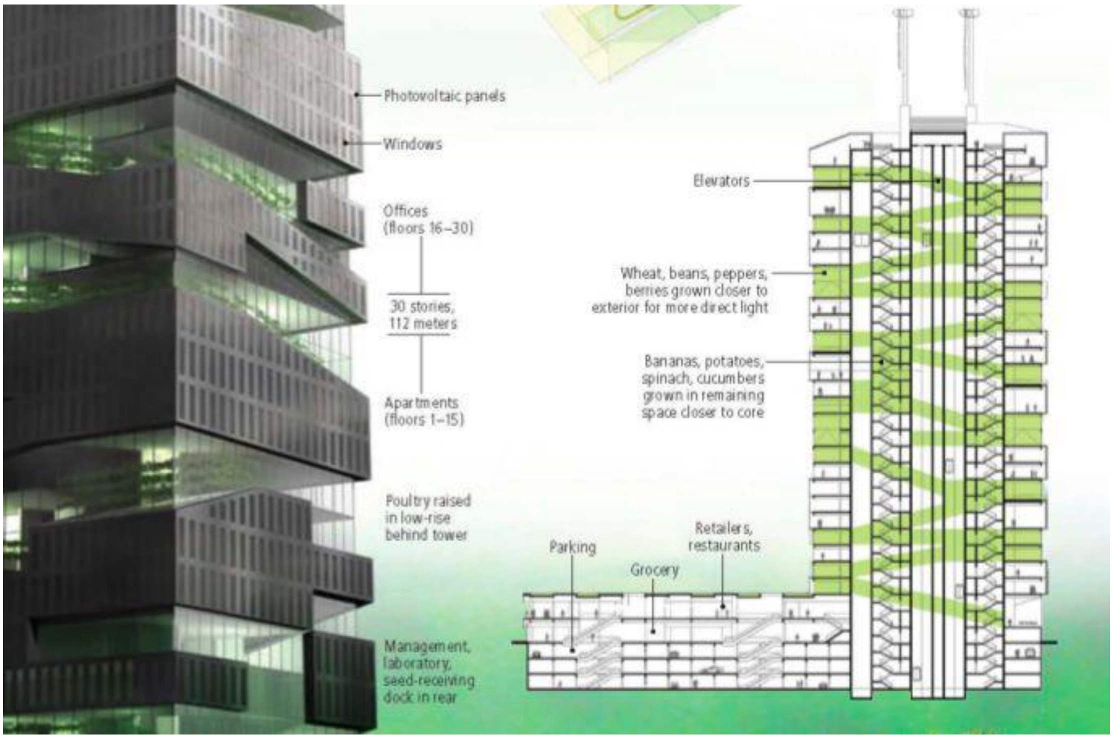
farmers and resource users. Europe lacks, for instance, coherently organised capacity to support the implementation of Integrated Pest Management as the preferred crop protection strategy[53].

Renewed attention to AKS would imply: a) steering development of capacity towards public goals, with a clear strategic focus; b) and redefining membership, by i) considering farmers, consumers and consumers' groups as important knowledge actors; ii) opening to non-conventional farm and rural representatives; iii) defining the roles and duties of private commercial actors iv) involving local administrations; and c) focusing on learning processes, information exchange, network building, knowledge hybridisation.

Farmers cannot be supported by AKS to follow new innovation paths supportive of public good goals if there is not a clear support from public agencies. The AKSs that have been developed outside the mainstream, to support organic, fair trade, and agro-ecological systems, are identified in a large proportion of the scanned documents as meriting greatly increased public and private investment. These documents also argue for bringing the lessons of existing sustainable, productive, profitable agro-ecological into the AKSs mainstream.

AKSs for instance would focus on ways to reduce the length of food chains, encourage local and regional markets, give more scope for development and marketing of seeds of indigenous crop varieties and foodstuffs, and restore the diversity of within-field genetic material, as well as of farming systems and landscape mosaics. AKSs also would focus centrally on climate change mitigation and adaptation in and by means of food and farming systems, as well as on finding ways to manage production-limiting phosphorous, water, fossil energy and biodiversity trends. The solutions could be surprising – see photo!

[53] see ENDURE reports, http://www.endure-network.eu/



Source: http://www.verticalfarm.com/[54]

d) Divergent opinions on how to redirect AKSs exist.

One group argues that food and agriculture are 'just industrial sectors' such that food security can be safely left to self-regulating competitive markets to push technical change, lower margins, create scale enlargement, and generate higher productivity. These studies are comfortable with the dominance of private interests in AKSs and on a neat separation between innovation producers and innovation users. In particular, farmers are seen only as adopters of innovations designed elsewhere.

Another group takes the view that ensuring the continued bio-physical potential for food production is so fundamental to human existence that agriculture can never be entirely left to market forces, that public value encompasses far more than profit and wealth creation, and that self-regulation has failed to safeguard the public good. They argue strongly for increased public investment in AKSs and strong public intervention to direct both private and public AKS capacities to serve the public good goal of food security under conditions of heightened uncertainty.

e) Research priorities and AKS

Consideration of the kind of research-based AKS needed for the near future increasingly is overshadowed by 'fears of the (unknowable) future' as climate impacts kick in, and conflicts over energy, water, and phosphorus erupt. The self-evident research needs to support 'profitable, productive, sustainable' agriculture and move (faster, deeper, more equitably) toward food security give way to a re-consideration of the following:

- role of small (not necessarily the most resource-constrained subsistence) farmers in conditions of uncertainty;
- food and farm technologies to mitigate climate change;

[54] More information about the project "Vertical farm": http://www.nytimes.com/2008/07/15/science/15farm.html?_r=1

- food and farm technologies that support adaptation to a carbon-constrained, water-constrained world full of 'surprise' biological responses to climate changes (that are themselves edging closer toward the edge of the knowable)
- an opening of AKS agenda-setting and assessment to wider sets of 'informed publics', to multi-stakeholder processes along value chains, to territorially based participation in 'climate change hotspots' (zones of heightened vulnerability).

4. Areas of agreement and disagreement

As we said in chapter 2, despite a growing consensus over the diagnosis of the situation and future needs, strong disagreements exist concerning solutions.

In great part, disagreement is related to scientific or policy paradigms, that is, to systems of cognitive meta-rules that guide the selection of problems, solutions and the evolution of the knowledge base.

According to Dosi (1988) scientific paradigms have the strength to create path-dependency, so that innovation within paradigms can be only incremental rather than radical. While incremental innovation is necessary in times of relative stability, in times of change, such as those we are experiencing, it is necessary to get off the path we are on and follow new paths. These paths are brought into being by alternative paradigms that, once put into practice (research programs, technologies, organizational patterns) in the changing environments, open up the innovation space to new problems, new solutions, and the development of a new knowledge base.

Disagreement is evident also with regard to policy paradigms. An analysis of policy paradigms done by the FARO project indicated a clear divide between a Muskateer (public sector must intervene to solve social problems) philosophy and a Marketeer (market liberalization will achieve solutions to social problems) philosophy (Table 6).

Table 6- Principles of the FARO-EU narratives

	Public intervention – Muskateer	Market liberalisation – Marketeer
General principles	There is a strong belief that the public sector must intervene to solve social, economic and environmental problems. The main aims of public intervention are social-economic equity, territorial equity and environmental protection. Subsidies, tariffs, public investment and regulation are important instruments to achieve these aims, and are paid for by society.	There is a strong belief that market liberalisation will achieve solutions to social, economic and environmental problems. The main aim of market liberalisation is strengthening competitiveness in the global economy to protect socio-economic achievements. Low taxation, light bureaucracy, market flexibility, and deregulation are important instruments to achieve these aims.

Likewise, in the field of food, two extreme positions have been identified, as shown in Table 7.

Table 7 – Extreme assumptions about selected aspects relevant to food

	Extreme 1	Extreme 2
Market	When markets forces are free wealth is generated	When markets forces are left free distribution of costs and benefits is uneven
State	The State should abstain from intervention the more the possible, and intervene when market fails	The State should balance the role and the action of the markets
People's concerns	People' s concerns over new technologies are largely unjustified, education and good communication is needed	Consumers' concerns over new technologies are often justified, more research on impact of technology is needed
Science and innovation	Innovation is produced by science, lay knowledge has scarce or no value	Innovation is produced by integration of science and lay knowledge
Science and distribution effects	Science-based innovation creates benefits to society	Science-based innovation distributes unevenly costs and benefits
Prevention / cure	Policies should give instruments to **solve** emerging problems	Policies should give instruments to **prevent** emerging problems
Sector approach / system approach	Sectoral policies don't have effects on other sectors	Sectoral policies do have effects on other sectors
Consumers' needs	Consumers' preferences are taken for given, they cannot be put into discussion	Consumers are manipulated, there is the need to educate them

With regard to agri-environmental issues, also two contrasting paradigms have been identified (Table 8).
Paradigm 1: Precautionary and appropriate application of technology based on agro-ecology
Paradigm 2: Break through and forced application of technology based on novel technologies

Table 8- Paradigms and assumptions related to the theme "Agriculture and environment/climate change"

	Paradigm 1 Agro-ecosystem & precautionary approach	**Paradigm 2 Technological break through approach**	**Synergies / conflict fields between the two contrasting paradigms**
Critical thresholds	Need for fundamental change - humanity is crossing some critical thresholds – no time to wait	Business as usual – humanity and technology able to adapt	
Guiding principles	Sustainability first (environmental, social and long-term economic dimensions)	Competitiveness (profit and market power) first	No clear decision procedures within the EU what comes first
Technological visions and concepts	Adapted and appropriate technology as response to needs of consumer and citizens and not to the need of profit-maximisation More downscaling and decentralized applications	More centralized and industrialized concepts and forced application Projections offered by genomics/biotech-based visions (nanotech, genomics, cognitive sciences & infotech will create a new agri-food revolution). (eea, 2008) –	Poor links between these differing concepts (eea, 2008)
Assessment	Participatory assessment of	Expert-led assessment of	Few institutional setting for

	Paradigm 1 Agro-ecosystem & precautionary approach	**Paradigm 2 Technological break through approach**	**Synergies / conflict fields between the two contrasting paradigms**
of tech-nologies	technologies (bottom up)	technologies (top down)	allowing both[55]
Role of market and regulations	Ecosystem services and public goods not ? Assumption that governments need to intervene to correct institutional inadequacies /market failures (eea, 2008)	Ecosystem services – if there is a need there is also a market State intervention maintains existing structures & constrains entrepreneurial innovation	Need for public private partnership No consensus about market failures or how the state should intervene (eea, 2008)
Role of Agriculture research	Science as interactive process between different actors. Potentials of participatory on-farm research. Importance of farmer's tacit knowledge. Innovation needs social settings	Science as the originator of change, and of a linear translation of science outputs into technology adoption by farms & enterprises, and of linear innovation processes	The increasing role of science in its 'alert' function is likely to need both approaches A paradigmatic shift is in process, confronting challenges never before experienced. Systems sciences are taking the mainstream, with power to inform integrated action

Also in the sub-theme report on rural development alternative approaches have been identified.

Table 9: Agricultural Policy Paradigms (Source: Van Huylenbroeck et al., 2007, adapted from Moyer and Josling, 2002)

	Dependent	Competitive	Multifunctional
	Old paradigm	New paradigm (used in U.S.)	New paradigm (used in the EU)
Nature of agriculture	Low incomes Not competitive with other sectors Not competitive with other countries	Average incomes Competitive with other sectors Competitive in world markets	Incomes from farming inadequated Producer of underrewarded public goods
Policy Objectives	Government needed to find markets Supply control necessary	Move towards free market Relax supply control	Preserve countryside Keep family business viable
Policy instruments	Border protection Surplus buying State trading Export assistance	Decoupled payments in transition Risk management Low safety-nets	Environmental subsidies Protection against monofunctional agriculture New institutional arrangements Rural development plans

[55] The IAASTD was the first global assessment to develop procedures and membership that aspired to combine both; an ongoing independent review of the lessons learned is likely to indicate innovative and effective experience has been created on which future assessments can build, as well as lessons about what to avoid.

As far as Agricultural Knowledge Systems are concerned we can identify strong differences in the way innovation processes are conceived (Table 10). In the 'linear paradigm', there is a clear unidirectional flow between scientific knowledge and users' knowledge. In the alternative paradigm, innovation occurs at any point of hybrid networks and is characterized by intense communication flows among researchers, engineers, producers, users, knowledge brokers. In particular, in the alternative paradigm, farmers are positioned as organized sources of new knowledge, technologies and practices.

Table 10- Alternative paradigms in innovation

	Linear paradigm	Alternative paradigm
Innovation processes	Innovation flows from science, innovation is mainly about technological change. A linear model accurately describes the process by which change in knowledge, information, technologies and practices drive agri-food systems.	Innovation occurs at any point of hybrid networks and it is characterized by intense communication flows between researchers, engineers, users, knowledge brokers.
Role of farmers	Farmers are adopters of technologies invented elsewhere.	Farmers are organised sources of new knowledge, technologies and practices. Innovation processes in the commercial sector routinely involve market research and the involvement of actors along the value chain in technology choice and the development of prototypes
Other actors involved in innovation	Transfer of knowledge occurs via the market (input providers) or through education, training and extension	Growing importance of farmers' and other civil society actors' expertise, skills and observations ('distributed knowledge') under rapid climate change.
Consumers	Consumers' needs are detected through marketing research and translated into research problems.	Consumers can be active participant in innovation processes, especially those implying changes of lifestyles.

The identified paradigms direct attention to rather different solutions to problems. At present, one paradigm is dominant (supported by strong institutions and economic interests), while the others are somewhat marginalized or neglected. Yet there is a growing perception that alternative paradigms offer possible solutions that cannot be neglected in times of change, and that therefore research policies should be directed to nurturing and sustaining their development as resources for system change.

5. Cross-cutting questions

From the analysis of drivers and the sub-themes, a number of cross-cutting questions emerge:

How to deal with the vulnerability of food and rural systems at different scales?

Vulnerability (and its contrary, resilience) is becoming a key challenge.

> **Attention to issues of vulnerability and resilience means privileging diversity over specialization, stability over maximization, resistance over artificial elimination of sources of stress, prevention rather than cure.**

A focus on vulnerability and resilience implies also looking at the complexity of processes, that is, at the interaction and synergies occurring between drivers, that may generate surprises or tipping points. For example, we have to expect that processes leading to the physical or economic exhaustion of oil or water will intensify competition among countries to procure land and water resources, secure biofuels or to appropriate the remaining reserves. Local crises may undermine social stability and amplify instability through mass migrations or by exporting terrorism. The disappearance of honeybees would remove a cornerstone species from agri ecosystems and imperil food security, as their 'free' pollination services control one third of the food produced. Introduction of new technologies without sufficient understanding of the underlying science or ex ante risk evaluation or social tolerability may bring irreversible unintended consequences.

The social dimensions of vulnerability and resilience are of particular importance. They include: local networks as social capital, local knowledge as human capital, trust in systems of social care and coping in times of stress, social distribution of wealth, can drive social cohesion or – in their absence - social conflict.

Consideration of vulnerability and resilience also brings to the fore the importance of establishing effective alert systems. At present, there is no (worldwide) observation and alert system that could serve as a basis to counter-act pressures and anticipate shocks. The problem is much more complex than the mere availability of data. No instrument has been built to ensure access to the basic information that might generate this flow. In fact, it puts into question the democratic distribution of access, interpretation, communication, decision making, distribution of power and resistance to change.

How to endogenize the limits to growth into agro-food paradigms?

The concept of sustainability, on which nowadays there is almost unanimous consensus, has to do inherently with limits to economic growth of the kind presently stimulated. However, when we turn to economic debate, this principle tends to disappear. Dominant agro-food paradigms do not take into consideration ecological footprints or social impacts: they only measure success and competitiveness in terms of capacity to grow economies and do not count the natural resource, ecological and social costs of that growth.

> **The challenge for research is to identify limits to growth in a systemic way rather than in a mechanical and linear way. On one side, technical, social, organizational innovation can reshape these limits and postpone the crisis or mitigate the costs of transitions; on the other side, synergies among drivers, tipping points and feedback loops may accelerate the crisis of human survivability if we go on pretending that we live in a world of limitless material and biological potential.**

What links between global public goods, ecosystem services and agriculture?

As we have said above, there is an increasingly recognized potential role of agriculture in mitigation of climate change. As photosynthesis can transform carbon into biomass while capturing solar energy, it is the only economic activity that can give a positive carbon balance and therefore make a substantial contribution to mitigation. At the same time, agriculture can also be a driver of adaptation, if the functions of water purification and storage biodiversity maintenance, soil fertility reproduction are well managed.

The concept of ecosystem services is a key to linking public goods and sustainable agricultural and food systems but a mechanism to integrate these services into the economic system has still to be found.

What role for state, market and civil society? New social and institutional arrangements

Many scanned documents underline the need for a different pattern of interaction between state, market and civil society. The recent crises have intensified criticism over approaches that bestow upon markets a privileged position, as the most important drivers for generating 'wealth'.

Agriculture has been identified as a sector where dis-investment and privatisation of services has produced significant damage. A new distribution of roles between State, markets, and civil society is needed in relation to access to and distribution of food, land, relevant knowledge, decision making. This is another key issue for building the resilience of agri-food systems. Climate change and environmental crises require a new state-market-citizen pattern of interaction.

Rural development effort can be re-directed, for instance, to conserve and enhance the capacity of rural areas to provide public goods, but the 2nd Foresight panel notes that a strong level of regulation and new institutional arrangements would be needed, that no longer held agriculture and rural activities in separated bureaucratic cages. Past experiences have demonstrated that without a strong civil society, the continued separation of effort is likely – because this serves the efficiency of top-down, supply-push interventions – but such separation is making society far more vulnerable than it need be. Civil society mediates the relationship between individuals and the State, introduces different voices into decision-making processes, stimulates social innovation and the co-production of goods and services.

6. Research needs and priorities

A more detailed analysis of research needs, as emerging from the scanned documents, is presented in part two. In the section on 'Drivers' we have indicated already the main research needs emerging from the analysis.

Here we classify the priorities into: 1) general priorities; 2) thematic priorities; 3) data priorities; d) methodology priorities. An analysis of consensus / disagreement on the priorities follows.

6.1 General priorities

a) Creating more resilient systems by emphasizing 'niche' research

'Niche' research, developing out of mainstream research and aimed at building new paradigms, has the property to anticipate change and to identify risks and tipping points that mainstream research tends to deny. The role of niche research should be emphasized by research policy, in order to introduce evolutionary mechanisms into present research systems.

b) Strengthening the alert function of science

Surprise, unintended trade-offs, tipping points: adaptive capacity in a complex, inter-dependent and climate-changing world requires integrated capacity in food and farming systems to signal dangerous trends and approaching thresholds.

c) Strong emphasis on interdisciplinary research

Despite the common agreement on the need for developing interdisciplinary research, agricultural and rural research is far from being truly interdisciplinary. Favourable funding mechanisms, educational capacity, institutional incentives or organisational hosts for this kind of research are insufficient compared to the scale of challenges, within member states and at European levels. European research policy should actively seek to remove existing barriers, including systems of evaluation of research quality, elaborating selection criteria able to reward truly interdisciplinary research projects, and by stimulating experiment on how to organise inter-disciplinarity)

d) More theoretical research (eco-eco, socio-eco, ecc.)

The changes affecting our lives show that research needs to reframe conceptual maps regarding agriculture, environment, competitiveness, markets, state intervention etc. This implies a new emphasis on theoretical research. In fact, as the existing paradigms are challenged, there is the need to move from interdisciplinarity – that implies a joint engagement of different disciplines in a common problem-solving activity, to transdisciplinarity – which has more to do with transgressing boundaries among disciplines and carrying to a 'fusion' among disciplines. For example, ecological economics is a new field of research which has not permeated mainstream economics, analysis of socio-technical systems is at its beginnings, system biology and agroecology challenge the way agricultural sciences have been carried out so far.

e) What and whose knowledge?

Analysis carried out before has put into evidence the inadequacy of existing bodies of knowledge to address properly the new challenges. Research policy needs to address the mechanisms of generation of new sources of knowledge, for instance through hybridization between disciplines and between knowledge actors. In particular, the role of local knowledge (based on individual as well as on social learning) as a source of distributed environmental monitoring and warning capacity, should be explored; the new information and communication technologies could offer innovative support to this endeavour.

6.2 Thematic priorities

f)Sources of vulnerability of the food systems and mechanisms of public good production

The concept of vulnerability and of resilience imposes a system thinking frame based on acknowledgement of the interdependencies between drivers, feedback loops and non-linear trends. Vulnerability and resilience of agri-food system can have multiple sources, and these sources may interact to generate unexpected responses. Resilient agri-food systems rely on ecosystem services that are generally public goods produced and reproduced jointly in the course of economic activity. Theoretical and empirical research is needed to measure and assess the inter-play of vulnerability and resilience in relation to the levels, quality and mechanisms for the production of public goods, with specific regard to agriculture. It is important that on all levels (EU, national, regional) but in particular on a regional level mitigation and adaptation measures has to be developed and combined with biodiversity measures in a participatory approach. Appropriate tools have to be developed for forecasting, monitoring and integration in policy support measures. More research is needed about the the environment- livestock interactions as this economically very important agriculture sector is responsible both for many environment problems (land degradation, climate change, water scarcity, biodiversity, residues in some food, pandemic diseases) along with potential technical and political approaches to mitigation and adaptation. How can the balance found between all the trade-offs between an appropriate (eco-functional) intensification in some areas and extensification linked to payments schemes for ecosystem services as the most important in vulnerable areas? (FAO (2006)Livestock's long shadow, d72)

g) Ressource-efficient post-oil agriculture production: sustain the consolidation of alternative paradigms

Agri-food research will have to revise its present mission, that has centered for a long time on yield-efficiency maximization and driven the food systems toward hyperspecialization, technological and bureaucratic control, dependence on external resources and on long distance markets. Foresighted non-renewable resource exhaustion raises the need of developing new methods of production based on renewable resources. How will be a post-oil agriculture? How to measure its inputs and outputs to be sure to evaluate correctly costs and benefits? Which technical, organizational and entrepreneurial principles will be needed? Which knowledge base? Progresses in this field have been already done, but the resources addressed to this goal have not reached the necessary critical mass to make alternative paradigms scaling up.

h) Organizational and social innovation in agriculture and rural development.

In a knowledge-based bio-economy innovation concerns any change that may contribute to solve societal, economic and environmental problems. As change, and not stability, is the dominant condition of this phase, it is important to develop a strong understanding of how systemic change takes place. A growing body of empirical evidence shows that innovation is related to organizational change and change in social patterns. ICTs - as opening new potentials for connectivity - have a strong role in accelerating this kind of systemic innovation. For example ICT support tools can facilitate new forms of land use and animal husbandry, without changing ownerships, and facilitate new forms of cooperation between farmers but as well in the communication with consumers. By contrast, the bulk of our research capacity increasingly is addressed to industry based goal-seeking.

i) Sustainable Consumption as a driver of innovation.

If there are limits to growth of the kind we presently enjoy, adaptation to these limits needs to act upon consumption. Sustainable consumption can offer a profound response to the environmental crisis. It does

not just imply a reduction of average consumption levels among well-fed populations. It implies over the medium to longer term a restructuring of the role consumption plays in society, of consumption infrastructures, and of consumption routines. Research methodologies and procedures are needed to further explore the potentialities of consumption-driven innovation. A stronger role for consumers in research networks may offer an impulse for innovation that drives toward sustainability.

J) Coherence between private competitiveness and public goals

Competitiveness, in the new phase, becomes much more related to survival in a turbulent environment rather than to capacity to dominate markets. If maintenance of public goods becomes a priority, how might competitiveness in these conditions be translated into coherent business models and appropriate business regulation? What are the obstacles to this goal? What competitiveness indicators can be used? What are the most appropriate policy measures for supporting this transition?

6.3 Data and indicators priorities

k) Measurement of public goods

Existing market and regulatory mechanisms are not able adequately to regulate the production and reproduction of public and private goods because price signals do not at present give a true reading of the full range of costs involved. If new forms of governance of food and agricultural systems are required there is a consequent need for tools able to assign value more appropriately.

l) State, structure and performance of European agricultural knowledge systems

There is no European policy addressing agricultural knowledge systems in an integrated way. We do not even have a clear understanding of national AKSs in Europe. Insufficient and incomplete documentation exists over the structure, the functions and the relevance of AKSs at all levels. Existing documents are related to a relatively few number of European countries and are incomplete. Documentation of the role of farmers in commissioning, contributing to, and funding research are especially poorly documented. The role of civil society organizations in mobilizing and digesting information from research and citizens, and in providing feedback from research and technology users, is hardly acknowledged. The potential contribution of consumers and citizens in providing continuous point source data is largely invisible (except, for instance, to retailers). A considerable and perhaps the largest part of the information and research data developed or held by private companies is no longer accessible to public scrutiny, being classified as proprietary information. There is scant capacity for integrating data and experience across sectors that are closely entangled (e.g. from water and agriculture; or from biodiversity trends, village expansion, landscape planning and agricultural technology choices…).

m) Effects of consumption styles on the environment

Numerous synthetic indicators have been built (footprints, food miles, virtual water etc) to assess the effects of public policies, to increase corporate responsibility and to facilitate sustainable consumption patterns. But development of methodologies and new systems of data collection are still in a very early stage. We are not in a sufficiently well informed position to answer robustly and beyond dispute even simple questions such as: what are the implications for the global environment of the choice between consumption of organic and conventional? And of a meat-based consumption style? Which trade-offs may occur in making such choices?

6.4 Methodological research priorities

n) Across scale and across sectors impacts

Research typically addresses questions largely confined to sectoral concerns, but there is increasing evidence that any sectoral choice or trend can affect substantially other sectors. Likewise, research carried out at global level is not able to detect differential changes at lower levels. New knowledge is required on methods and approaches that are better able to take into account cross-scale (spatial and temporal) and cross-sector linkages and impacts.

o) Are quantitative models sufficient to deal with sustainability?

The models currently used in EU27 research projects dealing with research on rural areas are useful tools for making consistent and quantitative calculations of the impacts of various scenarios. These models deal with the key exogenous drivers and aim to capture the complexity of economic, environmental and social processes affecting rural economies. The models provide quantitative outputs for indicators such as GDP, agricultural employment, population density, and land abandonment. These outputs form valuable indicators of processes affecting living and working in rural areas.

Unfortunately, there are several limitations to applying the present suite of models in research dealing with the three dimensions of sustainability. Most of these models were developed over the last decades and are not designed to cope with specific changes in European policies affecting rural areas, especially the social impacts linked to EU structural policies (i.e. ERDF, ESF, Cohesion Fund, the rural development fund and the fishery fund). For example, while direct agricultural subsidies and trade barriers are incorporated in the models, EU cohesion support is not considered. In addition some basic assumptions on which the models are built do not follow key issues in rural areas such as land abandonment, accessibility to services, human capital. In addition, indicators on GDP and employment are only available at national levels and are therefore difficult to translate to regional impacts.

p) How does agricultural and rural research take into account spatial differences within Europe and within regions?

With enlargement, European Union has strongly diversified the range of contexts in which agriculture is carried out, as well as agricultural structures and business models. Common agricultural policies, on the contrary, are built having before enlargement EU as a general context. More research is needed on impacts of the CAP on new entrants, and on their capacity to benefit from CAP.

7. Scenario exercise

The scenario exercise is based on the trends and uncertainties of drivers analysed in section 4. Three scenarios have been chosen: rural areas; intellectual property rights; the dairy (livestock) sector.

The general narrative of a scenario is based on the following statements:

- There is a state of the system based on regime drivers; the system is more or less resilient to change in scenario drivers
- Within the system, more or less niche drivers exist. They may be tolerated, encouraged, contrasted.
- Change may be caused: i) by change in the state of landscape drivers; ii) internal contradictions between regime drivers
- Change may happen also as the effect of a crisis or in anticipation of the crisis
- During the change, niche drivers can become incorporated into a regime
- The outcomes of the change will depend on the available alternatives provided by the niche drivers.

We first offer the three thematic scenarios. The exercise concludes with a scenario, in table form (table 13) that gives a synthesis of policy transitions, by decade.

7.1. Rural Areas Scenario: a post-productivist countryside in times of high oil prices[56]

2030. Urban-rural relationships have been revolutionised by the marked rise in fossil energy costs **(landscape economic driver)** and the restrictive policies concerning the greenhouse emissions **(landscape policy driver)**.

Therefore private transportation is expensive and people reduce their mobility and populations are concentrated in cities. Population in rural areas keep decreasing **(regime social driver)** and part of rural area functions (agricultural production, recreation, etc...) are moved close to the urban centres or even included in the urban areas (e.g. self-production of food in urban gardens). The migration from other countries that used to work in rural areas will move to the peri-urban areas in search of jobs **(landscape social driver)**.

The effects of these changes can be summarized as follows:

Land Use Changes

Urban boundaries expand **(niche economic driver)**. Some agricultural land remain agricultural, others are converted to urban uses, and there is also a conversion of agricultural land to various natural vegetation types. Agricultural production is moving to urban centres. There is also an expansion of intra-urban agriculture, which is characterized by its economic, social and environmental integration in a restrained area.

Because of the concentration of population in urban areas, large metropolitan regions appear, and the urban centres are connected by public transport and telecommunications nets. In this context of new rural-urban relationships, a particular challenge lies in the multifunctionality of peri-urban land use. The cities use rural areas by making available to them.

[56] Developed by Rosa Gallardo Cobos and Marta Peres Soba. This scenario is inspired by the "Scénario 3: les campagnes au service de la densification urbaine" of the INRA Study: Prospective Les Nouvelles Ruralités en France a l'horizon 2030 (2008)"

Countries have shifted to biofuels in response to rising oil prices and national policies for the purpose of energy security and climate change mitigation **(niche economic/environmental drivers)**. But biofuel production doesn't pose new food security risks because of the development of biofuels technologies, norms and regulations **(landscape technological driver)**. There is a great moderation and efficiency in energy consumption. It is now possible to increase biofuels output without encroaching on land used for food production or resorting to deforestation (second and third generation of biofuels) **(regime environmental driver)**. Agriculture and forestry are potential sources of alternative energy products (second-generation ethanol, biomass etc.). But the alternative technical solutions have not reduced energy costs, and the increase of transport costs tends to redistribute agricultural production relatively near to the city **(novelty economic driver)**.

As an effect of rising oil prices we assist to a clear distinction between three types of rural areas:

Peri-urban areas, that previously were diffuse residential areas, are now partly integrated into cities. Their land has become a mosaic of areas specialized in logistics, energy, environmental, etc… at the service of the cities.

Specialized agricultural areas provide food and fuel. As there is a strong competition for land, land prices have increased, and a process of concentration have occurred. Access to land is difficult to outsiders. Availability of migrant workers allows the growth of intensive systems of production, and environmental constraints push forward green technologies in the fields of energy efficiency and recycling of resources **(regime environmental /technological drivers)**.

In remote rural areas exploitation is difficult, and when agriculture disappears they become forest areas. There are also large protected natural areas, dedicated to environmental management. These areas are crucial for European society because they are highly concerned about environmental issues and urban pressures. Land prices are lower, and there is an in-flow of second generation migrant workers who activate small size multifunctional farming **(novelty social driver)**.

Food needs are sourced by a mix of "mass production", sourced in specialized agricultural areas, fresh food sourced by the periurban area, specialties, sourced mainly from remote areas endowed with particular characteristics, and imports. However, as prices of transport are higher, imports tend to be reduced **(niche economic driver)**.

The establishment of labels and signs of quality (health and environmental) is a way to offer information about production methods used, and also about the territorial links of the product. In the case of production in urban and peri-urban areas, risk control is particularly essential.

Governance

Because of the expansion of urban areas, the most important territorial planning is the urban one. Rural planning is now extremely dependant of urban planning **(novelty policy driver)**. For not peri-urban areas, the development of the nature and residential functions of these rural spaces goes together with an increased interest in public goods: amenities, biodiversity, landscape, etc. that are the basis of those functions. Therefore rural public goods are more and more valued and consumed **(niche environmental driver)**. New institutional arrangements appear to deal with this emerging complexity of the local situations.

There is strong concern regarding environmental challenges (climatic change, biodiversity, natural risks, etc.). Such a concern is taken over by world institutions and governments even in a liberal context. Rural residence is possible for wealthy urban people only (Residential rural). Farmers' influence declines due to the priority given to the preservation and maintenance of landscapes and natural resources that are managed by various rural actors (Productive rural). The whole of rural space is organized to meet the

environmental challenges (Nature rural). Therefore there is a new distribution of competencies among the various levels of public administration.

Demography

Population in remote rural areas keep decreasing **(regime social driver)** but the overall decrease in rural population is substantially less, because many urban residents move to live in rural areas near the urban centres (peri-urban areas), in order to enjoy a more peasant and healthy environment **(regime social driver)**. Important social conflicts arise in peri-urban areas because rural population is marginalized. Societal tension builds up as the impoverished and poor immigrants move to urban city centres or to remote rural areas **(landscape social driver)**, where we can find a process of repeasantization.

Rural Economies

This scenario leads to increased differences between urban areas and the countryside. As rural population is declining, and moving towards urban centres, rural economies are less diversified. This population movement implies a relocalisation of economic activities from rural areas to metropolitan areas **(novelty economic driver)**. Agricultural production is moving to urban and peri-urban areas where markets are easily accessible. In these areas, full-time agricultural production activity will be radically reduced, even abandoned, the land will be used – in favourable cases – for environmental, recreational, and other non-agricultural purposes. The prime drivers of rural economic growth will be: tourism, leisure and sports activities retirement-related services, environmental services, energy. In specialized agricultural areas big farms prevail, with the employment of migrant workers.

So, the productive and residential functions of some rural areas are less important, while the environmental function is the main one in this scenario. It means that in some regions rural employment opportunities have been radically reduced. These people look for new employment first of all in the urban centres.

These changes imply a conceptual modification of agricultural multifunctionality. The environmental function of rural areas is now less dependent of agricultural activity. The social function of agriculture is not fully linked to rural territories. It means that the rural territory, as an integrated and holistic concept and also as a social construction, is now a more spatial concept.

Effects on the Environment

Urbanisation is concentrated and rural development focuses on green belts around urban centres. The concentration of built up areas is linked to the decreasing demand for transport, and hence energy consumption **(novelty environmental driver)**.

There is a clear distribution of the space between productive and natural areas. The challenge of climate change raises the issue of reducing emissions of greenhouse gases by agricultural activities and livestock, as well as increasing the potential storage in soils with good agricultural practices. The specialization of the spaces provides a priori different responses to environmental disturbances related to climate change.

Because agriculture decreases, cropland and grassland strongly decrease. On the one hand, biodiversity, water, soil and air quality benefits from receding agriculture and creation of green belts. Surrounding rural areas play a crucial role in the management of water runoff from cities and they provide much-needed recreational opportunities for urban inhabitants.

Natural habitats develop in the wider countryside, but to the detriment of high nature value farmland **(novelty environmental driver)**.

In specialized agricultural areas, land tend to be exploited with monocultures or with intensive cultivation, bringing to erosion of biodiversity, water scarcity and soil erosion.

Some areas are specialized in providing ecological services **(niche environmental driver)**. It also raises the question of biological diversity in rural abandoned areas, and the potential role of agriculture and livestock to "keep" spaces.

Effects on food security

Food production is mainly concentrated in specialized agricultural areas, but as an effect of urban sprawl and of feed-fuel competition land dedicated to food is decreasing and food prices are high. This makes the problem of access to food by lower social groups very relevant in European towns, as they tend to increase in number. As reduced mobility makes more difficult for people not having a car to have access to fresh food stored in supermarkets, local food shops tend to grow, mainly run from migrants' families who have the necessary family labour power and flexibility **(niche economic driver)** .

Public Policies

Because of the increasing territorial divergences, more differentiated approaches are applied to regions which are in quite different situations. Heterogeneity is, without doubt, a difficulty and a threat for community governance, but simultaneously it is an opportunity as well. Differentiated approach can promote integration.

CAP: Agriculture enjoys in this scenario significantly less direct support and protection. The share of CAP in the community budget is substantially reduced. Consequently, rural areas undergo a fundamental transformation. It is possible a dismantling of the CAP **(novelty policy driver)**.

Rural Policies: As said before, the environmental function of rural areas is the main one in this scenario **(niche environmental/policy driver)**. High environmental standards are agreed at national and EU level. Agricultural subsidies are reduced, with remaining support specifically aimed at environmental sustainability and as a catalyst for rural development. So, farm subsidies are in particular targeted at the agri-environment and the maintenance of a viable countryside. There is an increase in protected areas. The maintenance of natural and cultural heritage is mainly publicly funded, and it is a government priority. Hotspots of biodiversity are protected by EU regulations and many other areas by national or subnational governments. There is a strong need of environmental policies, because in absence of this support land will be simply abandoned and exposed to different environmental hazards and to deterioration.

Cohesion Policy: Regional disparities are increasing both among and within countries. There are regions, where absolute decline has occurred. Therefore there is a strong need of regional and cohesion policy.

Other policies: Other important policies are those related to the investment in public transport and to land market regulation. Energy security is a matter of permanent national policy.

7.2. Radical reform of IPRs[57]

2030. It is 20 years' since the EU member states have introduced a regulation (**policy regime driver**) that makes it compulsory for all public research institutions, and private institutions that undertake research financed with public funds, to:

a) publish only on 'free to access' journals;

b) to register research products only under 'open source' regime (patenting is prohibited);

c) to use only methods upon which patents exist only if they manage to register the products of the research under 'open source' contracts.

EU regulation has also extended farmers' rights to farmer-to-farmer seed exchange, allowed registration of new varieties only under UPOV[58] rules and prohibited industrial patenting systems, adapted DUS and VSU[59] UPOV rules to facilitate implementation of small producers' seed networks, maintained and improved GMO approval procedures to take into better account potential social and environmental impacts, tightened coexistence rules to avoid accidental contamination.

The impacts of these changes in regulation are reported in an evaluation report that can be summarized as follows:

Big seed companies

Big seed companies are forced to change business strategies (**economic regime driver**). Profits from royalties have dropped as open source products have taken over a large share of the market, and competition in the seed market has intensified, giving room to new regional and national seed companies. Companies have started to tailor GMO products to local environments, so diversifying their product lines. In some cases, they have developed partnerships with local universities and contributed to the production of open source seeds (**niche technology driver**). Drawing from the huge knowledge accumulated in the field, seed companies are shifting from seed development to retailing and technical services. However, they address their marketing strategies mainly to large scale farmers strongly integrated with retail chains or with processors. As private companies can no longerpatent the products of public research nor can they patent varieties under industrial patenting regimes, they concentrate their funding on basic research and on environment-specific seeds.

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[57] Developed by Gianluca Brunori

[58] The International Union for the Protection of New Varieties of Plants or UPOV (French: Union internationale pour la protection des obtentions végétales) is an intergovernmental organization with headquarters in Geneva, Switzerland. UPOV was established by the International Convention for the Protection of New Varieties of Plants. The Convention was adopted in Paris in 1961 and revised in 1972, 1978 and 1991. The objective of the Convention is the protection of new varieties of plants by an intellectual property right. By codifying intellectual property for plant breeders, UPOV aims to encourage the development of new varieties of plants for the benefit of society. For plant breeders' rights to be granted, the new variety must meet four criteria under the rules established by UPOV.

1. The new plant must be novel, which means that it must not have been previously marketed in the country where rights are applied for.
2. The new plant must be distinct from other available varieties.
3. The plants must display homogeneity.
4. The trait or traits unique to the new variety must be stable so that the plant remains true to type after repeated cycles of propagation.

Protection can be obtained for a new plant variety however it has been obtained, e.g. through conventional breeding techniques or genetic engineering. (from Wikipedia)

[59] DUS stays for Distinctiveness, Uniformity and Stability; VCU stays for Value for Cultivation and Use (see footnote 58)

Small seed companies

The new regulatory framework opens room for development of small seed companies. They are either farm-based enterprises specializing in seed improvement or spin-offs of universities or specialized small seed developers **(niche economic driver)**. Enjoying the decreased cost of seed development, their business strategy is based on collaboration with farmers and provision of services rather than on goods (after the first generation, farmers tend to reproduce their own seeds) **(niche economic driver)**. Most of these companies specialize in regionally-specific seeds.

Effects on farmers' activity

During the 20 years period farmers have intensified their own activities in genetic improvement **(novelty economic driver)**. In many countries, farmers have created consortia to make participatory genetic improvement, linking up with universities to participate in participatory genetic improving programs, or have created start-ups specializing in seed development. As an outcome of this intensified activity, farmers have increased their relationships with neighbours for seed exchange and turned improved local seeds into 'geographically indicated' products. Most farmers buy seeds from local seed producers or exchange them in peer-to-peer networks **(novelty economic driver)**. Those farmers who buy GMO seeds from seed companies enjoy a substantially bigger freedom of choice among GMO seeds.

Reform of IPRs has contributed particularly to strengthening small farmer enterprises and local innovation. They have taken control of genetic improvement activity and of its rewards, reduced their dependence on input providers, and gained control of local markets. By developing direct communication with consumers, they can perceive their needs in terms of taste and functional requirements, and by having a voice on genetic improvement they can transfer these criteria into research.

Public research

Public research organizations enjoy an unprecedented freedom of research. They have access to growing open source databases, so that costs of research are consistently reduced. As climate change is still a top priority in research, many research groups address their research activity to developing seeds that help farmers in adaptation and mitigation **(regime technological driver)**. As diversity is rewarded by the market in the form of demand for differentiated products, there is a growing pressure to collaborate with farmers and rural communities to have access to local biodiversity. Genetic improvements embody participatory methods **(niche technology driver)**. There is much more attention to intra-species GMO rather than to inter-species constructs. Research objectives shift to development of varieties adapted to the environment, and there is a stronger interdisciplinary collaboration between 'in-field disciplines' and 'laboratory' disciplines.

AKS

As genetic improvement activity is diffused among network of farmers and public research institutes, a new category of specialists has grown in the field of extension: facilitators of genetic improvement and knowledge brokers **(niche economic drivers)**. Their role is to promote participatory breeding, link up to appropriate research institutes, facilitate networks of seed exchange between farmers, feed open source genetic databases, and advise farmers on best seeds to be chosen in relation to the characteristics of the environment.

Public sector

As the new regulation increases the number of laboratories that produce GMOs, control systems under coexistence rules are strongly developed. Constant monitoring allows the gathering of relevant information that improves the understanding of cross-pollination and contamination mechanisms and their impact on

the environment. This improved understanding improves and accelerates authorization procedures. Those varieties deemed to produce negative environmental effects are easily detected and excluded from introduction into Europe. The number of applications submitted to authorization procedures increase significantly. As intra-species GMOs reveal themselves as less risky, many seed developers are encouraged to address their efforts to this opportunity.

Effects on the environment

The new regulatory environment gives more space to the development of local varieties (and landraces), and this improves substantially agri-biodiversity. Problems of resistance of pests in GM varieties are still present but, on the one hand, this problem is considered in the process of approval for GM varieties and, on another hand, the large number of GM varieties on the market limits the vulnerability of food systems.

Systems of provision of food

As farmers gain greater control over genetic improvement, so they develop new systems of provision that allows them to communicate to consumers the distinctiveness of their products compared to corporate supply chains **(niche economic driver)**. They can rely, for instance, upon organic, GM free and local criteria to differentiate their business strategies. For their part, supermarkets are developing partnerships with seed companies and farmers' unions to develop new seeds (for example, based on nutriceutical characteristics, shelf-life, adaptability to ready-to-eat meals) **(niche economic driver)**.

Consumers

After 20 years of application of this regulation, consumers have attenuated their concerns about GMOs. They can identify clearly GM from GM-Free products, and at the same time they enjoy a greater freedom of choice as they can have access to a larger number of local as well as specialised products.

7.3. Scenario for milk farms[60]

2030. 30 June

On this day the town council of URBAN organized a tour to show interested citizens and consumers where their milk came from and how animal welfare issues are taken into consideration. They visit three farms.. A small team from the regional university and an experienced farm advisor, act as tour guides. They first provide an overview of how agriculture has developed over the last thirty years. Here is their report.

Strong change of farm structures in the 1990s

About 50 years ago, there were more than 300 farms around the town. By the 1990s price pressures and a change in agricultural policies as a result of world-wide market liberalization led to marked change in the structure of farming. Many farmers gave up or moved to part-time farming. The remainder began to specialize and to intensify. A third of the remaining 60 full time-farmers still had milking cows. At the beginning of the 20th century the process of specialisation intensified; price pressures forced most of the farmers either to acquire more land and animals or to find additional income opportunities such as direct marketing or part-time urban jobs.

Remarkable year: 2008

Climate change and rising energy prices began to shape the policy debate. The EU took a pro-active position on both these issues but the global context did not favour major change. The year 2008 is remembered as the year of simultaneous food, fossil fuel, financial and economic crises. After 2008 many governments gave more emphasis to interventions led by the state, although policies were not always

[60] Developed by Otto Schmid and Janice Jiggins

consistent between sectors. Although a majority of countries agreed to reduce greenhouse gas emissions under the Kyoto Protocol and also agreed to pay attention to biodiversity, animal welfare and soil protection in the implementation of these goals, effort was slowed by the economic crisis. The EU continued to subsidise farmers but the search for alternatives began. Growing competition between food and fuel created in some poor countries food security problems. Farmers everywhere experienced growing insecurity, making it more difficult to make long-term investments. Some dairy farmers in lowland areas began growing subsidized maize or rapeseed for energy than as fodder for their animals or for human consumption. Others further intensified their dairy operations; cows were treated as short-life biofactories; robots appeared for the first time in the milking parlour; mega-dairies began to dominate production in some countries. Nitrate, methane, and ammonia losses from dairying remained a key environmental concern. Continued subsidies encouraged ever-higher stocking rates on grassland and intensification of grassland management led to an accelerating loss of flower diversity and soil degradation. Nature conservation programmes in dairy farming areas remained fragmented and the ecological results were unsatisfactory. Consumer and citizen groups lost trust in farming.

Strong changes from 2015/16 onwards

The second decade of the 21st century experienced social and ecological turbulence. Politicians underestimated the importance of water resources. Global warming led to drier summers with higher temperatures, and arable farmers invested in irrigation systems, in particular for maize production, leading to additional pressures on supply. In the lowlands between 30-50% of the land was used for maize and rapeseed as well as sugar beets but yield was depressed by more virulent pests and diseases.. Farmers drove ever-higher levels of resistance and pollution by mis-use and over-use of synthetic crop protection, even if they grew GM crops, and although EU policies had tried to reduce strongly the use of pesticides. The majority of conventional and integrated farms converted to no till systems and the use of glyphosate herbicide, leading to an increasing problem of weed resistance and increased use of herbicides. Specialised beef farms experienced new pandemic diseases, and growing resistance to antibiotics and other drugs. New kinds of herd health strategies emerged in dairy farms, reliant on ICTS and robotic monitors.

Strong change of agricultural policies in the third decade

The number of milk farms further diminished; only 10 dairy farms remained and the size of the farms and stables had doubled under fiercely competitive markets. They were reliant almost completely on increasingly expensive concentrates and were caught in a classic cost-price squeeze.

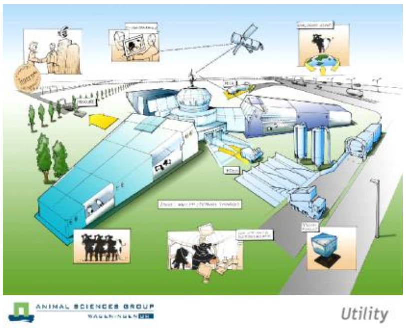
The EU and national governments negotiated a re-orientation of their policies, introducing environmental taxes, and direct payments for ecological services and agr-ecological practices. Resilience, vulnerability, security, and risk management became key policy concepts. The dairy industry bifurcates.

Mega-dairies in big cities become completely closed, automated systems, with full waste-heat recycling and advanced use of nano-tech, robotics and ICTs that reduce the need for labour (Picture 1). They remove dairying from the land and into the industrial areas of cities. They are developed in close association with pharmaceutical and speciality and functional food industries.

When dairy cows are moved into the ‘mega-units’, demand for water dramatically increases, from 3-5 litres/cow/day when eating grass, to around 10 litres/cow/day when fed semi-dried and dried matter, and from a diet of semi/dried food for a few winter months to 365 days/year. Such mega-units prove unviable in the increasing number of areas that are physically or economically water-stressed, and dairies are brought into direct competition for water with other users in a climate-changing world that is increasing water stress.

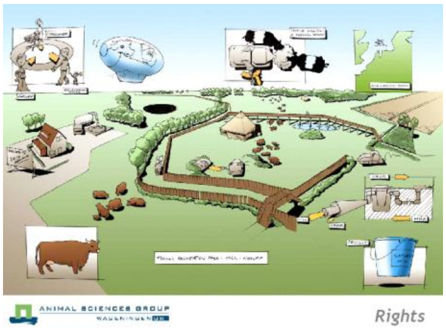
Prices of dairy products, far from falling under technology change, begin to increase steeply as water-pricing becomes the norm. A new dynamic begins to emerge. Poor consumers' nutrition status declines and governments once again add 'free milk' programmes to the school curriculum. In the countryside, the tradition of the 'house cow' begins to re-appear. Bio-technology and classical plant breeding, under stimulus from the world-wide introduction of carbon taxes, provide guidelines for dietary management to reduce GHG emissions from dairy cows reliant on natural grassland, and develop new forage crops with a high albedo-index that contribute to climate change mitigation. Nature managers perceive a new opportunity, relying increasingly on multi-purpose breeds to conserve natural grasslands and landscape values and to provide income through sales of high value 'quality milk' and dairy products. These trends spark a demand for new kinds of vocational and professional skills and services, and increasing rural employment opportunities.

While the 'factory cows' in the mega-units have complete commercial IPR protection, from the DNA through to the system levels, the counter-trends operate under 'open access' IPR that fosters rapid innovation among local actors strongly linked to regional and global information and research networks. In a rapidly changing environment, distributed knowledge and flexibility of response seem to offer better opportunities for co-evolution than the rigidities of highly concentrated industrial dairy enterprises.



Picture 1

Picture 2



Picture 3

[Graphic: Animal Sciences Group Wageningen University: HIGH TECH FARM – NATURAL FARM – COMMUNITY FARM[61]]

M*odernised mixed farming systems* apply ecological principles at enterprise and landscape scales. They use highly specialised integrated management techniques (including robotics and ICTs) to meet multi-functional goals, including conservation of breeds, grassland biodiversity, food cultures, and touristic values that attract ecological service and climate mitigation payments. Picture 2 shows this strategy applied to a family farm enterprise; Picture 3 shows the same principles expanded to community and landscape scales.

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61 The inspiration for this scenario is a Wageningen University project, Animal in balance - Interactive Strategic Planning for a Socially Acceptable Animal Husbandry. Animal Sciences Group. Wageningen University (2004-2005). See Spoelstra, S.F, J.W.A. Langeveld, P.W.G. Groot Koerkamp, J. Luttik, G.B.C. Backus en J. Grin 2002. Sustainable Technology Development applied to livestock industry in the Netherlands. In proceedings fifth IFSA European Symposium. Farming and rural systems research and extension. Florence (I), April 8-11. P90-99. Facolta' di Agraria, University of Firenze: Florence, Italy.
Relevant weblinks:
http://www.verantwoordeveehouderij.nl/index.asp?producten/index.asp?project=11
http://www.ser.public.lu/publikationen/buchstellentag/animal_balance.pdf
http://www.agrocenter.nl/animalinbalance/NL/

Drivers for the two strategies

The primary driver of urban industrial dairying is market-led economic growth in price environments that do not reveal the true costs of economic activity. Economic decision-making and policy thus is made on the basis of mis-leading or incomplete data. The institutional frameworks encourage increasing concentration of ownership along the food value chain and a narrowing of the 'innovation space' in favour of the interests controlling Intellectual Property Rights, especially as these relate to cloning, GM, veterinary products, processing of raw milk into a range of speciality and functional products , procurement, and retailing. 'Business as usual' dominates policy thinking for this sector.

The main driver of advanced mixed dairying is policy that favours the evolution of the dairy and livestock sector toward flexible, decentralised, and less tightly coupled solutions. They offer greater resilience in a climate-changing world, are less dependent on fossil fuels and synthetic fertilisers, and respond to health-led concerns that are driving change in human dietary preferences. Science and technology are applied to drive changes in grassland management, catchment and river system management, animal diets, breed selection (animal genetics) and housing to reduce GHG emissions, and to increase water and energy efficiencies. High value dairying leads the transition to integrated landscape management and new landscape designs that favour agro-silvo-pastoral culture, biodiversity and conservation, and the cultural heritage of food and landscapes. Civil society expectations encourage experimentation with context-specific strategies for mitigation, adaptation and resilience. 'Sustainable farming for the future' dominates policy thinking in this sector.

8. Synthesis of policy scenarios[62]

Table 11- Trends and development scenarios in the food and farming sector – outlined in policy stages in a reactive or procactive scenario

Policy stages of 4-8 years	**Macro-Trends (landscape environment, social, policy drivers)**	**Technology and *Research* Developments (landscape and regime drivers)**	**DISRUPTIONS & TURBU-LENCES AS DRIVER FOR CHANGE (EV. USE OF IMAGES)**	**Agriculture and Food Developments (regime drivers)**	**Development of important alternatives (niche drivers)**
Period 2008-2015	Climate change Finance and economic crisis Unequal mix of liberalisation policies Strong pressure on food and energy prices Stronger food segmentation Centralisation of food sector Only slow shift to more environmental orientation More functional and convenience food	More GMOs allowed in Europe Still slow development of new non-fossil based energies Only slow shift to more system-oriented research projects More Research related to climate change Research in nanotechnology Research in automation and information technology Research in automation and information technology	FINANCE AND ECONOMIC CRISIS CLIMATE CHANGE ENERGY CRISIS	Little change of the EU agricultural policies Faster acceleration of structural change Slow change of cross-compliance requirements Neo-productivity orientation Further development of integrated production More agrofuels of the first generation Acceleration of pesticide and fertiliser use on diminishing agricultural land. Soil degradation with multiple effects in sensitive areas will continue No halt of biodiversity loss.	Growing consumer demand for more ethically oriented products Continuous growth of the market of organic food and special quality food More international trade with organic products with higher risks for integrity Development of LEISA (low external input sustainable agriculture) More regional approaches for ecosystem payments Forerunner farms in automation and robotics
Period 2016-2023	Acceleration of water and soil scarcity Fossil energy use will still continue Kyoto II climate change measures Reorientation in Rural policies towards more ecosystem service Price segmentation will even stronger continue between premium and mass production. Strong importation from global players Strong migration flows Severe world-wide food scandals and pandemic diseases Strong civil society concerns and loss of trust.	Strong development of nanotechnology and genome based technologies GMO development will switch more to intra-species Still strong development of information technology Break through centralised technology Research more on the interlinkages and cross-cutting issues More open-space research Research of the full costs of food and farming systems	WATER AND SOIL SCARCITIES SEVERE FOOD SCARCITIES FOR THE POOR PANDEMICS AND BIOSECURITY SCANDALS RESISTANCE PROBLEMS AS SHORTFALL	Still strong centralization within the food and agri-sector Reorientation of CAP with much less money for direct payments Bio-and agroenergy boom Food shortages in some areas The push for high-yield crops will lead to more input use More environmental pressure More and more intensive arable production with maize and rape seed Livestock: more and more resistance problems Mostly big farms will profit of high-tech technology Strong change of ownerships of land Continued centralisation of the food sector more risks of widespread diseases. Use of cheap (seasonal) labour due to more	More regionality and different sustainable label claims Reconsideration of the value-basis New certification systems More coexistence problems between NonGMO- and GMO-farming Agricultural machine industry - development potential Some regions will remain completely without GMO More farmer based research breeding concepts

[62] Developed by Otto Schmid

Policy stages of 4-8 years	Macro-Trends (landscape environment, social, policy drivers)	Technology and *Research* Developments (landscape and regime drivers)	DISRUPTIONS & TURBULENCES AS DRIVER FOR CHANGE (EV. USE OF IMAGES)	Agriculture and Food Developments (regime drivers)	Development of important alternatives (niche drivers)
	Worldwide social tensions			migration	
Period 2024-2031	Much quicker climate change Policies are forced to fundamentally re-orientate the whole food system New political agreements for a more balanced use of resources More allergies are known for GMO-products	Fast development of robotics and of automation. Further development of new IT-supported f field parcel management Severe problems with centralisation of energy Raising problems with nanotechnology with complex transmission processes and impacts Reorientation of research of the long-term risks of new technologies and of society-dialogue systems	ENERGY COLLAPSES Regional and local resource collapses	Acceleration of regional and local resource collapses GMO plants and animals show more adaptation problems than expected New forms of peri-urban agriculture New direct payment systems for real public good services	Further developed organic and LEISA systems Promising results from more farmer-based participatory and smart breeding More agriculture –consumer-citizens collaborative forms w
Period after 2032	Global warming continues Realisation of new Global Earth policy “KYOTO III” - a holistic security and climate neutral concept More sustainable consumption styles Civil society has regained confidence in the agriculture and food systems Open-source knowledge systems	Long term sustainable technologies (smart, appropriate and careful) Nanotechnology will be only used in a controlled and limited way and are labelled Broad application of solar and wind energy Broad application of automation and robotics Broad interdisziplinary system research on Further developed non GM and traditional breeding techniques with Genom knowledge	STILL CLIMATE CHANGE AND RESOURCES GLOBAL EARTH POLICIES	Strong reorientation of agriculture has taken place towards more resilient systems (LEISA and organic farming) Sustainable and ethical entrepreneurship in food and farming sector Re-introduction of more sustainable rotation systems with locally adapted varieties Completely changed food cost structure New multi- and inter-cropping systems Agro/Biofuel 3rd generation Herbicide use has almost disappeared More added value trough ecosystem services Big and central operations will remain but have to follow strict more risk-oriented restrictions	More special intercropping and Agroforestry systems Regional territory approaches = life laboratories for social and technical innovation

* Reactive scenario:* The 8 years were chosen, as often presidencies in many countries often end up with two 4-year election periods (see USA)

In a more proactive scenario: shorter periods of 4-6 years possible, corresponding with the scenarios outlined in the chapter 7

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Appendix 1 - Further analysis of research priorities

Research priorities and cross-cutting questions

Table 12 is an exercise to test the relevance of each identified priority, under the lens of cross-cutting questions (see par. 5 and 6).

Table 12- Contribution of identified priorities to cross-cutting questions

	Vulnerability	Limits to growth	Public goods	State, market, civil society
General priorities				
Alert research systems	Providing a plurality of paradigms and technologies	Provide tools for diffused foresight capacity	Exploring new ways to produce and maintain public goods	Exploring new forms of governance (co-production)
Theoretical research	Providing new conceptual frameworks	Conciliating sustainability with competitiveness concepts	Framing the eco-eco, socio-eco relationships	Identifying the most promising patterns of interaction
Interdisciplinarity	Exploring social, economic, biological dimensions of vulnerability	How to embody the concept of limit in social action	Addressing the economical, ecological, social potential of public goods	Understanding regulation of complex socio-technical systems
Whose knowledge	Local knowledge as resource for monitoring and coping	Feedback information as basis for responsible action	Recognition of biodiversity; social practices related to conservation	Embedding local knowledge into official systems
Thematic priorities				
Sources of vulnerability	Providing data on vulnerability in different territories	Providing data on limits to growth	Ecosystem services	Effects of public policies on vulnerability
Back to production	Production systems able to cope with resilience/vulnerability	Post-oil, energy efficient agriculture	Balancing private with public goods	Governance of agricultural policies
Social innovation	Ability to cope	Sustainable consumption patterns	New mechanisms of production of pg	Role of ngos and of participation
Consumption as driver of transition	Sustainable consumption as a factor of resilience	Sobriety and recycling	Aware consumption of the real value of food	Role of consumers' organizations and networks
Coherence competitiveness and public goods	Linking social vulnerability with ecological vulnerability	Providing new entrepreneurial models	Making business with public goods without putting them into danger	Providing new governance models
Data and indicators priorities				
State of AKS	How AKS contribute to resilience / vulnerability	How AKS contribute to awareness of limits to growth	How AKS contribute to production of public goods	Governance of AKS
Env. impact of consumption	Sustainable consumption as a resiulience factor	Awareness of limits to growth	Awareness of impact of consumption on public goods	Providing decision making and consensus building tools
Measurement of public goods	Territorial databases for public goods as distributed monitoring capacity	Measurement of public goods as indicator of space for growth	Awareness of local communities and broader communities of public endowment of public goods	Incentives, motivations, rewards to production of public goods

Consensus and non-consensus among priorities

We have now reached the point where we can offer a consolidated analysis of areas of consensus and non-consensus on research priorities (Table 13). We indicate where there is a polarisation of positions and where attention is lacking but needed. For issues on which there is strong polarisation, research policy could contribute to the creation of convergence through dialogue and to the consolidation of the empirical evidence with respect to the thesis proposed.

Table 13- Consensus and non-consensus on research priorities

Research priority	**Degree of consensus**	**Comments**
General priorities		
Creating alert research systems by emphasizing 'niche' research	Moderate	The program 'creativity' has started the process, but mostly, funded research is concentrated on short to mid term goals
More theoretical research (eco-eco, socio-eco, ecc.)	Low	Transition requires new conceptual maps and new paradigms. Only theoretical research can offer them. European research policies favour applied research.
Strong emphasis on interdisciplinary research	High	There is a gap between goals and results. Interdisciplinary research faces strong barriers to its further development
What and whose knowledge?	Polarization of positions	Most mainstream official scientific research denies the role of users (especially farmers) as innovators and as creators of original knowledge.
Thematic priorities		
Vulnerability and resilience of systems: how to cope with them?	Moderate	Research evaluation processes favour evolution of existing pathways of science and technology development, rather than research that seeks out new questions and pathways
Back to production: sustain the consolidation of alternative paradigms	Polarization of positions	Stronger alliances are needed for a modification of existing paradigms in the face of strong defence of the present paradigm
Organizational and social innovation	Moderate	There is increasing recognition of the issue, but strong coalitions support heavily technology-based innovation
Consumption as a driver of innovation	No attention	So far this has been a niche research theme
Coherence between private competitiveness and public goals	High	High level of resistance from part of technological research establishment; strong obstacles posed by the emergent IPR regime
6.3 Data and indicators priorities		
Sources of vulnerability and resilience and impact assessment of policy measures to address them	High	Vulnerability and resilience have not been so far policy priorities
Measurement of public goods and analysis of drivers of change	High	Limitations of the mainstream paradigms to fully embody the concept of public good and public value
State, structure and performance of European agricultural knowledge systems	Low	So far this has not considered as an issue, as there has been a trend to privatisation
Effects of consumption styles on the environment	High	A lot of synthetic indicators have been built (footprints, food miles, energy balances) but data are scattered or non-available
6.4 Methodology priorities		
Across scale and across sectors impacts	No attention	So far this has not been considered an issue
Which role for qualitative models/methods?	Moderate	Mainstream paradigms under-value qualitative approaches and give strong priority to wealth generation (as conventionally measured)
How does agricultural and rural research take into account spatial differences within Europe and within regions?	Moderate	Due to prevalence of quantitative paradigms, spatial differences tend to be overlooked
Indicators for resilience and vulnerability	High	There is the need for validated and official indicators fit to feed

Research priority	Degree of consensus	Comments
		policies

Appendix 2: Methodology used by the 2nd Foresight Panel

What is our foresight exercise about?

Havas (2005) states that foresight exercises can be grouped into three types:

Table 1: Foci of foresight programmes

	S&T focus (type A)	Techno-economic focus (type B)	Societal/ socio-economic focus (type C)
Aims	Identify S&T priorities (following the logic of scientific discovery)	Identify research topics in S&T, of which results are believed to be useful for economic sectors	Identify research topics in S&T, of which results are believed to contribute to addressing major societal/ socio-economic challenges Devise other policies – or identify policy domains, which are relevant – to tackle these societal/ socio-economic issues
Rationale	Boost national prestige, achieve S&T excellence; Following the linear model of innovation, socio-economic benefits might also be assumed; implicitly or explicitly	Business logic: improve competitiveness Correct market failures: strengthen academia-industry co-operation, extend the short time horizon of businesses	Improve quality of life (enhance competitiveness as a means for that) Correct systemic failures, strengthen the National Innovation System
Participants	Researchers, policy-makers (e.g. S&T and finance ministries)	Researchers, business people, (some) policy-makers	Researchers, business people, policy-makers, social stakeholders (lay persons?)

Source: http://www.eranet-forsociety.net/ForSociety/files/document/Deliverables/ForSociety-WP1-HU-001-Terminology-a-2005-03-16.pdf

Our exercise belongs to type C, as we are looking for results that are shown in the scanned documents to contribute to addressing major societal/ socioeconomic challenges.

How have we dealt with scenarios?

Scenarios are an important feature in many for the foresight exercises we have examined. The outcomes of our work constitute the basis for further exercises in scenario building. The examples given in section 7 are rough first attempts to show how scenarios can be developed out of the analysis done.

Scenarios can be classified also according to the characteristics of their **elements** (Zurek and Henrichs, 2007). Our scanning exercise identifies the key elements of the scenarios described in the documents. These may be classified as follows.

Assumptions and decision making paradigms

We have identified existing assumptions (often taken for granted) and taken a critical approach towards them. We 'deconstruct' current assumptions by highlighting contradictions and proposing new definitions and new assumptions - for example, those relating to the social and geographical distribution of costs and benefits of technologies, of climate change, territorial impact of policies etc.

We have identified a sub- group of assumptions related to decision making paradigms. They mainly concern variables such as the role of the state, the market and of civil society, centralized/decentralized decision making, private goods versus public goods, top-down versus. Bottom up processes, etc., but also are related to specific groups of actors, such as consumers (what are the assumptions behind consumers' behaviour? Is consumption an individual action or a social action?)

In addition, we clarify the assumptions related to complexity and uncertainties of the driving forces.

Boundary conditions

Boundaries are criteria that distinguish 'internal' from 'external' elements. They are defined mainly by time and space scale and by object of analysis (rural/urban, agriculture/other sectors, etc.). External elements are supposed not to be directly modified by internal decision-making.

'Boundary conditions' can be understood as the degree to which external conditions constrain action or leave autonomy to internal forces within the identified scenario. Not all external conditions, in fact, have the same rigidity.

Drivers

We have analysed drivers in depth in order to identify any that might have been under-valued or over-looked in other foresight exercises. Social drivers, in particular, are strongly undervalued in the first Foresight exercise, and therefore have been examined in some detail. We also have identified a number of 'missing' drivers and have incorporated these in our analysis. In all cases we support our choice of new drivers with data and reference to the scanned documents

The EEA Research Foresight for Environment and Sustainability[63] identifies five groups of key issues related to drivers: trends, uncertainties, surprises/tipping points, interlinkages with other drivers, research needs. We have adopted this model for the 2nd Foresight exercise; see example below.

TECHNOLOGY drivers: key Issues	Trends	Uncertainties	Surprises, tipping points	Interlinkages with other Drivers	Long term research needs for Environment and Sustainability
Technology and society	Technology Regulation (in general and specific technologies)	Three paths imagined: Strong government regulation *vs.* Government incentives for innovation *vs.* Stakeholder (corporate) approach	A major technology failure, e.g. global computer virus attack	Influence on technology development	- Major new technologies can have wide-ranging environmental and societal impacts: these can be difficult to predict and maybe even imagine - New ethical dilemmas for environment and human life
	Integrating environment in technology and engineering	Will respect for environment become a central engineering principle?			New civil engineering approaches could radically change our use of land and natural resources
	Technology and employment (e.g. robotics)	Will technology development increase unemployment?	Backlash against certain technologies	- Economic systems (need for greater flexibility) - Need for ongoing education and training	Will technology "speed up" life, creating greater time squeeze, or will it help us find solutions?
	Technology and the work place: e.g. working from home	Will ever greater numbers work from home?		- Economic systems - Education: growth of distance learning	Influence on society: greater leisure? Less community? More precarious jobs? What influence on mobility and land use?
Convergence in technologies	Bio, nano- and information technologies and cognitive science could converge	- Requires new interdisciplinary frameworks and systems thinking in academia - Could trigger a new industrial revolution		- These technologies may have a major influence on health technology	

Table 14 – Scheme of analysis of drivers.

How to analyze issues?

What we call **issues** has helped us to explore the links among drivers, assumptions, decision making paradigms and alternatives related to the object of our exercise. Issues have been generated by questions or groups of questions (for example: which environmental services do provide rural areas? how to improve productivity of ecosystem services of rural areas?). On the basis of the issues analysis we are in a position to challenge existing assumptions, identify new drivers, analyzing relations between drivers, exploring alternative future outcomes in relation with alternative decisions, identifying risks and opportunities.

We also identify hierarchies of issues, and consequently priorities and posteriorities. The way we take into consideration these elements in turn affects our identification of knowledge gaps.

[63] http://ew.eea.europa.eu/research/info_resources/reports/Final_Literature_Review_Report_FINNov07_9473.pdf

How to adapt methodology to these considerations?

The idea of using matrixes departs from the need to have a quick tool for synthesis, to compare and contrast, to organize discussion, to report. They matrices offered in this report do not replace the narrative text. They have provided a framework to the Panel members for systematic coordination

Phases of the work

The Panel's work has been based on five phases:

First phase

During the first phase the Panel has identified the relevant set of foresight documents to be reviewed; the initial list of documents provided by the EU commission has been integrated, especially to take into account documents coming from sources like NGOs and technology platforms.

Second phase

During the second phase the Panel has carried out individually a quick-scan and assessment of relevant issues. Quick- scan and assessment has been based on the following questions:

1 – What are the main assumptions, boundary conditions, decision-making paradigms, legitimacy of the recent foresight studies?

2 - To what extent are the drivers identified in the first FE appropriate to the 2nd FE? Which additional drivers should be taken into consideration?

3 - Which issues emerge from new and relevant foresight studies? How will the selected issues impact or will affected by above mentioned drivers? Which are the potential risks, opportunities and likely future developments and challenges?

The Panel has carried out its scanning exercise on the basis of forms illustrated. The filled forms subsequently have been integrated.

Third phase

The third phase has been dedicated to homogenisation of the relevant issues and to priority ranking. The Panel exchanged the results of their individual scanning exercise by e-mail and agreed the classification and ranking of the issues during a meeting in September. 2008.

Fourth Phase

The fourth phase has been dedicated to writing the thematic analyses and preliminary drafting of the final synthesis report.

Fifth phase

The coordinator and the rapporteur have written the synthesis report, in close collaboration with all Panel members.

At the end of each phase the Panel has communicated with the EU Commission and with members of SCAR.

European Commission

II SCAR FORESIGHT EXERCISE

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In the framework of a wide Foresight process, launched by the Standing Committee on Agricultural Research (SCAR) and aiming to identify possible scenarios for European agriculture in a 20-year perspective, DG RTD/E of the European Commission established a high-level Consultancy Expert Group (CEG) that analysed and synthesised foresight information in order to provide research policy orientations, tacking stock of the report from the first Foresight Expert Group (FEG) published in February 2007. This second exercise resulted in a report that has been based on a scanning of foresight studies and reviews of challenges to European agriculture in a global context as well as an analysis of priority research areas. The CEG report should feed into the SCAR Foresight Monitoring and Signalling Mechanism, which aims at providing, at regular intervals, early signals and warnings about emerging and new problems that we may face in the years to come, and to suggest ways of tackling them. This approach was strongly encouraged by the Commission's Communication "Towards a coherent strategy for a European Agricultural Research Agenda".

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