FORESIGHT4FOOD WORKING PAPER

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1. Setting the Scene

This working paper has been prepared as background to support discussion during the Food Systems Foresight Workshop – 22-23 March 2017. The paper provides justification for the foresight event, an overview of a food systems perspective, terminology and approaches to foresight and scenario analysis, a view on how foresight relates to change in complex systems, a stock-take of current food systems foresight work and initial ideas for a possible follow up initiative. It is not intended to be a full review of all these areas but is rather to offer some perspectives for helping to frame and enrich discussions during the workshop.

Is the world sitting on a food "time bomb" and if so what can be done about it? Predicting the future is a difficult game. However, it is clear that growing demand for food in the context of resource depletion and climate change will put unprecedented pressures on what is already a fragile system. Some two to three billion poor people still depend on food production for their livelihoods with major development implications and changing food consumption patterns, leading to obesity, are undermining other health gains made in the 20th Century.

Globally, on average, it seems likely that the world can produce sufficient food to meet demands at least in the medium term. Instead, the risks come from a possible confluence of shocks to the system such as extreme weather events, outbreaks of disease or disruptions to trade. The critical issue is whether into the future food systems at the global level and/or in specific geographic locations will be sufficiently resilient to cope with such shocks without creating major humanitarian, political and economic crises.

Clearly, food and nutrition security will be one of the biggest challenges facing the global community this century and has been given prominence in the 2030 Agenda for Sustainable Development. Almost half of the Sustainable Development Goals contribute to achieving food and nutrition security by ending poverty, achieving gender equality, providing sustainable water and sanitation, ensuring responsible production and consumption, combating climate change, and protecting land use and ecosystems.[1][1] Because such complex dynamics exist across the food system from production to consumption, a systemic perspective is called for taking into account synergies, trade-offs and spillover effects between differing social, economic, environmental and political goals.

Achieving greater resilience in the food system will require a better understanding of how the global food system can adjust to a number of global trends, including population growth, urbanization, and their corollaries in terms of dietary transition; competition for land and water[2]; growing demand for bioenergy ; a warming climate[3]; biodiversity loss and ecosystems collapse ; structural unemployment and rising income inequality hampering access to food[4] ; and the triple burden of malnutrition[5]. It will also require a deeper level of insight into how uncertain futures might unfold, as these drivers are further compounded by critical risks[6] linked, for example, to large-scale forced migration; protracted crises ; instability ; and food safety in a context where the global governance for food and nutrition security as a global commons is characterized by fragmented roles and responsibilities across international institutions and forums, and multiple interests pushed forward.

Foresight about possible futures is a key tool for government, business and civil society to be responsive to future risks and opportunities. However, in a complex world, the future is not easily predicted. Constant reassessment of the is essential—all the more so with rapid technological advances such as bio-innovation, gene editing, robotics, and artificial intelligence[7], innovations expected to create unprecedented amounts of micro/macro/smart data[8], and a rethinking on the meaning of well-being, prosperity, liveability, and quality of life with new business models emerging[9]. In this context,

[1] SDG 2, SDG1, SDG5, SDG 6, SDG 12, SDG 13, and SDG 15 respectively; UNGA, 2015
[2] FAO, 2011.
[3] IPCC, 2014.
[4] UNDP, 2015.
[5] Approximately half of people in the world experience malnutrition in one of its many forms. IPFRI, 2016.
[6] WEF, 2016.
[7] WEF, 2017..
[8] Data is doubling every two years. PBS, 2014. Mayer-Schönberger & Cukier, 2013.
[9] Duckworth et. al., 2016.

change is brought about not just by the availability of information but through informed dialogue and the creation of coalitions for change between different stakeholders across government, business, civil society and research.

2. A global food systems perspective

Global food and nutrition security is a nexus issue. It is a both a driver and an outcome of many other global challenges be they climate change, water availability, energy supply, health, environmental degradation, migration and social and political stability. Yet historically agriculture, health, nutritional, energy and environmental issues have often been dealt in siloes without a systemic perspective.

The challenges of the SDGs make it clear that a global food systems perspective will be required to make substantial progress and bring about the underlining transformations that will be required.

There is also a need to move beyond the traditional split of food issues in the "North" and food issues in the "South". Food and nutrition security is increasingly an issue that needs to be tackled globally and with a deep understanding of the relations between rich and poor nations. Health problems related obesity, for example, have become a major issue for all countries.

"Nearly every country in the world faces serious health problems linked to the consumption of either too little nutrient-rich food or too much energy-dense food."

Global Nutrition Report 2015

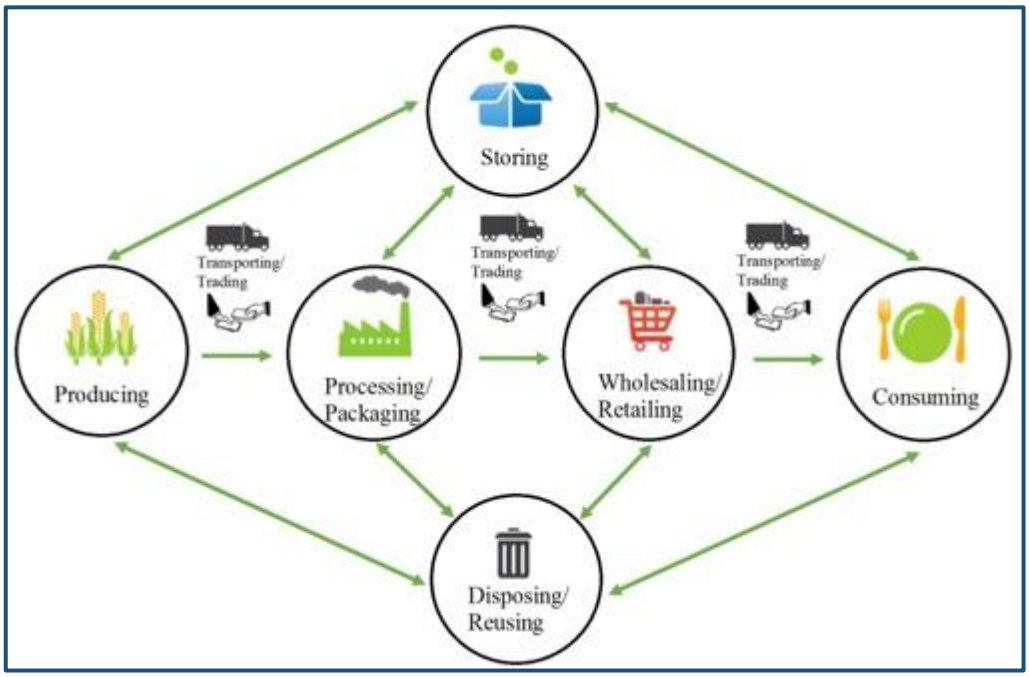
Consequently the debate has shifted from secure food supply mainly delivering enough calories, towards a broader approach to include nutritional issues and embrace multiple stakeholders and sectors such as health, trade, research, environment, or energy while value chains are increasingly characterized by vertical coordination, automation of large-scale processing, and higher capital and knowledge intensities.[10] It is in this context that efforts are undertaken to build a more inclusive and resilient global food system, which can be referred to as a set of activities and inputs provided by actors along the agri-food value chain in such a way that they generate healthy food for all, and do not compromise the economic, social, and environmental bases for future generations.[11]

As illustrated in Box 1, a food system can be considered as of set of interconnected activities that include producing, processing and packaging, storing, wholesaling and retailing, consuming and, disposing and reusing[12].

[10] FAO. 2017.

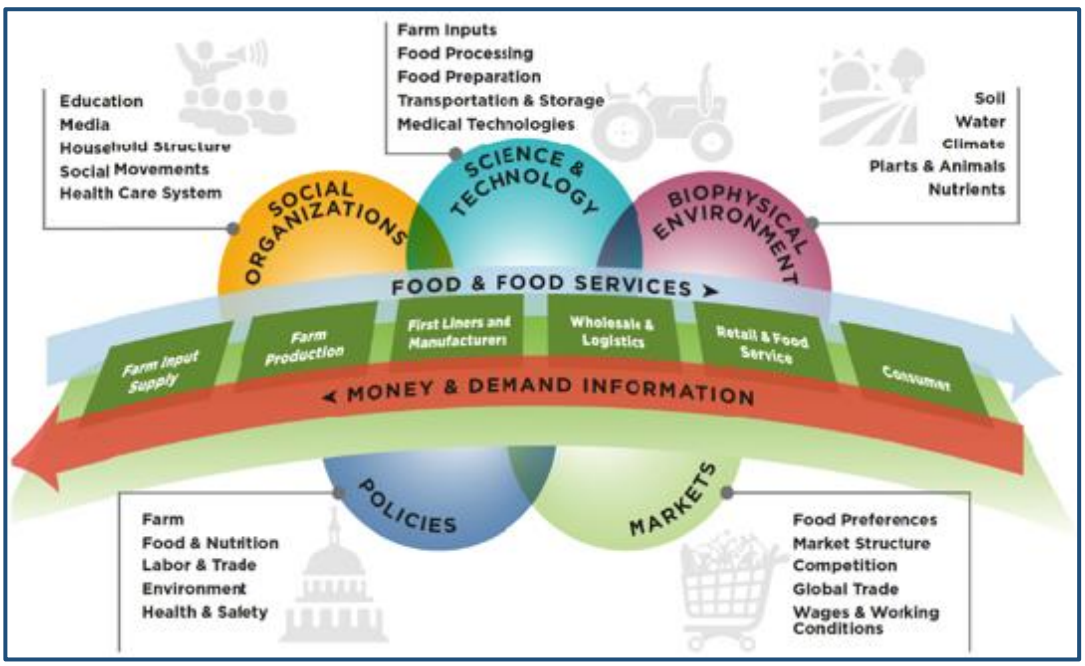
[11] Definition adapted from the definition agreed on by the High level Task Force of Global Food and Nutrition Security in the framework of the Zero Hunger Challenge initiative. 2015.

[12] Ingram 2017, pers.comm.



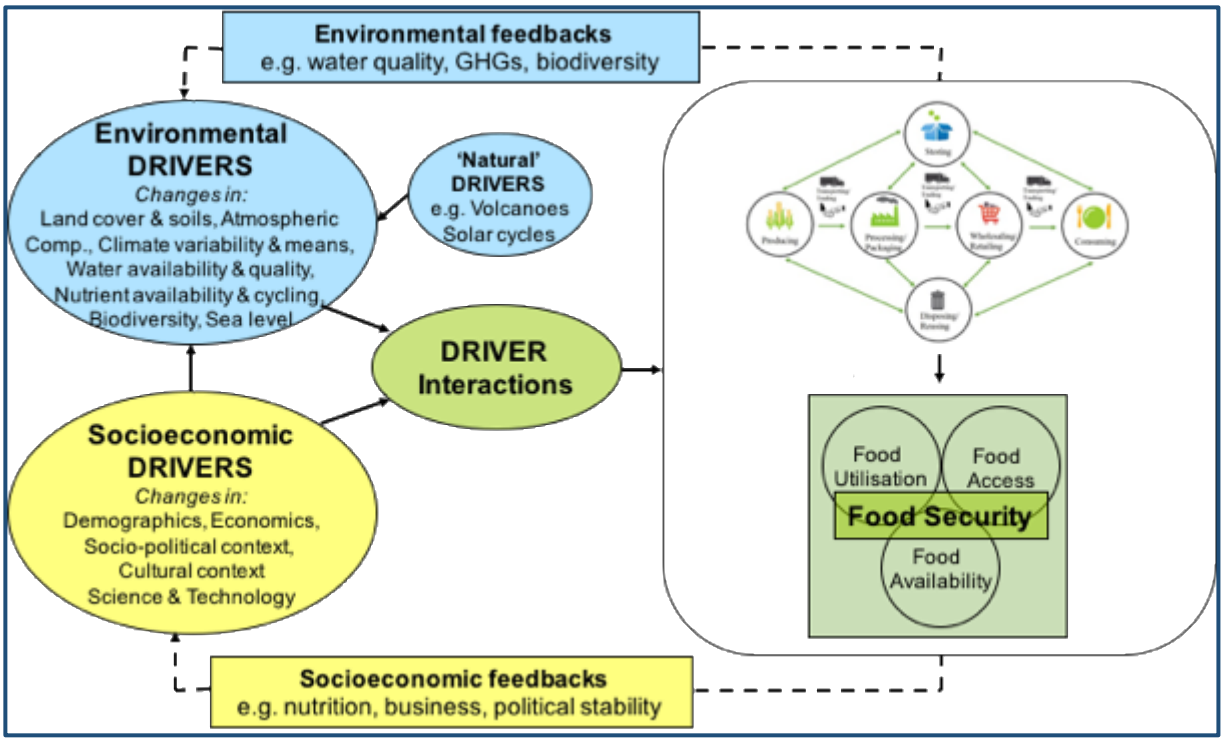
Box 1: Food system elements

Box 2 illustrates some of the key dynamics to be considered in a food system.



Box 2: Food system dynamics

From a systems perspective, as illustrated in Box 3 it can be helpful to consider the drivers of food system change, the feedback mechanisms and the outcomes for food and nutrition security.



Box 3: Food system drivers

Six drivers that are key to understanding the dynamics of the global food system include:

1. **Growing population, urbanization, and increased demand for high protein diets**: of the projected global population growth of 3 billion, 1 billion will be in Africa, 1.5 billion in Asia and 0.25 billion in Latin America. This will also coincide with mass urbanization with 70% of the world's population living in cities by 2050. Asia's vast population, with rapidly increasing wealth, will have massive resource requirements.

2. **Scarcity of land and water resources, soil degradation, declining fertilizer resources, and bioenergy demand**: these factors will collide to create new political economic dynamics, with significant risks and opportunities for poorer countries that have underutilized agricultural resources. Biofuel production from crops (rapeseed, maize, canola, sugar cane, soy, palm oil) will continue over the medium term, while related investments in developing countries have decreased due to concerns over food security, environmental conservation, and land grabbing.

3. **Changing, unpredictable and unstable climate conditions and increasing severity of natural disasters**: the negative effects of warming temperatures[13] and shifting precipitation patterns on the global food supply are increasingly likely to impact trade policies and exacerbate malnutrition, health issues, and inequality in least developed and most vulnerable countries.[14]

4. **Increasing wealth inequalities, especially between rural and urban populations**: inequality—affecting especially young people, migrants, and other vulnerable communities—is a potential threat to long-term social and economic development. Gender inequality is expected to inhibit the performance of the agricultural sector and more broadly growth as well as to undermine women/household/social wellbeing, in particular in poor countries.

5. **Triple burden of malnutrition**: one billion people do not have access to sufficient calories; over two billion people lack sufficient micronutrients; two billion people consume too many calories. High economic and human costs of overlapping challenges of undernutrition **and** obesity, which are rising in every region and becoming a staggering global challenge. Rates of wasting, stunting, and micronutrient deficiencies are increasingly reported in urban contexts. A deeper knowledge about

[13] In the future, droughts will affect more people than any other climate-related impact.
[14] FAO, 2015.

the underlying causes of malnutrition is needed to mobilize investments across sectors and prevent them as driver of conflicts.

6. **Globalization of procurement and increasing penetration of supermarkets**: food safety risks are likely to impact global supply chains and the large-scale distribution systems which are increasingly gaining ground in response to the evolving demands for food and dietary preferences. A particular challenge will be to connect local food systems to urban markets where distribution systems should increasingly be concentrated.

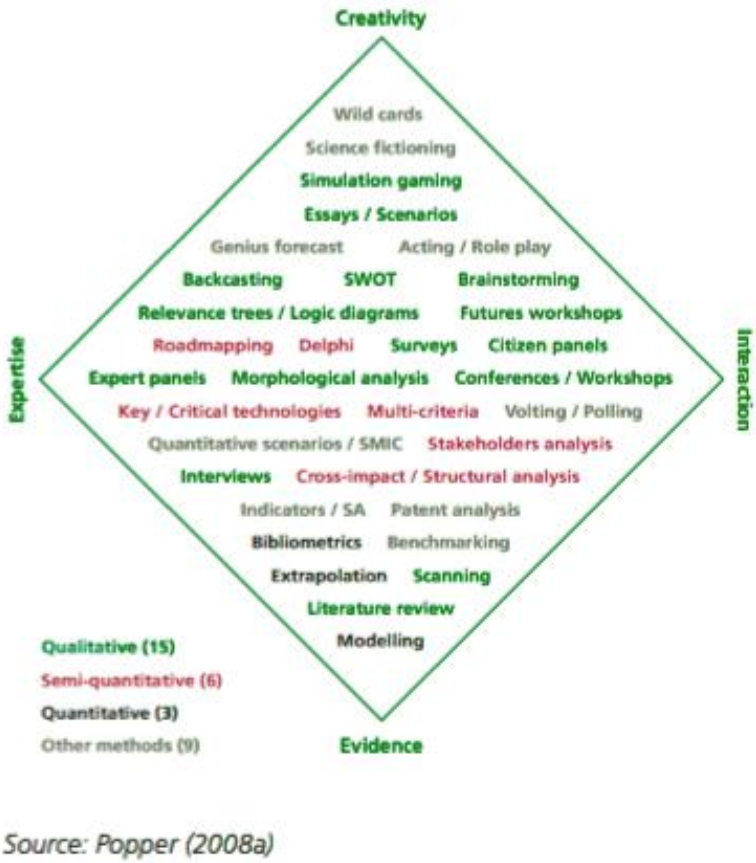
3. What Is Foresight?

Foresight is a term used to describe a broad spectrum of methodologies, areas of study, and work which help inform decisions, and which might involve the people most concerned. It has been defined as "a systematic, participatory, future-intelligence-gathering and medium-to-long-term vision-building process aimed at enabling present-day decisions and mobilizing joint action"[15].

Foresight empowers decision makers and policy planners to use new ways of thinking about, talking about, and implementing strategic plans that are compatible with the unfolding future. It is a useful research tool to set the scene, to raise contextualized research questions and generate strategic research agendas, create a process for dialogue across groups with differing views and enhance linkages with policy-makers and society.

Fully-fledged foresight work tends to have the following aims[16]:

- **To bring together holders of different types of knowledge.** Various foresight projects involve a variety of knowledge holders across academic disciplines and/or other types of knowledge (e.g. local knowledge) and planning experts.
- **To develop (strategic) visions often using interactive, participatory methodologies.** These projects use structured approaches to develop forward looking work or strategic plans within groups of experts and/or informed stakeholders.
- **To have a set of outputs** which inform policy-making and priority-setting.
- Informally, **to establish networks between concerned agents of change**: these can allow members to share information and awareness regarding new trends.



Source: Popper (2008a)

Box 4: Foresight techniques (Popper 2008)

[15] Andersen, A. D., & Andersen, P. D., 2012.
[16] EFILWC, 2003.

Disciplines of Foresight

The Foresight Alliance[17] puts forward a model of foresight disciplines, which can be integrated into organizations. This is one model among many, but can be seen as a useful step to visualize the application of foresight to food systems.

- **Leadership:** Clear ownership and active leadership to implement and institutionalize foresight capability.
- **Framing:** Establishing the boundaries and scope of the endeavour.
- **Planning:** Ensuring that the plans, people, skills, and processes support the organizational vision.
- **Scanning:** Collection of appropriate and relevant information in a format and timeframe that support useful retrieval.
- **Forecasting:** Description of long-term outcomes that contrast with the present to enable better decision-making.
- **Visioning:** Creation of a preferred future that imaginatively captures values and ideals.

Foresight Methods

Methods used by different foresight initiatives tend to be manifold, and combined into different integrated foresight exercises to suit whichever context and time horizon the work might deal with.

For our purposes, however, it may be useful to categorize the methods into three major areas along axis of complexity and uncertainty inherent in the investigated system (see Box 5)[18]. While predictions and projections require a higher degree of system's understanding and certainty about its possible behaviour scenarios work allows for deeper exploration of uncertainty and complexity issues in a structured manner before one might end up in speculations about 'the' future.

Scenarios in Foresight

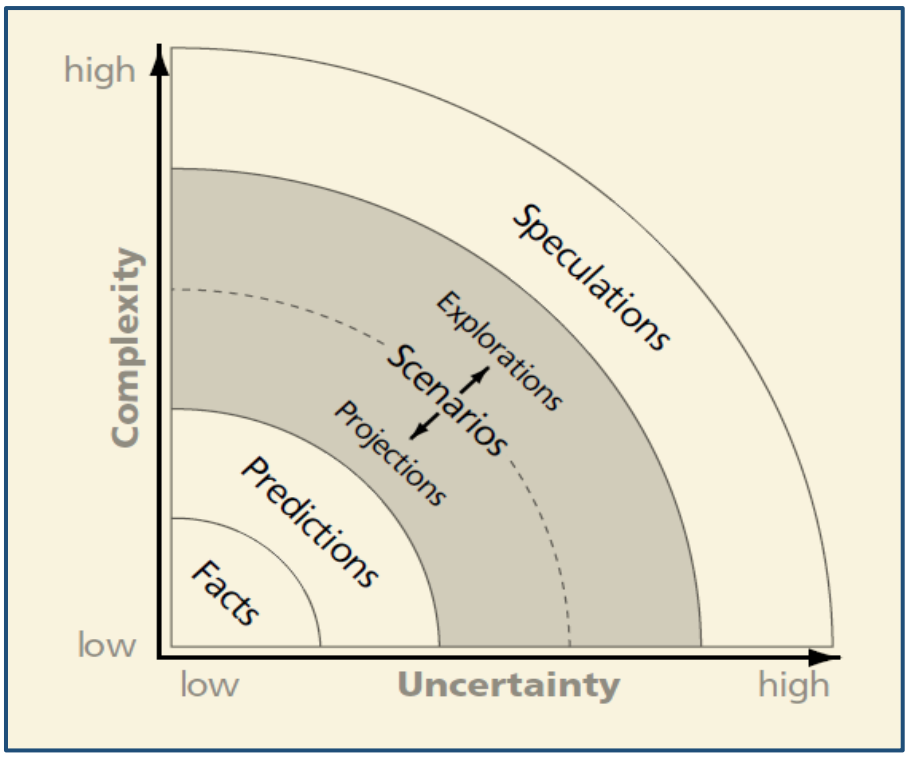
Across foresight initiatives, scenarios are so commonly used that they are often conflated with the notion of foresight studies[19]. They can be defined as "plausible and often simplified descriptions of how the future may unfold based on a coherent and internally consistent set of assumptions about key driving forces, their relationships, and their implications for ecosystems"[20]. In their various iterations, they tend to be used because they can easily mix subjective and objective data (i.e., models with stakeholder inputs); tend to be participatory, including across various scales; and allow for the adjustment of aims, and the creation of robust plans, rather than strictly predicting the future. Scenarios can be broken down into three principal types[21]:

- **Reference scenarios** also referred to as "predictive scenarios"; they attempt to explore what is *expected to happen* within a given context without any change in policies,
- **Explorative scenarios** attempt to map what *might*, or *could* happen; they explore how the future might be affected via external or internal drivers and are mainly built by going from the present into the future,

[17] Grim, 2009.
[18] Zurek, M., and T. Henrichs. 2007.
[19] Diaz-Bonilla et.al. , 2013
[20] Ash, Blanco, Brown, et.al., 2011.
[21] Ash ibid.

- **Normative scenarios** are anticipatory scenarios and aim to illustrate how a particular target might be reached; these will include back-casting exercises to explore options and pathways for reaching specific targets or visions.

Additionally, scenarios differ in their qualitative and quantitative applications. Ash et. al. explain that "**qualitative scenarios** are predominantly presented as narratisve descriptions of future developments, commonly in the form of phrases, storylines, or images. **Quantitative scenarios**, in contrast, expand on numerical estimates of future developments—presented as tables, graphs, and maps—and are often based on the output of simulation modelling tools"[22]. Qualitative scenarios are usually built using stakeholder and expert knowledge while quantitative scenarios employ a range of mathematical models and tools to underlay assumption about driver developments and their interactions. In many projects today (e.g. IPCC, Millennium Ecosystem Assessment) both techniques are combined to reap the benefits of creativity and flexibility of qualitative exercises together with the rigour in applying tested scientific knowledge and ground trothing of assumptions brought to the table by quantitative scenarios work. In general, scenario exercises allow for participatory, complex assessments of future needs within a system, and work across levels and sectors to involve participants. Their increasing use in food systems analysis and policy-making reflects their flexibility and utility.



Box 5: Zurek and Henricks, 2007

[22] ibid., p 153.

4. Foresight and Systemic Change

Improved food systems foresight needs to be understood within a context of systemic change and the uncertainties of complex adaptive systems. Purposefully steering a transition from unsustainable to sustainable food systems will arguably require a feat of human ingenuity that goes well beyond present capabilities. While endowed with a great capacity for technological development we are still on a very steep learning curve when it comes to the challenges of adapting socially, politically and economically to the risks of resource scarcity, climate change inequality or the health consequences of modern consumption and lifestyle patterns.

Human social, economic and technological history has been characterised by a series of often dramatic 'transitions'. However, past transitions - the mechanisation of agriculture, the use of external inputs, the growth of supermarkets and the globalisation of supply chains – have evolved in largely undirected ways on the back of technological advances and in response to unplanned socio-economic factors. Now, however, we are talking about a very different type of transition, one that implies a purposeful and goal driven transformation towards sustainability. How realistic is such a degree of 'steered' change? And, if it is realistic what will be the drivers, the incentives and the innovation mechanisms and how does foresight figure in such change processes?

A starting point for exploring such questions is to recognise that our social, economic, political and natural worlds are all complex adaptive systems. They change and evolve in unpredictable ways functioning as a complex network of interlinked elements (agents). They are not controlled or directed by top-down plans or hierarchies of decision makers. Yet, historically our political, policy making and scientific institutions have indeed often assumed false degrees of linearity, simplicity of cause and effect relations, and unrealistic possibilities for hierarchical control and command. Coming to terms with the dynamics of change in complex systems is critical for understanding how resilience of the global food system can be enhanced and the role of foresight.

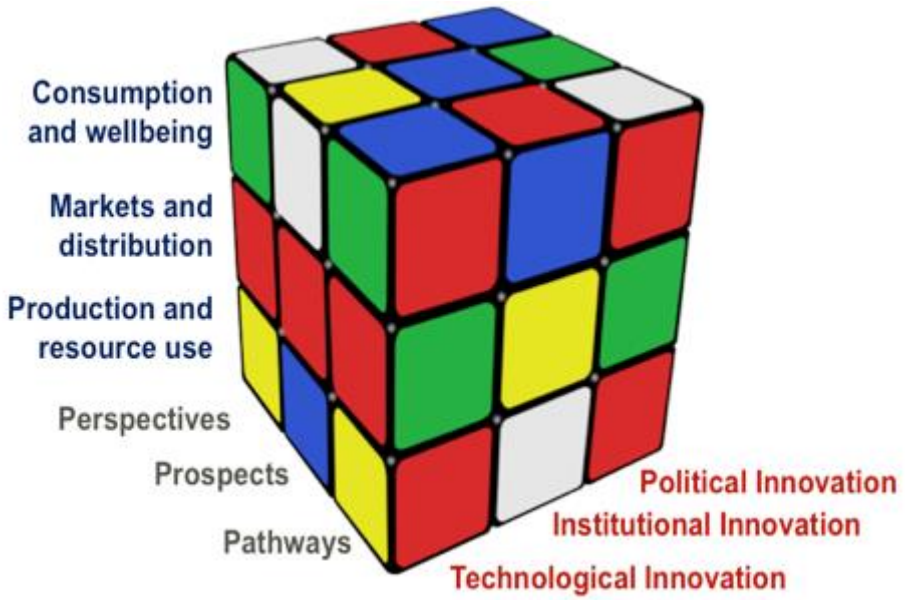
The nature of complex systems is not all with which we must reckon. The other side of the coin is how humans function cognitively. Over the last decades, developments in cognitive science have led to a much more sophisticated understanding of how we 'make sense' of our worlds and where the powers and limitations of the human brain lie. For example, there is a deep human tendency, that becomes embedded in our institutions, not to see, accept and own up to failure. Yet high degrees of failure are inherent in the evolution in complex systems. This cognitive limitation constrains feedback mechanisms and slows down our adaptive capacities, often making us blind until crisis hits. In terms of global food systems, the consequences of waiting for crisis to be the instigator of serious change is potentially dire. This cognitive aspect has major implications for how foresight links with decision making and policy process and societal perceptions and attitudes.

Mapping Food Systems Transformations

One perspective on the overall food system is the 'Rubik's Cube' framework on agri-food innovation[23]. Along one axis food systems can be looked at in terms of **consumption, markets,** and **production –** a complete value chain perspective from 'paddock to plate'. On the second axis is the need for a combination of **technological innovation, institutional innovation** and **political innovation**. Both 'hardware' and 'software' will be critical to agri-food transitions. Yet, too often these dimensions are not well integrated. Further, knowledge institutions and research practices face significant challenges to function in ways that enable them to move beyond 'research' and become active brokers of innovation and change.

The third axis illustrates that transitions involve three core process elements. One, working with multiple different **perspectives** that stakeholders have about future trends and risks and what for them would be desirable improvements. Two, for change, **prospects** are needed. For example, ways of reducing household food waste, supply chain management mechanisms that reduce greenhouse emissions or new plant varieties that enable quick adaption to climate change. Creating prospects requires innovation and creative thinking, effective use of research findings and the capacity for coupling of science with 'problem owners' and policy makers. Three, prospects mean little if they are not 'mined'. **Pathways** of change are needed to test out prospects and bring about the desired transformations. Pathways involve looking carefully at the motives and incentives for people to behave differently.

Foresight needs to deal with these multiple dimensions of systemic change in the food system.



[23] Woodhill, 2014.

5. Stock-take of foresight work in food systems

Appendix 1 provides a summary list of foresight initiatives, while **Appendix 2** provides additional details.
The stock-take of initiatives is provided as a Microsoft Excel file.

This paper provides a stock-take of the major foresight initiatives related to food and food systems[24]. It includes multi-year initiatives and one-off reports/studies released for either outreach, policy development or exploratory purposes, the underlying modelling approach and/or datasets informing the initiatives and reports/studies and, their spatial scales and intended geographic coverage. While it's by no means an exhaustive list of initiatives, its aim is to cover major areas of foresight.

Food systems research indicates that areas of the food system between initial production and consumption gain least attention in foresight and scenarios analysis, with a majority of future-looking methodology focused on production modelling and resilience-building[25], or on consumption patterns and waste management. There appears to be less attention for processing, retail, and trade[26].

Trends in foresight
Foresight work has increasingly gained importance since the 2011 financial and economic crisis - period of "heightened uncertainty" for the global economy during which economic tools and models have been fairly criticized due to their inability to support projections and identify "the importance and strength of key transmission and amplification channels, especially those linked to uncertainty."[27]

For example, foresight studies have increased dramatically in the EU scene according to a recent TRANSMANGO report on EU foresight highlighting [28]: (i) their participatory dimension; (ii) their focus on production and environmental drivers even if production studies are not dominant (around 50-60% are production focussed); (iii) their shorter-term (<10 years) perspective although and longer-term (>10 years) foresight process are increasingly developed; (iv) and the limited number of integrated qualitative and quantitative exercises. The stock-take corroborates with this assessment in terms of:

***Focus on production**:* many of the initiatives are production oriented. This trend also tends to be focused towards long-term initiatives; while some of the one-off reports/studies (UK's Future of Food and Farming, or the FAO's Future of Food and Agriculture etc.) encompass other sectors such as health and nutrition, most continuous initiatives and models focus on production —possibly at the expense of other food systems dimensions such as processing, trade, and consumption. The production focus is corroborated by the sectoral coverage of initiatives, which similarly leans towards agriculture and land use.

Time horizons: while most one-off reports/studies consider mid-term time-horizons (2030), multi-year initiatives tend towards the long-term (2050). More variable timespans exist for broader initiatives. Implications for outreach may mean that higher-impact reports may inform policymakers only to a certain point into the future, while more complex, longer-term foresight studies may be more difficult to communicate.

***From outreach to policy*:** While many of the assessed initiatives may focus on **exploration** of possible food futures (see CLIMSAVE or World Agriculture Towards 2030/50, for example) or use their findings in **outreach** towards governments, institutions, or civil society (FAO or GLOPAN), less projects directly collaborate with policymakers to create strategic, foresight-informed food policy. Multiple stakeholders continue to inform policy development, but direct collaboration with governments remains scarce.

Some notes on models
Foresight and scenario analysis work aim to contribute to a set of individual or combined objectives including strategic policy reforms, research agenda setting in the medium to long term, scientific

[24] See Appendix 1
[25] See Appendix 1, including OECD-FAO, 2011; FAO, 2010-2016; CSIRO, 2006-2011
[26] Vermeulen, Campbell, & Ingram, 2012.
[27] Kenny & Morgan, 2011.
[28] Vervoort et al., 2015.

evidence-base building, and investment prioritization.

Most of the initiatives are governed by academic and research consortia, and combine quantitative/qualitative, narrative-based enquiry. Narratives are based on a selection of drivers of change that may significantly impact food systems and quantitative exercises (more prevalent at the global/regional level) include either (i) Computable General Equilibrium (CGE)[29] models which aim to represent the different agents of an economy (producers, consumers, governments etc.) and the different flows (goods transaction, factor remuneration etc.) occurring between them or (ii) Partial Equilibrium models covering one or specific sectors of the economy.

The main CGE models include, for example, the Modular Applied General Equilibrium Tool (MAGNET) consortium[30] designed by the Agricultural Economics Institute of Wageningen University to simulate the impacts of agricultural, trade, land, and bioenergy policies on the global economy with a particular focus on the impacts on land use, agricultural prices, nutrition, and household food security.

The main Partial Equilibrium[31] models captured in the stock-take include (i)the Global Biosphere Management Model (GLOBIOM) designed and used by the International Institute for Applied Systems Analysis to provide policy advice on global issues related to land use competition between major land-based production sectors and the conversion of natural land, and (ii) the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) developed by the IFPRI to examine alternative futures for global food supply, demand, trade and prices.

IFPRI currently supports the African Growth and Development Policy Modelling Consortium (AGRODEP)[32], a modelling and data network aimed at furthering African foresight infrastructure. The initiative relies heavily on IMPACT, as well as a group of CGE and PE models and data sources, developed by IFPRI, in order to facilitate access to infrastructure and modelling capacity. The resulting consortium of models spans international trade, climate change, food prices, and demographics, among other sectors.

As part of its scenario analysis, the FAO recently developed a new partial equilibrium modelling system (GAPS) - a standard recursive dynamic multi-market and multi-regional partial equilibrium model designed for supporting FAO's long-term projections on food demand and supply. It allows to study the development of global food markets in the long-term and to assess how socioeconomic fluctuations, climate change and investment pay-offs may affect future global food demand.

FAO is considering developing a Global Economic Model Framework for Sustainable Agriculture and Food Security (GEM-SAF), which may have a general equilibrium model at its core, linked to other modelling frameworks, including GAPS model. The modelling framework should support the scenario analysis in preparation of the FAO report: "World Food and Agriculture towards 2050-80" report and updates thereof.

As results for long-term global scenario for agriculture differ, the Agricultural Model Intercomparison and Improvement Project (AgMIP) is an international effort[33] contributing to systematic intercomparisons across leading global modelling exercises, linking climate, crop and economic models, to ultimately better understand climate change challenges to agriculture and food security.

A special issue of Agricultural Economics provides broad insights into how the modelling communities approached the effects of climate change, bioenergy policy, and socioeconomics on agriculture including land use, prices, consumption, and production. The research includes 10 models and present thematic results from a range of partial and general equilibrium modelling.[34] One of the conclusions relates to

[29] General equilibrium representations include global production, consumption and trade, in which sectoral and economy-wide variables including aggregate income, factor prices and real exchange rates are simultaneously determined in an internally consistent manner.
[30] Van Dijk et.al. 2014
[31] A partial equilibrium approach treats global markets for individual agricultural commodities one by one in isolation from each other. In these models, regional demand and regional supply for each agricultural commodity is a function of its market price for given levels of income and given productivity drivers, and the model solves endogenously for the world market price that equates global supply and demand.
[32] AGRODEP, 2017.
[33] IFPRI Climate Change, 2014
[34] Nelson & Shively, 2014

the need of more interdisciplinary modelling efforts to cross-fertilize analyses at different scales.

One suggestion is a "stress testing" of the global food system, much in the same way that there is stress testing of financial institutions. In this context, foresight and scenarios analysis have proven to be useful tools in analysing food systems.

6. Opportunities and challenges for enhancing foresight and scenario analysis

As the stock-take illustrates, there is already valuable foresight, reporting and scenario work underway. However current different efforts are often fragmented and results are not always synthesized to provide the public, business and political leaders an integrated "big picture" perspective – a food systems "dashboard". A considerable amount of work limits itself to the current state of affairs or shorter term prediction and gives less insight into longer term trends and their possible implications. Gaps also exist in underlying analysis and the work of different research institutions is not necessarily well coordinated; nor do many user/visually friendly frameworks exist to map the complexity of current food systems and future trajectories. There is also limited assessment and analysis of how business and government are responding, how these responses are changing over time and what the impacts are or might be on all parts of the system.

A strengthened global capability for foresight and scenario analysis that synthesizes and assesses risk across relevant issues and disciplines is a key requirement for successfully adapting to the emerging challenges of food and nutrition security and for responding to the SDGs. This need seems to be recognized by key stakeholders and such additional capability can easily build on and support existing efforts.

Strengthening global food system foresight could potentially be realized through a collaborative effort of key international agencies, universities and businesses, perhaps called foresight4food.

The overall purpose of a Foresight4Food initiative could **be to provide political, business and community leaders with regularly updated knowledge and perspectives on the longer term outlook for food and nutrition security and trends important for global and national food systems**.

It could support and enhance existing efforts to:

- **Collate and synthesize** relevant scientific studies to present an overview of threats and opportunities both on a global as well as national or local level, as required;
- **Encourage coordinated action** to fill gaps in knowledge and conduct foresight and scenario analyses,
- **Support** scenario guided policy assessments and to examine specific issues based on stakeholder needs;
- **Provide information** to inform policymakers, businesses and the media, and to support dialogue and debate;
- **Undertake risk analysis** of food systems to identify key drivers and triggers;
- **Stimulate forums and set up strategic conversations** across stakeholders to improve understanding across policy, business, civil society and science.

Such an initiative would be based on existing analyses and engage groups of stakeholders active on food systems resilience and nutrition security – specifically the Committee on World Food Security, the Food and Agriculture Organization, other UN systems organizations, the International Food Policy Research Institute, and the World Economic Forum, as well as existing strategic planning units of businesses or civil society organizations. It would encourage adaptive systems approaches to develop knowledge, apply them to complex situations, and communicate credible forecasts. It would take account of the perceptions and communication patterns of key actors. It would assist to better anticipate events that are unexpected and unforeseen. By creating a space of 'unusual' and strategic conversations across stakeholder groups, it would develop a platform for knowledge exchange and creative thinking about possible futures and response options. It would adopt approaches to dealing with complexity and uncertainty and avoid linear predictions.
Improved foresight and scenario analysis needs to be driven by a set of strategic questions. Clarifying such questions would be an important first step in a foresight initiative.

Indicatively, these questions might include (many of which are already been addressed by focused initiatives but not connected within a food systems perspective):

- How will climate change impact on growing areas and yields with what implications for overall food supply and trade?
- What will growing food demand in different countries mean for longer term global trade patterns with what opportunities and risks?
- What are the future options for small-scale agriculture in the global food system with what social and economic consequences?

- What level of public investment is needed to unlock a commercial transformation of small-scale agriculture with what economic returns?
- What could be the economic dividends of effectively tackling both under-nutrition and obesity?
- What would be the consequences several lost monsoons across a region like South Asia with a high population, high levels of poverty and poor nutrition?
- What are the key dynamics in the nexus between food water and energy with what long term implications?
- What are the food security risks from human or animal disease outbreaks and what are the key options for managing such risks?
- How likely is large scale industrial (non-farm) food production in the future with what consequences for the overall food system, health and the environment?
- What are the food security implications of mass-urbanization?

There is a wide diversity of indicators, measures and data currently being used by different groups to articulate the food security and nutrition situation. Formulation of a key set of indictors and trends that can be more rigorously monitored and updated through collective rather than disparate efforts is now being drive by the SDG process, but much work remains to be done in developing methodologies and gathering data.
The concept could be developed by a group of leading actors on food and nutrition security connected with initiatives such as the Committee on Food Security, World Economic Forum, the Consultative Group on International Agricultural Research, the G7 and G20. If sufficient resources are available, it could be advanced as a jointly-owned ongoing public good which serves as a basis for collective efforts to ensure food security and nutrition for all people.

The initiative would need work creatively across different sectors and interests in a neutral manner and be flexible in implementation. Co-ownership by a range of institutions would make it possible for their research and policy analysis to be incorporated and updated at regular intervals.

Areas for collaboration that could be a focus for driving forward the initiative are:

1) **A strategic food systems foresight dialogue that links science, policy and business**. This could be "Chatham House" or "Jackson Hole" type event on resilient food systems where the best available understanding of future trends in the food system is presented using good visualization tools. A key objective of such events would be to translate key understanding into practical insights for decision makers.
2) **Development of a global food systems "dashboard"** that provides an accessible visualization of key trends and relationships.
3) **A series of collaborative working groups** on "hot topics" that aim to help progress overall food system foresight efforts.

Outcomes from such work would contribute to dialogue and decision making forums such as CFS, G7, G20, WEF, CGIAR, food industry organizations such as Consumer Goods Forum, and civil society platforms.

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Appendix 1: Summary List of Foresight Initiatives

For additional information, please refer to the attached stock-take spreadsheet; for detailed descriptions of initiatives, please refer to Appendix 2.

Initiative	Organization	Starting Date	Description	Reference
SCAR Foresight Exercises	European Union / The Standing Committee on Agricultural Research (SCAR)	2006	Since 2005, the SCAR has launched four separate foresight exercises to identify possible futures scenarios for European agriculture as the basis for prioritising research and other activities in the medium to long term. In 2014, the SCAR launched a 4th exercise exploring the interactions between the primary sector and the bio-economy highlighting three scenarios in a long-term perspective (2050) based on varying levels of biomass supply and demand.	https://ec.europa.eu/research/scar/index.cfm?pg=home;
Global Futures and Strategic Foresight	International Food Policy Research Institute / CGIAR	2010	The GFSF is a joint project working with all 15 CGIAR research centres. Designed to improve agricultural productivity and environmental sustainability, especially in developing countries the GFSF uses quantitative methods for strategic foresight to inform policy decisions and develops global scenarios. The project uses IMPACT models to explore how drivers can shape alternative futures in terms of food production, demand, price, trade and resource use.	http://globalfutures.cgiar.org/strategic-foresight/
CIIMSAVE (CLimate change Integrated assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe)	Environmental Change Institute	2010	The CLIMSAVE project developed an integrated assessment approach that enabled stakeholders to explore and understand the cross-sectoral benefits and conflicts of different adaptation options to better inform the development of robust policy responses. An integrated assessment web-based Platform was developed integrating climate change scenarios, and four socio-economic storylines	http://www.climsave.eu/climsave/

African Growth and Development Policy Modeling Consortium	International Food Policy Research Institute	2011	The African Growth and Development Policy Modelling Consortium (AGRODEP) is an initiative facilitated by IFPRI aiming at positioning African experts to take a leadership role in the study of strategic development issues and the broader agricultural growth and policy debate facing African countries. AGRODEP facilitates use of economic modeling tools, promotes access to data sources, provides training and research grants, and supports collaboration between African and international researchers	http://www.agrodep.org/
Global Biosphere Management Model (GLOBIOM)	International Institute for Applied Systems Analysis	2011	GLOBIOM is a global, recursively dynamic, and partial equilibrium model assessing the competition for land use between agriculture, bioenergy, and forestry. The GLOBIOM's analytical process captures the multiple interrelationships between the different systems involved in provision of agricultural and forestry products, for example, population dynamics, ecosystems, technology, and climate.	http://globiom.org/
Global Foresight Hub; Foresight For Better Futures	Global Forum on Agricultural Research	2013	The Global Foresight Hub, facilitated by GFAR, is a global network aiming to improve foresight, support forward-looking, anticipatory research and analysis that integrates the diverse views of farmers and other stakeholders on specific opportunities and problems facing them. The Hub enables GFAR to fulfill its mandate as a catalyzing mechanism by linking CGIAR centres, Advanced Research institutes, National Agricultural Research Systems, international policy bodies and initiatives with national/regional organization including CSOs.	http://www.gfar.net/our-work/foresight-better-futures-0
Predictive Technologies for Climate-Smart Agriculture	Consultative Group for International Agricultural Research / Climate Change, Agriculture and Food Security	Unknown	The project uses projection-based frameworks, models and global and regional scale analyses to consider potential changes in land-use dynamics in agriculture, and crop-specific breeding needs. Multiple research activities, including investigating climate-smart agriculture practices under climate scenarios; crop modelling under future climate scenarios; and investigating adaptation options for breeding practices. Funding partially provided by CCAFS, CIAT, and FutureEarth.	https://ccafs.cgiar.org/predictive-technologies-climate-smart-agriculture#h3_4

TRANSMANGO PROJECT	Consortium coordinated by the Catholic University of Leuven	2014	The Transmango project (2014-2018): aims to develop a comprehensive picture of the effects of a number of drivers on the European food system by (i) designing an integrated conceptual framework around food and nutrition security that encompasses the whole food system, (ii) developing new system modelling approaches to capture the empirical diversity of food securities, vulnerabilities and sovereignties, (iii) improving the assessment of food system vulnerabilities through specific initiatives, and (iv) formulate recommendations for EU policy makers in order to promote social innovation that contributes to medium- and long-term food and nutrition security. The project is funded by the EU 7th Framework Programme (funding 4,9 million including EU contribution EUR 3,9 million)	http://www.transmango.eu/
Metrics, Models and Foresight for European SUStainable Food And Nutrition Security (SUSFANS) PROJECT	Consortium coordinated by the Wageningen University & Research	2015	SUSFANS aims to develop metrics, identify and analyse drivers, integrate data and modelling and formulates foresight for EU sustainable FNS, building on a common scientific evidence-base which accounts for the perspectives of the various actors and factors that play a role in the food system. Regarding long-term modelling, SUSFANS develops and uses a suite of well-established models commonly applied to trade, agricultural policy, biofuel policy and climate change issues for the European Commission and member states including the economic model MAGNET, the economic/biophysical models CAPRI and GLOBIOM, and the biophysical model EPIC. These models are strengthened with respect to the producer, food chain and consumer side behaviour	http://susfans.eu/system/files/public_files/Publications/project_paper/Template%20project_paper_1-upload.pdf
OECD/FAO Agricultural Outlook	Organisation for Economic Co-operation and Development, Food and Agriculture Organization	2005	The reports bring together the commodity, policy, and country expertise of OECD, FAO, and input from collaborating member countries to provide an annual assessment of prospects for the coming decade of national, regional and global agricultural commodity markets. The reports are based on an economic model integrating OECD's Aglink and FAO's Cosimo sub-modules. Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to simulate developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide.	http://www.agri-outlook.org/abouttheoutlook/

Future of Food Initiative	Oxford Martin School	2011	The programme aims to link together existing research on the food system at Oxford and support new interdisciplinary research that addresses the challenges of feeding the global population sustainably, healthily and equitably. This includes scientific, economic, social and environmental issues of food production and consumption, as well as challenges for health, sustainability and development. Research includes for example "Modelling The Relationship Between The Food System And Health, Development, and The Environment » project and studies on the impact of climate change on food production.	http://www.futureoffood.ox.ac.uk/about-programme-future-food
Agricultural Model Intercomparison and Improvement Project	Consortium led by Columbia University Earth Institute	2012	The Agricultural Model Intercomparison and Improvement Project (AgMIP) is an international effort to assess the state of global agricultural modeling and to understand climate impacts on the agricultural sector. AgMIP's mission is to improve substantially the characterization of world food security as affected by climate variability and change, and to enhance adaptation capacity in both developing and developed countries.	http://www.agmip.org/
FOOD SECURE PROJECT	Consortium coordinated by the Wageningen University & Research	2012	The project aims to develop (i) a conceptual framework for the quantitative assessment of food and nutrition security in the long-term, (ii) scenarios for alternative visions of the future (to 2050) including the implications for food and nutrition security, and (iii) a modelling toolbox - developed on the basis of six models MAGNET, MIRAGE, IMPACT, GLOBIOM, IMAGE and EPIC - capable of analysing the food and nutrition security impacts of a range of policies. Funding : EUR 10,5 million including EU contribution EUR 8 million.	http://www.foodsecure.eu/Default.aspx
Agrimonde-Terra foresight study on 'Land use and food security in 2050	Centre de coopération internationale en recherche agronomique pour le développement/Institut national de la recherche agronomique	2006	Agrimonde-Terra programme is a continuation of the Agrimonde programme. The Agrimonde-Terra study "Land Used and Food Security" released in 2016 explores five land-use scenarios based on qualitative and quantitative analysis. The impacts of the scenarios in terms of land use (according to five dimensions of land use: agronomic potential, access to land, degree of intensity of land use, distribution of land between different uses and services provided by land) agricultural production and trade in the 14 world regions and globally have been assessed through quantitative simulations using the biomass balance model GlobAgri-AgT.	http://www.foresight-platform.eu/wp-content/uploads/2011/10/EFP-Brief-No.-196_Agrimonde.pdf

World Agriculture Towards 2030/2050. The 2012 revision.	Food and Agriculture Organization	2012	This paper is a remake of Chapters 1-3 of the 2006 Report World Agriculture: towards 2030/2050. It models major food and agriculture variables on two time horizons, including food demand, production growth, nutrition, crop production, global outlook, land use, irrigation, and crop yields.	http://www.fao.org/publications/card/en/c/de5f0205-8484-50c3-ad57-8a05f7a450f0/
Future of Food and Farming	Government Office for Science UK	2011	The report explores the increasing pressures on the global food system between now and 2050. It highlights the decisions that policy makers need to take in the years ahead, to nutritional and caloric needs for a global population of 9 billion. The report recommends changes in civil society, sustainable intensification, advocating the importance of sustainable agriculture in development, and including the environment in food system economics as priorities for policymakers. It examines the case for a low-carbon food system as well as the policy implicatons of deforestation.	https://www.gov.uk/government/collections/global-food-and-farming-futures
GLOPAN Foresight Project	Global Panel on Agriculture and Food Systems For Nutrition	2016	The report provides insights into changes in diets across the world and highlights the impact of major drivers of change in dietary patterns, including population growth, rising incomes, urbanization and globalization. The report complements the 2016 Global Nutrition Report in delivering evidence to underpin policy change. Data focus on the challenges that decision makers face when attempting to integrate nutrition within current food systems and agricultural policies. The report sets out ways to approach these challenges so that policies are shaped in a way that delivers healthy, safe and nutritious diets for all.	http://www.glopan.org/foresight
FAO's Global Perspective Studies: The Future of food and agriculture: trends and challenges	Food and Agriculture Organization	2016	The report aims to increase understanding of the nature of the challenges that agriculture, rural development and food systems are facing now and will be facing into the 21st century. The report provides further insights into what is at stake and what needs to be done through the analysis of 15 global trends strongly interdependent which, combined, inform a set of 10 Challenges to achieving food security and nutrition for all and making agriculture sustainable.	http://www.fao.org/global-perspectives-studies/en

FAO's Global Perspective Studies: The Global Agriculture Perspectives System (GAPS)	Food and Agriculture Organization	2016	The paper describes a new analytical tool that enables FAO Global Perspective Studies team to undertake a broad set of simulations : the partial equilibrium modelling system (GAPS). The GAPS is a standard recursive dynamic multi-market and multi-regional partial equilibrium model designed for supporting FAO's long-term projections on food demand and supply. It allows to study the development of global food markets in the long-term and to assess how socioeconomic fluctuations, climate change and investment pay-offs may affect future global food demand.	http://www.fao.org/global-perspectives-studies/methodology/en/
Delivering on EU Food Safety and Nutrition in 2050 – Future challenges and policy preparedness study	European Commission / Joint Research Center	2017	The study aims to assess the future resilience of the current EU food safety and nutrition policy and regulatory framework by examining potential scenarios up to 2050 and the challenges they may present, and suggests possible policy options. Four challenging scenarios were developed based on different combined developments of specific drivers of change. The study also identifies research needs and suggests a set of food-chain related indicators that could indicate well in advance whether the EU is heading towards one of the study's scenarios.	https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/delivering-eu-food-safety-and-nutrition-2050-future-challenges-and-policy-preparedness
Foresight Series Report: Global Food Security 2030. Assessing trends with a view to guiding future EU policies	European Commission / Joint Research Center	2016	The study aimed to establish a structured and inclusive discussion - based on scenario analyses - that could be useful for guiding future EU policies - showing that it is essential for Europe to move towards an integrated examination of a much broader landscape. By 2030 and beyond, food security will increasingly be considered as securing food supply in response to changing and growing global demand. The report calls for an evolution of present-day policies on food security and beyond into a Common Food Systems Policy in which both the systemic and global dimensions of food security are fully incorporated.	https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/global-food-security-2030-assessing-trends-view-guiding-future-eu-policies
Shaping the Future of Global Food Systems: a Scenario Analysis	World Economic Forum	2017	This report identifies two critical incertainties (demand shift and market connectivity) and presents the implications of four scenarios for the future of global food systems (survival of the richest/unchecked consumption/open-source sustainability/local is the new global). It aims to provoke and challenge leaders to think in new ways about what the future may bring and to motivate action on the key issues that will shape that future.	http://www3.weforum.org/docs/IP/2016/NVA/WEF_FSA_FutureofGlobalFoodSystems.pdf

Appendix 2: Detailed descriptions of foresight initiatives

The stocktake has looked 22 foresight initiatives. This includes 8 one-off foresight studies and 14 ongoing modelling programmes/projects. mainly implemented by consortium of research and academic organisations publishing regular foresight studies as well.

Foresight studies encompass **i)** from a national perspective a report produced for the UK Government exploring the increasing pressures on the global food system until 2050 to inform policy decision-making; **ii)** from a European perspective, two studies published by the Joint Research Centre (European Commission) assessing trends related to the global food system and guiding future EU policies; and **iii)** from a global perspective FAO's work related to Global Perspectives Studies and to the *OECD-FAO Agricultural Outlook* annual, forward-looking assessment of market and policy issues, the Global Panel on Agriculture and Food Systems For Nutrition report highlighting the impact of major drivers of change in dietary patterns, and the World Economic Forum report providing a high framing for foresight options vis à vis demand shift and market connectivity uncertainties (Shaping the Future of Global Food Systems: a Scenario Analysis).

Foresight projects mainly include (i) EU regular foresight exercises and four projects[35] funded by the EU (under DG Research and Innovation programmes) which aim to develop modelling approaches, tools, and knowledge sharing; (ii) Under the Climate Change, Agriculture, and Food Security programme, the CGIAR aims to assess and prioritise climate-smart agricultural practices in Latin America and Africa[36] an to inform policy decisions and develop global scenarios; the latter project is implemented by IFPRI which also facilitates the African Growth and Development Policy Modelling Consortium.

Foresight knowledge sharing and knowledge building : in addition to the Consortium mentioned above, the Global Foresight Hub project facilitated by the Global Forum on Agricultural Research37 (GFAR) contributes to linking CGIAR centres, Advanced Research institutes (ARIs), National Agricultural Research Systems, international policy bodies and initiatives with national and regional organization including Civil Society Organizations. From a modelling perspective The Agricultural Model Inter comparison and Improvement Project (AgMIP) project provided broad insights into how different modelling groups approached the interactions of climate, socioeconomics, and bioenergy policy on agricultural outcomes, including land use, prices, consumption, and production. Project's phase II (2015-2020) is focused on coordinated Global and Regional Assessments of climate impacts on agriculture and food security using multi-model, multi-scale, multi-disciplinary, and multi-method framework.

[35] Transmango, FoodSecure, CLIMSAVE, and SUFSAN.
[36] Predictive Technologies for Climate-Smart Agriculture project
[37] Hosted by FAO, the GFAR is funded by the European Commission (EUR 8 million), and the DGIS, SDC, MAEDI, FAO, and IFAD.

EU and foresight

1. EU SCAR foresight exercises

The Standing Committee on Agricultural Research (SCAR) is an European advisory body on research policies for the European Member States and the European Commission. The SCAR plays an critical role in establishing the European Research Area through the execution of regular foresight exercises[38] contributing to strategic policy advice.

In 2014, the SCAR Plenary launched a 4th exercise exploring the interactions between the primary sector and the bio-economy highlighting three scenarios in a long-term perspective (2050) based on varying levels of biomass supply and demand ("BIO Scarcity", "BIO Modesty" and "BIO Boom") used to describe opportunities and risks for different sectors, social groups and regions and to identify research needs .

SCAR foresight and horizon scanning activities are financed by the European Commission Horizon 2020 financial instrument implementing the Innovation Union, political initiative to ensure the competitiveness of Member States (funding EUR 80 billion)[39]. Underpinning this approach is the European Commission strategy launched in 2012[40] for 'Innovating for sustainable growth: a bioeconomy for Europe'.

2. Projects funded under EU 7th Framework Programme

Transmango project (2014-2018): aims to develop a comprehensive picture of the effects of a number of drivers[41] on the European food system by (i) designing an integrated conceptual framework around food and nutrition security that encompasses the whole food system, (ii) developing new system modelling approaches to capture the empirical diversity of food securities, vulnerabilities and sovereignties, (iii) improving the assessment of food system vulnerabilities through specific initiatives, and (iv) formulate recommendations for EU policy makers in order to promote social innovation that contributes to medium- and long-term food and nutrition security. **Funding** 4,9 million including EU contribution EUR 3,9 million.

Climate change Integrated Assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe - CIMSAVE project (2010-2013)
The CLIMSAVE project developed an integrated assessment approach that enabled stakeholders to explore and understand the cross-sectoral benefits and conflicts of different adaptation options to better inform the development of robust policy responses. The project developed (i) an integrated Assessment web Platform that enables stakeholders to explore the complex multi-sectoral issues surrounding impacts, adaptation and vulnerability to climate and socio-economic change within the agriculture, forest, biodiversity, coast, water and urban sectors; (ii) a range of climate change scenarios to allow users to explore the effects of climate change uncertainties on impacts and vulnerabilities; and (iii) four socio-economic storylines. The project was implemented at two scales: Europe and Scotland. **Funding** 4,1 million including EU contribution EUR 3,1 million.

FOOD SECURE project (2012-2017) is a research project including project work packages dedicated to short and long term modelling. The project aims to develop (i) a conceptual framework for the quantitative assessment of food and nutrition security in the long-term, (ii) scenario results for alternative visions of the future (to 2050) including the implications for food and nutrition security, and (iii) a modelling toolbox - developed on the basis of six models MAGNET, MIRAGE, IMPACT, GLOBIOM, IMAGE and EPIC - capable of analysing the food and nutrition security impacts of a range of policies. **Funding** : EUR 10,5 million including EU contribution EUR 8 million.

3. Projects funded under EU Horizon 2020 Programme

SUSFANS' project (2015-2019): to gauge the policy reforms needed for a move towards a diet that supports sustainable food consumption and production major societal challenge, SUSFANS aims to develop metrics, identifies and analyses drivers, integrates data and modelling and formulates foresight for EU sustainable FNS, building on a common scientific evidence-base which accounts for the perspectives of the various actors and factors that play a role in the food system. Regarding long-term modelling, SUSFANS further develops and uses a suite of well-established models commonly applied to trade, agricultural policy, biofuel policy and climate change issues for the European Commission and member states including the economic model MAGNET, the economic/biophysical models CAPRI and GLOBIOM, and the biophysical model EPIC. These models are strengthened with respect to the producer, food chain and consumer side behaviour.

[38] SCAR has launched four foresight exercises since 2005, which have developed future scenarios for European agriculture as the basis for prioritising research in the medium to long term.

[39] The EU has identified seven priority challenges where targeted investment in research and innovation can have a real impact benefitting the citizen including food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy (funding EUR 3,8 billion).

[40] Communication of the European Commission on 'Innovating for Sustainable Growth: A Bioeconomy for Europe' COM (2012), 60

[41] Climate, economic concentration and market structure, financial power, resource competition, marginalization, property rules, geo-political shifts, consumer preferences, consumption patterns and nutritional transitions, and poverty and marginalization

Funding : EUR 5,2 million including EU contribution EUR 4,9 million.

4. Studies

JRC Foresight on Global Food Security 2030 study brought together a group of experts and stakeholders to develop a vision for food security in 2030. This vision was then challenged by an extended group of experts in a test of resilience on unexpected occurrences and/or underestimated trends. The process was designed to establish a structured and inclusive discussion - based on scenario analyses - that could be useful for guiding future EU policies. The report shows that it is essential for Europe to move towards an integrated examination of a much broader landscape.

By 2030 and beyond, food security will increasingly be considered as securing food supply in response to changing and growing global demand. Food security is not only a global and systemic challenge, but also an opportunity for the EU to play a role in innovation, trade, health, wealth generation and geopolitics. The report calls for an evolution of present-day policies on food security and beyond into a Common Food Systems Policy in which both the systemic and global dimensions of food security are fully incorporated.

Delivering on EU Food Safety and Nutrition in 2050 – Future challenges and policy preparedness study (2016): To assist policy makers in ensuring a regulatory framework fit to address future challenges in food safety and nutrition, the European Commission's Joint Research Centre (JRC) together with the DG for Health and Food Safety carried out the foresight study assessing the future resilience of the current EU food safety and nutrition policy and regulatory framework by examining potential scenarios up to 2050 and the challenges they may present, and suggests possible policy options.

Four challenging scenarios ("global food", "regional food", "partnership food" and "pharma food scenarios) were constructed based on different combined developments of specific drivers of change that may significantly impact the food system such as global trade, EU economic growth, agri-food chain structure, technology uptake, social cohesion, food values, climate change, depletion of natural resources and world population growth. The study also identifies research needs and suggests a set of food-chain related indicators that could indicate well in advance whether the EU is heading towards one of the study's scenarios.

CGIAR – IFPRI foresight

The African Growth and Development Policy Modelling Consortium (AGRODEP) is facilitated by IFPRI in cooperation with the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA), the West African Council on Agricultural Research and Development (CORAF/WECARD), and the Food, Agriculture, and Natural Resources Policy Network (FANRPAN).

The initiative aims at positioning African experts to take a leadership role in the study of strategic development questions and the broader agricultural growth and policy debate facing African countries. AGRODEP enable stakeholders to receive training in modelling and analysis by:

1) Promoting and allowing access to economic modelling tools; AGRODEP provides a platform for sharing existing core economic models dealing with sector, national, and international policy issues as well as long-term projections in areas such as agricultural growth and poverty, trade, nutrition, climate change, natural resources management, and science and technology:

2) Facilitating access to existing data sources for agricultural research and policy analysis, developing methodologies and standards to improve the quality of available datasets, and complementing higher-level sources in order to increase local relevance; and

3) Building a support network and a research community for the African science community.

Funded principally by the Comprehensive Africa Agriculture Development Program (CAADP).

The IFPRI/CGIAR Global Futures and Strategic Foresight project is a joint project working with all 15 CGIAR research centres. Designed to improve agricultural productivity and environmental sustainability, especially in developing countries the GFSF uses quantitative methods for strategic foresight to inform policy decisions and develops global scenarios.

The project uses IMPACT models to explore how changes in population, income, technology, water resources, climate, diet, trade policy etc. can shape alternative futures in terms of food production, demand, price, trade and resource use — and how these in turn affect progress towards achieving the Global Development Agenda.

Funding: Bill and Melinda Gates Foundation, the CGIAR Research Program on Policies, Institutions and Markets (PIM), and the CGIAR Research Program on Climate change, Agriculture and Food Security (CCAFS).

The Predictive Technologies for Climate-Smart Agriculture project is implemented under the **CGIAR/ Climate Change, Agriculture, and Food Security (CCAFS)** research program and works across a range of spatial and temporal timescales to enable the integration of multidisciplinary knowledge for evaluating climate-smart agriculture practices and facilitating decision-making.

The research uses projection-based frameworks, models and global and regional scale analyses to answer key scientific questions regarding potential changes in land use dynamics in agriculture, and crop-specific breeding needs. Research activities, including investigating climate-smart agriculture practices under climate scenarios; crop modelling under future climate scenarios; and investigating adaptation options for breeding practices. Funding partially provided by CCAFS, CIAT, and Future Earth.

The Global Foresight Hub facilitated by Global Forum on Agricultural Research[42] (GFAR), is a global network aiming to improve foresight, support forward-looking, anticipatory research and analysis that integrates the diverse views of farmers and other stakeholders on specific opportunities and problems facing them.

The initiative is implemented in the framework of the GCARD Roadmap4 with the aim of generating policy-informing, science-based options by exploring emerging trends and issues beyond the presently perceived boundaries of either their possible consequences or the technical and policy options for addressing them and by highlighting the benefits and trade-offs among the potential responses.

The Hub is expected to enable GFAR to fulfill its mandate as a catalyzing mechanism by linking CGIAR centres, Advanced Research institutes (ARIs), National Agricultural Research SystemsNARS, international policy bodies and initiatives (e.g. the Commission on Sustainable Agriculture and Climate Change) with national and regional organization including Civil Society Organizations.

The Agricultural Model Inter comparison and Improvement Project

The Agricultural Model Inter comparison and Improvement Project (AgMIP) project aims to assess the state of global agricultural modelling and to understand climate impacts on the agricultural sector. AgMIP's mission is to improve the characterization of world food security as affected by climate variability and change, and to enhance adaptation capacity in both developing and developed countries.

During its Phase 1 (2011-2014), the project conducted an extensive model inter comparison including 10 models with results published in 2013 in a PNAS (Proceedings of the National Academy of Sciences of the United States of America) paper[43] providing broad insights into how the modelling groups approached the interactions of climate, socioeconomics, and bioenergy policy on agricultural outcomes, including land use, prices, consumption, and production.

Results have also been published in 2014 in a special issue in the Journal of Agricultural Economics[44] containing articles on model performance in assessing the effects of climate change, bioenergy policy, and socioeconomics on agriculture. The special issue includes seven peer-reviewed articles that present thematic results from a range of modelling strategies, with partial and general equilibrium modelling as a high level distinction but a myriad of differences within these two model types.

During its Phase 2 (2015-2020), the project will focus on coordinated Global and Regional Assessments (CGRA) of climate impacts on agriculture and food security. The CGRA utilizes the networks and findings of AgMIP's 30+ activities to construct a multi-model, multi-scale, multi-disciplinary, and multi-method framework capable of exploring major questions related to adaptation, mitigation, food policy, and food security in the face of an uncertain future.

[42] Hosted by FAO, the GFAR is funded by the European Commission (EUR 8 million), and the DGIS, SDC, MAEDI, FAO, and IFAD.
[43] Nelson et. al., 2013.
[44] Von Lampe, 2013.

Funded mainly by: UK Department for International Development (UKaid), US Department of Agriculture, CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS), and the United States Agency for International Development (USAID).

OCDE-FAO Agricultural Outlook Reports
The reports bring together the commodity, policy, and country expertise of OECD, FAO, and input from collaborating member countries to provide an annual assessment of prospects for the coming decade of national, regional and global agricultural commodity markets. The reports are based on an economic model integrating OECD's Aglink and FAO's Cosimo sub-modules. Aglink-Cosimo is a recursive-dynamic, partial equilibrium model used to simulate developments of annual market balances and prices for the main agricultural commodities produced, consumed and traded worldwide. [45] Aglink-Cosimo models ten years into the future.

FAO paper on the Global Agriculture Perspectives System (GAPS): Version 1.0
Since 2012 and following the recommendations of the internal evaluation of the Global Perspectives work of FAO, the Global Perspective Studies (GPS) Team has included scenario analysis as part of its methodology including global economy-wide general equilibrium and sector-specific quantitative models. The GPS has recently developed a partial equilibrium modelling system (GAPS).
The GAPS is a standard recursive dynamic multi-market and multi-regional partial equilibrium model designed for supporting FAO's long-term projections on food demand and supply. It allows to study the development of global food markets in the long-term and to assess how socioeconomic fluctuations, climate change and investment pay-offs may affect future global food demand.
GAPS is a simulation model in that it simulates the operation of national and international agro-food markets by supply and demand behaviour in all markets. It is an equilibrium model as it solves for quantities and prices that equilibrate markets by equating world supply and demand. It is a partial equilibrium model because it deals only with agricultural activities and food commodities and so it covers only part of the entire economic activity. Finally it is a recursive-dynamic model because the solution of one period serves as starting point for solving for the next period.
FAO is considering developing a Global Economic Model Framework for Sustainable Agriculture and Food Security (GEM-SAF), which may have a general equilibrium model at its core, linked to other modelling frameworks, including GAPS model. The modeling framework should support the scenario analysis in preparation of the FAO report: "World Food and Agriculture towards 2050-80" report and updates thereof.

The International Institute for Applied Systems Analysis – GLOBIOM Model is a global, recursively dynamic, and partial equilibrium model assessing the competition for land use between agriculture, bioenergy, and forestry. The GLOBIOM's analytical process captures the multiple interrelationships between the different systems involved in provision of agricultural and forestry products, for example, population dynamics, ecosystems, technology, and climate.
GLOBIOM accounts for the 18 globally most important crops. The GLOBIOM-EU version extends this to 27 crops, a range of livestock production activities, forestry commodities, first- and second-generation bioenergy, and water.

Using the year 2000 as the baseline, GLOBIOM simulates demand and supply quantities, bilateral trade flows, and prices for commodities and natural resources at 10-year-step intervals up to 2050. This gives planners a basis for setting future land use and, more importantly, for identifying possible shortfalls in food and biomass supplies.

The Future of Food and Farming report explores the increasing pressures on the global food system between now and 2050. It highlights the decisions that policy makers need to take in the years ahead, to nutritional and caloric needs for a global population of 9 billion. The report recommends changes in civil society, sustainable intensification, advocating the importance of sustainable agriculture in development, and including the environment in food system economics as priorities for policymakers. It examines the case for a low-carbon food system as well as the policy implications of deforestation. Funded by the UK Government.

The Oxford Martin programme on the Future of Food aims to link together existing research on the food system at Oxford and support new interdisciplinary research that addresses the challenges of feeding the global population sustainably, healthily and equitably. This includes scientific, economic, social and environmental issues of food production and consumption, as well as challenges for health, sustainability and development. Research includes for example "Modelling The Relationship Between The Food System And Health, Development, and The Environment » project and studies on the impact of climate change on food production.

[45] Aglink-Cosimo Model Documentation - A partial equilibrium model of world agricultural markets (2015). OECD/FAO.

The Global Panel on Agriculture and Food Systems For Nutrition report provides insights into changes in diets across the world and highlights the impact of major drivers of change in dietary patterns, including population growth, rising incomes, urbanization and globalization. The report complements the 2016 Global Nutrition Report in delivering evidence to underpin policy change. Data focus on the challenges that decision makers face when attempting to integrate nutrition within current food systems and agricultural policies. The report sets out ways to approach these challenges so that policies are shaped in a way that delivers healthy, safe and nutritious diets for all.

The INRA-CIRAD Agrimonde and AgrimondeTerra exercises

Launched in 2006, the Agrimonde programme focused on scenarios and challenges for feeding the world in 2050 with the objective to inform research programming and specific international policy debate. Agrimonde intended to "pluralise not only the substance of the scenarios considered, but also the methods to develop and represent them".

As an alternative of existing economic models (e.g. IMPACT) linking scarcity, prices and technological progress, Agrimonde developed quantitative framework, based on physical balances between biomass resources and uses. The study on "World food Security in 2050" was released in 2011.

Agrimonde-Terra programme is a continuation of the Agrimonde initiative and aims to focus on system analysis and causal relationships while in Agrimonde the quantitative work was complemented by a qualitative analysis. The Agrimonde-Terra study "Land Used and Food Security" released in 2016 explores a variety of land-use scenarios based on qualitative and quantitative analysis.

Long-term dynamics of the land use and food security system were analysed, with a focus on the five dimensions of land use (agronomic potential, access to land, degree of intensity of land use, distribution of land between different uses and services provided by land) and key drivers of land use change selected, hypotheses on how each driver might evolve in 2050 were produced and five scenarios built by combining one or several hypotheses per driver.
The impacts of the scenarios in terms of land use, agricultural production and trade in the 14 world regions and globally have been assessed through quantitative simulations using the biomass balance model *GlobAgri-AgT*. The five scenarios and their outcomes were then appreciated both quantitatively and qualitatively.

Conclusions of the study:
There is no given pathway to food and nutrition security. Because the challenge is complex, with many overlapping and interlinked issues that cut across sectors, territories and actors, changing the course of on-going trends requires systemic transformation, public policies and consistent actions from a wide range of actors. Each country and region will have to find its own pathway in coherence with common responsibilities for facing global challenges.

Changes in both supply and demand are necessary for transition towards diversified and healthy diets and the reduction of waste and losses.

Future cropping and livestock systems are a cornerstone issue for food security and further research is needed on their economic, environmental and social performance.
The importance of trade and the roles of new actors require a rethink on how it is organised.

All of the above imply securing access to land for all types of farming structures and that we care about rural development.