

# NEW WAYS OF PROVIDING KNOWLEDGE TO TACKLE FOOD AND NUTRITION SECURITY: WHAT SHOULD THE EU DO?

Expo 2015 EU Scientific Steering Committee  
*Recommendations*



MILANO 2015  
FEEDING THE PLANET  
ENERGY FOR LIFE



Official Participant

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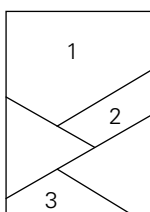
EUR 27562 EN

ISBN 978-92-79-53476-8

ISSN 1018-5593

doi: 10.2788/802016

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# FOREWORD

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Research and innovation are the most effective tools to increase global food and nutrition security. The European Union has therefore highlighted in its participation at Expo 2015 that new knowledge is central to address the pressures on the global food system and to feed a growing and more animal protein demanding population without exhausting our limited natural resources.



search and multi-sectorial, multi-interest and cross-government dialogues to facilitate the sharing of expertise and policy experience. Instead of academic and political silos more holistic and integrated system views are needed.

The Scientific Steering Committee cannot emphasise enough how urgent and important new initiatives are to address the challenges of sustainable global food and nutrition security.

The European Commission together with the European Parliament and the Italian Presidency of the Council launched in March 2014 an independent Scientific Steering Committee made up of 11 scientists of international repute and several representatives of international organisations, industry and civil society. This committee was invited to follow the EU's scientific programme for Expo 2015 and to develop a European Research and Innovation agenda for Global Food and Nutrition security including clear and straightforward recommendations for European policy makers.

This final document will contribute to the legacy of Expo 2015 by fostering international research and development and by presenting recommendations on how to accelerate the efforts to achieve sustainable global food and nutrition security.

The first part identifies the most burning research and innovation challenges and where the EU can add most value. We have grouped the research challenges in 7 research clusters and we address also the decisive structural issues, which apply across all research themes. We are convinced that without systematic foresighting, stimulating inter- and transdisciplinary research and action as well as education and engagement with the general public global food and nutrition security can never be achieved.

Dealing with the future challenges demands significant changes: Politically, from the decision makers, from farmers and industry and from consumers around the world. It will be important to break down the existing research and policy silos to foster interdisciplinary re-

In order to systematically address these challenges four recommendations are suggested to target the levels of change. At its core "system thinking" is required (rec.1). In turn such thinking must raise awareness by "developing debate and engagement" (rec.2) to obtain social license. These social and political licenses will open up new business opportunities and reinforce the speed of change through "innovation and impact" (rec.3).

Finally it is suggested to move towards an "International Panel on Global Food and Nutrition Security (IPFN)" in order to create the political license to tackle the global food and nutrition challenge.

After working together intensively and creatively over one and a half years, I would like to thank all members of the Scientific Steering Committee for their commitment and valuable contributions and especially the drafting team for their incredibly fast and efficient production of the final document. I would also like to thank the representatives of the Commission and the Parliament for their excellent cooperation and last but not least the staff of the Expo 2015 Taskforce in the Joint Research Centre for their enormous support.

Mr. Franz Fischler,  
Chair of the Scientific Steering Committee

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# EXECUTIVE SUMMARY

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*Feeding the Planet, Energy for Life* was the theme of the 99<sup>th</sup> World Expo in Milan in 2015. To provide expert advice on the Expo's theme, the EU established a scientific steering committee. This committee produced two publications, now updated and combined into this single document. The first, launched as the Expo opened, outlined the scale of the challenges and the breadth of research needed for food and nutrition security. The second, launched near the end of the Expo, drew together some of the discussions and made four recommendations to the EU for how knowledge should be generated and used.

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## THE ISSUE

Currently, 805 million<sup>1</sup> people are chronically hungry in the developing world<sup>2</sup>. Around 2 billion more people suffer from micronutrient deficiencies. Lack of adequate nutrition is primarily due to lack of access to food and this is in most cases due to relative or absolute poverty<sup>3</sup>. Furthermore, limited access to food and rapid food price inflation can be a cause of civil unrest and drive human migration. Paradoxically, at the same time as billions suffer food insecurity through lack of food, more than 2 billion people are overweight or obese, often associated with poverty, and as a consequence of over-consumption of calories and lack of access to nutrition, as well as a lack of physical activity. Caloric overconsumption progressively increases personal, public-health and environmental costs and thereby increases the pressure on the global food and health systems<sup>4</sup>.

Food and nutrition security is therefore an issue for, and in, all societies.

Historically, global production of food has outpaced consumption growth as evidenced by falling real prices. However, this "outpacing" is now slowing due to constraints on supply alongside continued growth of demand. More people are each demanding more food that is more resource-intensive to produce (like meat); and, in addition, in most places, considerable food is wasted. On the supply-side, historic yield growth has slowed or plateaued in recent years, and the acceptability of technological solutions to increasing yields is sometimes disputed. In addition, there is increased competition for land, water and other natural resources which may impact on global food production and climate change is also threatening production growth in many areas. A further constraint is that reducing the environmental impact of agriculture, aquaculture and fisheries, including greenhouse gas emissions, may require changes in the way food is produced.

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## WHERE ARE THE RESEARCH & INNOVATION CHALLENGES?

The food system is complex from production to consumption and its affects on health. Part of its complexity is its global nature, such that, for many, food is produced far away from where it is consumed. As a result of the complexity, there is unlikely to be any single or easy solution to tackle

food and nutrition security fully<sup>5</sup>. Many of the challenges in addressing global food and nutrition security require the participation of the research community to generate knowledge, seed innovation, engage with the public and help to shape the food system in a beneficial way. In the past, the focus of research has been on increasing food production to meet a growing demand but more recently it is argued that food and nutrition security is as much a challenge concerning consumption as it is about production. This stems partly from the realisation that up to a third of the world's food production is lost or wasted<sup>6</sup>. Moreover, food consumption patterns in combination with sedentary lifestyles can turn into significant and rising burdens on public health<sup>8</sup>. Thus, it is of paramount importance to take a "food systems" view. This requires equal attention on improving agricultural and fisheries' productivity, reducing the negative environmental impacts of production (including reducing emissions of greenhouse gases), reducing loss and waste at all stages in the food chain and in helping citizens eat more healthily, whatever their income and wherever they live. The EU has excellent intellectual resources which can be brought to bear to mitigate the growing risks of global food and nutrition insecurity, with the desired outcomes of improving economic growth, public health and the environment. To address these broad challenges both new knowledge and much enhanced movement of knowledge into use is needed. The Committee identified research challenges grouped into 7 broad themes which are: improving public health through nutrition, reducing losses and waste, increasing food safety and quality, understanding food markets, increasing equity, increasing agricultural outputs sustainably and managing the land for all environmental services.

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## WHERE CAN THE EU ADD MOST VALUE?

The EU is a unique institution which invests significant resources in research and coordinates policy and practice that impacts upon a large number of countries. It hosts a large human capital of researchers, with significant amounts of world-leading expertise. Many of the issues raised by the food and nutrition security challenge are inherently interdisciplinary, multi-sectoral and culturally-entrenched. The EU already has a strong track record of coordination between research providers, across countries, and research users across policy domains. The EU therefore has an important role to play in delivering research against the challenges, but also in showing international leadership in research and innovation for economic and societal benefits by generating sustainable economic growth and employment and for enhancing health and well-being.

As well as highlighting the research needs to address the food and nutrition challenges, the Expo provided an opportunity for significant engagement with stakeholders about how to address the challenges. This discussion took place in over 200 events, sponsored by the Committee, and through an online consultation on the initial paper. Following this discussion, it was possible to highlight four key areas where the EU can particularly add value to its research investment. The four recommendations are not about the specific areas of academic research required in the 7 themes, rather they are aimed to guide how knowledge is generated and used in order to meet the challenges previously set out.

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## RECOMMENDATIONS

In addition to the specific areas where there are knowledge needs, there are a number of cross-cutting structural issues that can enhance the creation and use of knowledge from research in the EU.

The premier issue is that the food system is complex. Solutions sought in one area, like production, may contribute to problems in others (whether to the environment, public health or through increasing waste), yet few people - academics, policy experts or citizens - understand the whole system well. As the need is to make the food system work better to provide sustainable food and nutrition security, understanding the whole system, and predicting how it will change with future challenges ("foresighting" and horizon scanning) are pre-requisites of systemic change through social and business innovation. Our recommendations are therefore primarily about how we think about, generate and use knowledge about the food system. The recommendations are:

1. Promote systems approaches, by conducting foresight exercises and research, to identify the best leverage points where interventions will have the greatest impact. This may be from minimising trade-offs, or identifying synergies. Following the analysis to identify these "leverage points", invest in inter- and trans-disciplinary research to develop integrated solutions.
2. Using synthesis of knowledge, engage with citizens (and stakeholders) about the impacts of food choices on nutrition and the environment. This is needed to cut through the complexity and confusion of how to eat healthily and sustainably. This dialogue can empower and underpin necessary societal change.
3. Stimulate an innovation environment by incentivising a greater degree of co-designed and co-executed work with stakeholder groups with an interest in adopting innovations. "Innovation" is defined broadly to include political, institutional, social and business actions to effect positive change via economic growth or reducing economic costs, or cost-neutral changes in social well-being.
4. Finally, and in support of (2), the EU should show international leadership to support establishment of a new science based global assessment mechanism for global food and nutrition security: this could start as an International Panel on Food and Nutrition Security (IPFN). This will provide an evolving synthesis of scientific knowledge, help to set research agenda on contentious issues, stimulate problem solving new research, and contribute to transparent public discourse on instruments, synergies, trade-offs and risks.





# INTRODUCTION

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The 99<sup>th</sup>, Universal Exposition took place in 2015 in Milan on the theme “*Feeding the Planet, Energy for Life*”. Since 1851, “Expos” have been major international events serving as a forum for dialogue between governments and institutions, and also acting as an opportunity for knowledge exchange with the public on the Expo theme. “*Feeding the Planet*” is one of the most pressing challenges of our time and Expo 2015 provided an opportunity to communicate with citizens, and also a platform to foster global research and policy development through international conferences, workshops, exchanges of best practices and joint declarations on actions. The initial goal was for the Expo 2015 theme to have a lasting legacy by stimulating a policy debate among the 148 participating countries and international organisations.

The EU is an important stakeholder in the global debate on how best to provide food to enable sustainable and healthy eating patterns for all. Many EU policy areas are related to this issue: from agriculture to development, from trade, food safety and consumer health to environmental protection, from industry to research and innovation; and the EU has an important role to play in providing solutions. Research within Europe, and alignment of Europe’s research (and funding) with other countries’ has a significant role to play to address food and nutrition security in Europe and globally. A Steering Committee was established to provide expert advice on Expo’s theme. The Steering Committee (Annex A) published two papers to encourage discussion. The first, launched as the Expo opened, outlined the scale of the challenges and the breadth

of research needed (Part 1, below). The second, launched near the end of the Expo, drew together some of the discussions held during the Expo and made four recommendations to the EU for how knowledge should be generated and used (Part 2 below). This current paper combines, and updates, both papers.

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## WHAT IS FOOD AND NUTRITION SECURITY?

Food security<sup>9</sup>, as defined by the Food and Agriculture Organisation (FAO), occurs when *all people, all of the time, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life*<sup>10</sup>. Clearly, with an estimated 805 million<sup>11</sup> who are chronically hungry in the developing world now, and 165 million children who are stunted and will carry the burden of this through their lives, we are far from this, globally. A further 2 billion individuals suffer from iron deficiency or other micronutrient deficiencies (vitamins, minerals, trace elements)<sup>14</sup> highlighting the importance of the need for nutrients beyond calories. For billions of people, the problems of gaining adequate nutrition and calories are primarily due to lack of access to food. For most, this is due to poverty<sup>15</sup>. Beyond impacts on health, lack of access to food can destabilise communities especially

in periods of rapid food price inflation<sup>16</sup>. Food and nutrition insecurity can also act as a driver for changing patterns of human migration, including transnationally<sup>17</sup>.

The developed world also has food insecure people: growing income inequality means that the number of those struggling to feed their family is increasing. Across the EU some 50 million people face material deprivation, with 18 million receiving food aid in 2010<sup>18</sup>. Malnutrition is not just a problem of under-consumption<sup>19</sup>: more than a third of all adults are overweight or obese<sup>20</sup>; leading to personal, public-health and environmental costs and adding more pressure to the global food system<sup>21</sup>. In the developed world, obesity, and its associated non-communicable diseases like diabetes, is more prevalent with increasing poverty<sup>22</sup>. We therefore include discussion of the research challenges that arise from a high caloric intake and inadequate physical exercise with the need to encourage healthy and sustainable eating patterns. Part of the issue, when food insecurity is a global problem, is the amount of food that is lost and wasted. Reducing this can potentially help to reduce food insecurity as well as the environmental burdens of production.

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## THE SUSTAINABLE DEVELOPMENT GOALS

Towards the end of the Expo 2015 Milano, in September, the Sustainable Development Goals were adopted by the UN General Assembly<sup>23</sup>. The first two top level aims are to :

(1) *"end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfil their potential in dignity and equality and in a healthy environment, and*

*(2) to protect the planet from degradation, including through sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future generations".*

The 17 Sustainable Development Goals (SDGs) apply globally, not just to the developing world. Many of them explicitly or implicitly address the issue of sustainably providing food for healthy lives. By 2030, the aim is to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" (Goal 2), but this in turn will depend on a range of other actions, encapsulated in many of the SDGs. For example, "ensure healthy lives and promote well-being for all at all ages"(Goal 3), "achieve gender equality and empower all women and girls"(Goal 5), "ensure the availability and sustainable management of water and sanitation for all"(Goal 6), "ensure sustainable consumption and production patterns"(Goal 12), "take urgent action to combat climate change and its impacts"(Goal 13), "conserve and sustainably use the oceans, seas and marine resources for sustainable development" (Goal 14), "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (Goal 15), as well as the primary goal of "end poverty in all its forms everywhere" (Goal 1). Meeting these goals, as outlined in Part 1 below, requires significant new knowledge to support shaping the food system from production to utilisation of food and to do so in new and beneficial ways.

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## WHERE CAN THE EU ADD MOST VALUE?

The EU is a unique body with coordination in research, policy and practice across a large number of countries, geo-climatic regimes and cultures. The EU hosts a huge human capital of researchers, with significant amounts of world-leading expertise. Many of the issues raised by the food and nutrition security challenge are inherently interdisciplinary, multi-sectoral and culturally-entrenched. The significant research investment under Horizon2020 aims to undertake strategic-and-policy-relevant research for the benefit of the member states. The EU has a strong track record of coordination between research providers, within and across countries, between research users across policy domains; indeed this is an area where it can claim to be world leading.

Given the global importance of the EU, there is an opportunity for it to play an important research leadership role. This will involve not only conducting world-leading research to overcome the food and nutrition security challenges for the EU and globally, but also showing international leadership in how knowledge is generated and used for the good of society: enhancing health and well-being, sustainability and generating economic growth and employment.

# PART 1

## KNOWLEDGE NEEDS

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# WHY IS FOOD SUCH AN ISSUE?

## DEMAND AND SUPPLY

### UNDER INCREASED PRESSURE

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Historically, global growth in production of food has matched or slightly outpaced growth in consumption, as indicated by the downward trend in real food prices in the 20th Century. However, this “outpacing” has slowed due to both growth in demand and constraints on the production side.

Demand for food and other agricultural<sup>24</sup> outputs (especially biofuels) is growing rapidly. By the middle of the century, there will be about a third more people on the planet. At the moment, about 2 billion people are in the global middle class income bracket of \$10-100 per day and this number is expected to rise to 3 billion by 2030; the bulk of this increase will be in the Asia-Pacific region<sup>25</sup>. As people get richer, their diets change, typically eating both more and differently. Some demand projections to mid-century suggest a need for 60-110%<sup>26</sup> more food. This is primarily driven by growing demand for, and intensification of, livestock production (crops for feed currently represent 53% of global plant protein production, and 36% of calorie production, enough to supply calories for 4 billion people)<sup>27</sup>. Similar demand growth of the products of aquaculture and fisheries is projected.

On the supply-side, increasing world food production to meet growing demand faces three main challenges. First, the yields per hectare of the main agricultural crops are currently increasing at rates that are insufficient to match long-term demand without using significantly more land<sup>28</sup>. Innovation is therefore needed to raise

yields in ways that do not undermine sustainability.

Second, competition for natural resources is growing. Productive agricultural land is increasingly used for producing biofuels and other non-food products, as well as being converted into urban infrastructure; some is also lost due to degradation of soils<sup>29</sup> and desertification. Deforestation to create further land for agriculture is undesirable due to the associated social and environmental costs especially biodiversity loss and greenhouse gas emissions. Water for agriculture currently accounts for 70% of abstraction from rivers and groundwater globally<sup>30</sup>. A recent analysis suggests that to meet demand, and assuming yield gaps are reduced through research and technology, 56% more water for irrigation would be required by 2050<sup>31</sup>. In many areas, even with efficiency gains, it may not be possible to meet such increased water demand.

Similar issues occur in the seas: pressures on marine resources are leading to the depletion of fish stocks, threatening over 500 million people<sup>32</sup> who depend, directly or indirectly, on fisheries and aquaculture for their livelihoods. Furthermore, fish is paramount to food and nutrition security as it provides a significant component of animal protein for over 4 billion people<sup>33</sup> and at least 50% of animal protein and micronutrients for 400 million people in the poorest countries. A parallel development is that aquaculture has been the fastest growing food related activity but it also brings its own challenges, akin to those of agriculture



(i.e. space needs, inputs and pollution). Increasing competition for resources applies not just to primary production, but across the whole food-chain: for example, food processing accounts for 5-10% of industrial water use, and 17% of aluminium use is for packaging, the majority for food and drink<sup>34</sup>.

Third, the climate, and therefore the weather, is changing. Estimates of the impact of future climate change – on today's farming systems – vary according to the methods used, the crop, and the location. For the period 2030-2049, about 10% of projections are for yield gains of more than 10% relatively to the late 20th century; but about 10% of projections indicate yield losses of more than 25%, mainly in the low latitudes<sup>35</sup>. Such estimates highlight the need for agricultural adaptation, including changing genetics of crop plants, to avoid yield loss<sup>36</sup>. In addition to changes in average yields, there is considerable uncertainty about the impacts of changing patterns of extreme-weather on production. Current projections are for yields to become more variable, with year-on-year variability perhaps increasing by 50%<sup>37</sup> by 2050. To exemplify the potential impact of climate change, a recent study on maize in France concluded that, over the next two decades, yields would have to increase by >12% simply to offset the increasing frequency of very hot days<sup>38</sup>. Climate change also affects oceans and aquatic systems for example through rising sea levels, acidification, warming of waters and storms. Although fishing activities may impact stocks and ecosystem more than climate change, weakened fishery resources are more vulnerable to collapse due to climate change<sup>39</sup>. In addition to the need to adapt to climate change, globally, agriculture and associated land use change account for between a quarter and a third of greenhouse gas emissions<sup>40</sup>; mitigation of climate change via reducing emissions is itself a considerable challenge and may in future require farming in different ways.

In conclusion, demand for food is growing and supply growth faces a range of significant constraints. These challenges play out in an increasingly globalised world, where international trade in food is growing exponentially<sup>41</sup>. Trade creates connections between spatially separated parts of the world, such that production (and its impacts) is separated from consumption. In principle, it allows more efficient allocation of resources and, with appropriate responses from policy and the market, shares the burden of supply shocks reducing price volatility<sup>42</sup>.

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## FINDING SOLUTIONS TO GLOBAL FOOD AND NUTRITION SECURITY: THE NEED FOR RESEARCH AND INNOVATION

Many of the issues associated with meeting the demand for food in the face of climate change, potentially with access to less space for agriculture and aquaculture, more competition for natural resources (like water), and lower environmental impacts require research and innovation. There is unlikely to be any single or easy solution to tackle food and nutrition security fully<sup>43</sup>. In the past the focus has been on increasing food production to meet growing demand but more recently it is argued that food and nutrition security is as much a challenge concerning consumption as it is about production. This stems partly from the realisation that up to a third of the world's food production is lost or wasted<sup>44</sup>. Moreover, increasingly food consumption patterns in combination with sedentary lifestyles turn into significant and rising burdens on public health<sup>45</sup>.

Thus, it is necessary to take a “food systems” view<sup>46</sup> giving equal attention to improving agricultural and fisheries’ productivity, reducing the negative environmental impacts of production, reducing waste at all stages in the food chain and helping citizens of all countries eat more healthily. The EU has excellent intellectual resources for research and innovation which can mitigate the risks associated with global food insecurity and lead to simultaneously improving economic growth, public health and the environment. An important strategic innovation addressing these issues is the concept of the knowledge-based “bioeconomy”, pioneered by the EU, and Germany in recent years, and subsequently adopted by many other countries.<sup>47</sup> Agriculture is increasingly considered as a key part of the bioeconomy, i.e. the production, transformation and utilization of bio-based resources and materials.

The agri-food system – and its impacts on the environment and public health – is inherently complex. Whilst research may be able to abolish or resolve some of the inherent trade-offs, e.g. between production of food and environmental protection, many will remain. A trade-off implies the need for a societal choice on how best to balance (“optimise”) between the different ecosystem services and whilst research can help identify the issues, and underpin good policy by providing knowledge, it cannot itself determine the right solutions.

# WHERE ARE THE RESEARCH CHALLENGES IN ADDRESSING FOOD AND NUTRITION SECURITY?

To address the global food and nutrition security challenge both new knowledge and enhanced movement of knowledge into use are needed. Informed by a range of horizon scanning, foresight and research prioritisation exercises<sup>48</sup> including those underpinning the development of the Horizon2020 programme<sup>49</sup>, the Committee identified some prime research areas which are grouped into 7 themes (Figure 1), and described in detail below.

A number of generic issues apply across the themes. Climate change will have profound effects not just on production, but may also impact on food safety and spoilage, international trade via weather-related disruptions<sup>50</sup> and interact with nutrition to affect health. Climate change mitigation may also require both changing diets and changing practice along the food chain which may affect production, transport and consumption. Many of the areas below highlight “wicked

Figure 1



problems”, where there are trade-offs between social objectives; navigating these to produce an equitable outcome can be very difficult. Delivering outcomes contributing to the SDG’s top-level aims of simultaneously improving prosperity, public health and environment may require social or institutional reform, not just research. There is thus a broad governance task of making and implementing appropriate societal choices to optimise the agri-food system. This issue is revisited below, as recommendations are developed.

All 7 themes are important, and all have to be tackled. First, consumption patterns and food safety and quality themes are discussed to reflect that these are areas where Europe has greatest need and demonstrates examples of best practice respectively that could lead the way to more sustainable food systems. These are followed by waste-reduction, resource management and sustainable agriculture themes, indicating areas high on the policy agenda of the EU where Europe can provide examples for others to follow. The description ends with the themes on trade and global equity, as these may require concerted global action.

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## THEME A: IMPROVE PUBLIC HEALTH THROUGH NUTRITION: HEALTHY AND SUSTAINABLE CONSUMPTION

Globally, access to more and better food has increased in recent history, and a functioning agri-food system that provides a diversity of produce, cheaply, at all times, is something many of us take for granted. The life expectancy of European citizens is steadily increasing<sup>51</sup>, and good nutrition and agri-food processes have contributed to this. However, adverse nutritional outcomes also arise from the agri-food system. For the global poor, including the poor in Europe, access to sufficient food for a healthy diet remains a daily struggle, with a significant proportion of the global population suffering from chronic hunger and nutrient deficiency, and with poor maternal nutrition leading to lifelong consequences for children. Despite this, the major causes of death and disability worldwide are now non-communicable diseases (NCDs), such as heart disease and diabetes<sup>52</sup>. Topping the risk factors for NCDs are dietary factors. In 2013, an estimated 32 million adults aged 20-79 in the EU had diabetes, and the health expenditure allocated to treat and prevent this disease and its complications was estimated to be in the order of 100 billion euros<sup>53</sup>. In addition, unhealthy diet is linked to increased cancer risk and heart disease. Across the world obesity is increasing. In the EU, about 20% of people are obese (~150m people)<sup>54</sup>.

With diet-related non-communicable diseases becoming a global driver of ill health, encouraging healthier diets, coupled with the promotion of more active lifestyles is

a positive strategy for enhancing public health. Informing consumers about the implications of their food choices will also benefit the environment. There are therefore increasing needs to recognise that agriculture, food, nutrition and health are intertwined<sup>55</sup>: what is grown, its nutritional composition, and how it is consumed are all important drivers of public health in rich and poor nations alike.

Enhancing the nutritional composition of agricultural production and the formulation of foods to benefit public health present research challenges. For the poorest, this may be about production of sufficient nutrition (Theme E), empowerment (Theme G) and access to markets (Theme F). In the developing world economic growth is creating dietary transitions from subsistence-diets to more westernised diets. How can research help underpin transitions which are positive for health? In the developed world, perhaps even more important is the understanding of how to promote wise consumption decisions and therefore, at a population level, eating sustainable healthy diets.

### **Exemplar research areas**

- Better understanding of the specific nutritional requirements of different demographic groups (e.g. the aged) or different genotypes is required. What is the role for “personalised nutrition” and how it can be achieved?
- Enhancing the ability to provide healthy, safe and sustainable food for those on low incomes
- Understanding consumer behaviour better to find ways of creating changes in food consumption that reduce the public health burden and environmental costs of farming: understanding and promoting “sustainable nutrition”.

- Given economic growth, and developing countries’ associated dietary transitions, defining interventions that most effectively reduce (or prevent) the twin public-health burdens of malnourishment through under- and over-consumption.
- Enhancing the nutritional quality of food through identification, and promotion of, alternative farming systems, including more diversified ones, or different crops.
- Developing biofortification, fortification and reformulation of food for health outcomes whilst ensuring public acceptance of this.
- Better understanding is needed of the human metabolic system and how it interacts with diet, including the role of the gut microbiome in healthy and diseased states.

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## **THEME B: INCREASE FOOD SAFETY AND QUALITY**

In addition to nutrition for good health, globally consumers need food that is safe to eat as well as water that is safe to drink. Increasing food safety requires attention throughout the food chain from “plough to plate”. There are risks associated with chemical contamination of products (e.g. some use of pesticides), or contaminated ingredients (sometimes substituted for economic reasons), spoilage, microbial contamination, and adulteration (as a form of fraud, or even bioterrorism). Identifying risks and mitigation actions can take many forms, technological, regulatory or social, e.g. better understanding of food storage and labelling.

Food safety requires transparent supply chains, and labels that consumers trust to ensure authentic, unadulterated and uncontaminated food. Food safety is also implicit in themes A and C: healthy diets and managing food waste. Ensuring safety requires significant regulation and the development of food preparation, transport and logistics, which are safe and transparent, coupled with enhanced testing for adulteration or contamination. Safety also requires better education about risks.

A related area concerns certification and labelling schemes to promote quality and other attributes. The EU's "Geographical Indication" scheme recognises the geographical origin of certain foods, to promote attributes of traditional production systems. Organic agriculture is also supported to foster diversification of food production and to reduce its environmental impact. Such schemes allow traditional local expertise to participate in global markets and may function as social protection. Many important research questions remain about the role that such schemes have for balancing consumers' vs producers' interests, and the role they play in international trade.

### **Exemplar research areas**

- Enhancing production, storage, processing and logistics, especially in the developing world to mitigate the contamination risks of food or water by, for example, microbial contaminants (including from poor sewerage, or aflatoxins arising from poor storage) or improper use of pesticides.
- Developing smarter food production, processing and logistics to limit the potential for adulteration or contamination of food (including food fraud and bio-terrorism).
- Developing sensors and sensing systems, for laboratory and field, to ensure safety and traceability of food during transport, processing and retailing. Improving scientific (e.g. genetic fingerprinting) and legal tools to combat counterfeiting and enhance traceability.
- Improving our risk assessment and management strategies for complex whole foods of microbial, plant or animal origin (including identifying allergenicity risks).
- Innovating food safety regulations (and labels) that minimises waste and enhances safety by promoting consumer understanding of risks.
- Enhancing research in order to promote harmonization of labelling and information systems, including the development of communication tools for ethical (eg. animal welfare), environmental and social attributes of food products<sup>56</sup>.
- Enhancing organizational and institutional cooperation to promote best practices in building and managing certification systems in developing countries.
- Promoting social research to better understand consumer attitudes to "values" (quality, environmental standards) rather than simply the value (economic price). This understanding will enable consumers to easily make informed choices in light of changing food products in terms of composition, origin and health and environmental impacts.
- Investigating which "quality" regulations are important for society and which are primarily of interest to producers and may, in specific cases, negatively affect society.



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## THEME C: REDUCE LOSSES AND WASTE: MORE EFFICIENT FOOD CHAIN

Significant agricultural production is lost or wasted from the farm to the home<sup>57</sup>. In developing countries, food losses result from wide-ranging managerial and technical limitations in harvesting techniques, storage, transportation, processing, cooling facilities, infrastructure, packaging and marketing systems. Across the EU, an estimated 90 million tonnes of food is wasted<sup>58</sup>; for example, in 2012, Sweden wasted 127 kg of food per person. This estimate does not include the food wasted in the production phase (agriculture and fishing) and the inevitable food waste from the food processing industry. Of this amount, 81 kg per person was generated in households<sup>59</sup>. In sum, the food wasted by the EU and North America is equivalent to the total food production of sub-Saharan Africa. Little reliable data exists for on-farm losses in the EU but they may be significant<sup>60</sup>, due to weather, outgrading and “insurance” production for supermarket contracts.

Finding ways to minimise loss and wastage of food (as well as energy and nutrients) through the supply chain, from “farm to flush” will need many technologies such as longer-range weather forecasting for agricultural planning and demand forecasting, smarter packaging and supply chain logistics, changed genetics for improved storage, recycling technologies. Changes in consumers’ knowledge, attitudes and food cultures may also be as important. Whilst we focus on food loss and waste, the broader challenge exists of increasing efficiency and reducing waste across agri-food supply chains. Furthermore, where waste is unavoidable

(including human sewage waste) there is a need to increase the recovery and reuse of the nutrient content, especially phosphorus and nitrogen, to restore organic matter to land, and to recover energy, e.g. via anaerobic digestion.

### Exemplar research areas

- Developing better knowledge about where food is lost and wasted throughout supply chains, and therefore where the leverage-points are for action, and understanding the costs-and-benefits associated with them. This applies to local and global food-chains, and both in the developed and developing worlds.
- Improving genetics for enhanced storage (whilst maintaining taste, quality and safety).
- Across the world, creating smarter logistics, packaging, storage and supply chains to reduce spoilage, recognising the differences in developing and developed worlds’ supply chains.
- Enhancing public understanding of quality assurance (sell by/best before/expiry) dates to reduce waste as well as other interventions in the home (meal planning, smart fridges).
- Improving prediction to align demand and supply (e.g. seasonal weather forecasting) to minimise “insurance” production that goes to waste if supply and demand is mismatched.
- Developing recovery and recycling technologies to optimise recovery of energy, organic matter and nutrients from waste and ensure its safety for reuse.
- Developing innovative products from food industry residues.
- Increasing innovations to improve efficiency and reduce any form of waste (e.g. water, energy, aluminium and other packaging) across supply chains.

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## THEME D: MANAGE THE LAND FOR ALL ECOSYSTEM SERVICES: SUSTAINABLE RURAL DEVELOPMENT

Agricultural landscapes provide a wide range of goods and services to society. These “environmental services<sup>61</sup>” include provision of food, and also fuels, fibre and clean water, and “non-provisioning” services, such as the cultural value of the landscape. Agricultural landscapes provide habitat for biodiversity that aids production (such as pollinators, natural pest control and soil biodiversity) but also culturally important biodiversity exemplified by flowers, butterflies and birds. Agricultural landscapes also affect water-flow and flood-risk downstream, and provide important recreation and amenity use, improving health and well-being. They can sequester carbon. They support rural livelihoods and have cultural value. Agricultural landscapes thus have important heritage protection roles for cuisine, dress, customs, language, architecture. Rural recreation and tourism and the non-food provisioning services are of massive economic, social and cultural importance in Europe; they are an important part of what EU rural development policy aims to encourage and protect. Agricultural land creates a nexus between many different goods and services that societies value.

Agricultural management (Theme E) plays a part in maintaining the range of environmental services at local as well as at larger scale. It does this through appropriate use of inputs, tillage, and management of non-cropped areas providing habitat for

biodiversity and protection of water-courses. However, some integrated land-use planning may be needed to ensure that agriculture, rural development, and wider ecosystem service provision are maintained in a place-appropriate way. Agricultural landscapes also interface with estuarine and coastal ecosystems so land-based agriculture may affect environmental services in fresh and salt water. In the marine environment for both wild-caught fisheries and aquaculture, similar issues apply around maintaining environmental services at a large scale.

Whilst this theme focuses on balancing land use to produce all that society requires, these issues also arise at global scale. Globally, some areas of land have higher agricultural potential, whereas others may support globally significant environmental services, e.g. tropical rainforests. What mechanisms of global analysis and governance can apply to balance global land uses for food versus other important services and ensure economic equity and sustainability?

### Exemplar research areas

- Better understanding of the “earth system” is needed and how it will respond to increased atmospheric carbon dioxide, including the impacts on climate, weather and yield potential, and increased nutrient flows.
- Enhancing research on which to build decision-support tools for optimising land use, which will maintain a range of environmental services (including production of food, fuel or fibre), specific to place and at appropriate scale. This includes better knowledge of the link between small-scale practices (at the field scale) and outcomes, such as on water quality or biodiversity, at the landscape, or catchment scale. This requires understanding, and managing, the potential conflicts between different land uses (and their users) and their impact of different services. Such decision support tools may be needed at the landscape (or

community) scale as well as at bigger scales sub- to supra-national.

- If decision-support tools, highlighted in the bullet above, facilitate our actions the next step involves investigating how to implement these decisions at a community/country/regional level. This may especially be the case in small-scale farming systems in marginal areas, and, in the tropical world, ways of incentivising forest preservation rather than deforestation. The challenges are (a) to identify how to reward the ecosystem services these areas can supply; and (b) to discuss the farming structures needed to deliver this and the restructuring processes to get there. This broadly includes “social farming” in the potential for using small-scale agriculture to provide social or educational care services for the vulnerable.
- Identifying the existence of thresholds which, if crossed, cause environmental services, including food provisioning, to decline rapidly (local- and planetary boundaries). Develop ways of assessing the trajectory towards them, and predicting when they may be crossed. These questions should be investigated at all scales.
- Developing a stronger, publically available, evidence-base to underpin the sustainable implementation of EU policy instruments such as the Common Agricultural Policy, Rural Development and Structural Policy or Water Framework Directive.

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## THEME E: INCREASE AGRICULTURAL OUTPUTS SUSTAINABLY: SUSTAINABLE INTENSIFICATION

Given that little, if any extra land is available for agriculture, there is a need to increase yields from the existing agricultural land area whilst simultaneously reducing the environmental impact. This is “sustainable intensification”<sup>62</sup>. These issues about productivity and sustainability apply as much to fisheries and aquaculture as agriculture. Sustainability is an essential requirement, without which there is the potential to cross local- and planetary boundaries, beyond which agricultural performance may decline. In addition, sustainability encompasses the need for maintaining livelihoods, as well as environmental services for wider societal good (Theme D). One route towards sustainable intensification may come from systems’ analysis of ecological systems (sometimes called “agro-ecology”<sup>63</sup>) to drive ecological intensification. A related route comes from organic agriculture, which has reduced environmental impacts compared to conventional farming, but requires more research to close improve productivity. In addition, as highlighted above, the important societal outcomes from the agri-food system include health: so when considering “yields”, the nutritional quality and food safety (themes A and B) are as important as the amount of food.

As places may differ significantly in many characteristics, one-size-fits-all solutions do not universally apply. Opportunities exist for developing different approaches for different locations to provide overall yield gains in a

sustainable way. For any farmed plant or animal its phenotype (and thus its yield), depends on a complex interaction between its genes, the local environment and the way it is farmed. Better understanding the gene x environment x management (GxE<sub>M</sub>) interaction is needed to support agriculture and sustainable management appropriate to location, and in relationship to climate change, “climate smart agriculture”<sup>64</sup>.

Genetic improvement of crops and livestock, including fish for aquaculture, whether for the quality or quantity of yield, or resistance to pests, heat or drought, requires the utilisation of modern biotechnology. These are techniques which span a continuum between conventional breeding and genetic modification. Modern biotechnology, along with related emerging technologies aimed at genetic adjustment and improvement, such as synthetic biology, and other technologies that may be used in agricultural and food production processes, such as nanotechnology, require significant dialogue with society to ensure legitimacy and the minimisation of risks. These can be environmental, health, economic or to livelihoods. Specifically within the livestock sector, sustainable intensification also requires consideration of a range of welfare issues.

Agricultural land management sits within wider land uses (Theme D) and agriculture’s impacts affect these. Improving sustainability at the farm scale requires more than improvement in efficiency. Sustainability requires better management of inputs, including their potential substitution, to reduce their effects on the wider environment. However, the impacts of a management practice may depend on the location, so operationalising “sustainable intensification” in a place-appropriate way is a subject of significant research, including developing appropriate measurement systems and understanding of trade-offs between yields and environmental impacts.

And, of course, there are broader issues of social sustainability (themes D and G) which may also trade-off against economic sustainability (which typically depends on the volume of yield) or environmental impacts. Similar issues apply in managing the sustainability of aquaculture and managed fisheries.

### **Exemplar research areas**

- Developing metrics for measuring sustainability and resilience, as well as impacts upon ecosystem services and natural capital.
- Developing greater understanding of the potential impact of climate change on production at a variety of spatial scales, and including understanding of the uncertainty of the estimates.
- Developing precision crop and livestock agriculture; including sensing at animal/plant, field and landscape levels, and their engineering applications (including robotics) and decision-support tools. For livestock this includes formulating food and manipulating the gut microbiome for positive outcomes for growth, methane reduction and efficiency, and developing individual health surveillance to avoid prophylactic antimicrobial therapy.
- Developing better integrated soil management for nutrients, carbon-storage, water quality and retention to ensure long-term sustainability.
- Developing or enhancing alternative farming systems.
  - Enhancing the development of approaches to improve re-use and recycling to create “circular” agricultural systems. This includes the recovery and recycling of phosphate, nitrates, potash and organic matter from the nutrient surplus areas (urban areas and areas of intensive livestock production) to nutrient deficit areas, typically arable areas. Research is needed on how to manage this technically, institutionally, for food safety

and culturally such as social acceptance of treated sewage sludge for food crops.

- Developing urban and peri-urban farming systems, including vertical farming, to provision cities.
- Utilising agro-forestry or permaculture to enhance both carbon storage and production<sup>65</sup>.
- Utilising ecological processes and interactions to increase resilience. For example, soil regeneration; enhancing mycorrhizal associations and natural pest control to reduce inputs; or the development of long-term carbon sinks through intercropping with, for example, the Iroko tree which builds carbonate layers in soil<sup>66</sup>.
- The goal of “sustainable nutrition” (Figure 1, Theme A) implies changes in diets and therefore agricultural production. Horticulture places different requirements on soils, water, management, as well as requiring different genetics. What crops should be developed and where? Investigating the structural changes that can promote changes in farming systems that are sustainable environmentally and for livelihoods of rural communities is needed.
- Utilising new sources of protein (such as algae, plants, insects, or from stem cells) for feed and food production. Improving aquaculture systems for delivery of protein with high-welfare and low environmental impact.
- Improving genetics of crops and livestock is necessary to tackle many issues of increasing yields, and their quality, whilst also coping with other challenges. For example:
  - Developing genetics for the changing climate (whether more extremes of heat, drought or rainfall, or via resilience to variability to maintain yield stability),

and for specific places (to optimise the GxExM).

- Given increasing competition for (and societally-led regulation of) inputs, improving resource-use-efficiency (nutrients, pesticides, water etc) will be important, as well as development of agronomic practice to this end.
- The concentration on a small number of agricultural products, over larger land areas, creates a risk in the homogeneity of production and consumption at a global scale<sup>67</sup>.
  - > New pests and pathogens are likely to arise due to globalisation and changing climate. Developing new means of breeding for sustainable pest resistance, as well as predicting, and tackling pests, are important areas of endeavour.
  - > Developing new crop varieties to reduce risks and enhance nutritional outcomes
- Improving the nutritional quality of agricultural products including biofortification and new varieties of crop for commercial use. Improving genetics, especially for livestock, and agricultural practices to enhance food safety.
- Improving photosynthetic efficiency to better harness sunlight by plants and developing perennial and nitrogen fixing crops are long-term innovation challenges.
- Understanding better how to engage with citizens and their attitude to the potential benefits/costs/risks associated with new technologies in agri-food and the environment.
- Better understanding is needed of how to develop governance systems and

strategies for sustainable intensification based on participation, precaution and the polluter pays principle.

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## THEME F: UNDERSTAND FOOD MARKETS IN AN INCREASINGLY GLOBALISED FOOD SYSTEM

International trade in food has grown faster than production, though it is still the case that most agricultural production is consumed in the same country. Traditionally benefits from trade accrue because it allows production to expand where resource endowments confer the greatest advantage. Trading infrastructure, both physical and financial, that facilitates open trade also enables the widest sharing of adjustments to market shocks. Conversely, trade inhibition invariably destabilises markets, widening price volatility. From a European perspective, trade offers the opportunity to export high quality food and drinks and import beverages, agricultural raw materials and feedstuffs for which our temperate climate is less suitable. As the price gap between the EU and world markets has closed, and also to the extent that Europe may be more immune to climate change impacts than many parts of the rest of the world, markets for EU exports may expand.

There may be some concerns that reliance on global markets for importing significant quantities of food could present increasing risk if production conditions become more variable and the commitment to trade liberalisation falters. So steps are needed to ensure our food system is resilient. Some are

concerned that longer, and more complex, supply chains may reduce transparency and increase risk to food authenticity and safety. Improving the transparency of production, consumption and stocks and understanding the evolution of the global market and how it responds to emerging unprecedented climatic and geo-political shocks are further areas where research is needed.

### Exemplar research areas

- Developing tools that help to understand how the global food system may be affected by events not previously experienced like a multiple food system failure (e.g. driven by extreme weather events - El Nino<sup>68</sup>). What would happen to trade, price, access and local land-use decisions?
- Better understanding of how to predict, and manage, risks for safety, authenticity and price stability within logistically efficient and transparent food chains.
- In an era of rising prices, investigating what steps can be taken to lessen the regressive effects on global and local poor.
- Understanding the role of EU production in global food and nutrition security, as well as its potential for economic growth whilst minimising risks.
- Understanding better the risks of globalised and sophisticated just-in-time supply chains and how they relate to local economic growth and its resilience.
- Assessing the robustness and resilience of food, energy, nutrient and other factor markets.
- Understanding the balance of economic, environmental and social effects of foreign direct investment in land and other production assets within and outside Europe.



- Investigating the integration of ecosystem services and climate needs into trade agreements.

## THEME G: INCREASE EQUITY IN THE FOOD SYSTEM

The Sustainable Development Goals (SDGs), published in 2015, are over-arching goals for sustainable economic development. Many of the SDG's aims have a strong social, ethical or gendered component. Goal 1 is to end poverty everywhere<sup>69</sup>; agriculture has a significant role to play in this for many rural communities in the world. The second goal is to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.

As the Sustainable Development Goal 2.3 highlights, one important area is to double the *"incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, and opportunities for value addition and non-farm employment"* This goal emphasises that access to resources (eg. knowledge, finances, inputs) is a major issue for many, and highlights the needs of women. Women are often major care-givers and important for production in many smallholder farming systems, however, they often have poorer access to nutrition, education, income, and to agricultural knowledge and technologies. Furthermore, there are very marked life-course and inter-generational<sup>70</sup> impacts of poor maternal and child nutrition during the first 1000 days of life, so the nutrition of

women and children is a key area of focus. When men may have the economic power, how best to implement policy to target women and children requires significant research.

Land tenure is also highlighted in Goal 2.3. This is perhaps particularly important given the recent upwards trends in large scale land acquisitions (LSLA) whereby investors (including governments) seek new land for investment purposes. Many commentators have argued that LSLA have tended to benefit the investors over local communities, displace small farmers and even impact upon food security<sup>71</sup>. Is this necessarily the case, are land rights well and fairly established and traded?

If demand growth exceeds supply growth, it will lead to upward trends in food prices. For rural net producers this can provide welcome income growth. But the landless and urban poor will find their real incomes declining in such circumstances. How will equity of access to food for the poor be ensured? Many analyses suggest that when food prices increase, the poor pay more, trade down and buy less. In richer countries, cheaper foods are often highly caloric with a poor nutrient composition<sup>72</sup>. Hence in addition to hunger, high food prices can also lead to severe malnutrition and chronic health issues. Ensuring both economic growth and equity is a challenge for policy and governance, and requires significant social science research to inform.

### Exemplar research areas

- Identifying culturally sensitive interventions to improve women's nutrition, child nutrition, and women's economic empowerment as food producers, processors and retailers
- Given the importance of malnutrition in the first 1000 days of life, we need to better ensure food and nutrition security for local- and global

maternal and child health. Identifying what are the best ways to do this for any given socio-cultural situation?

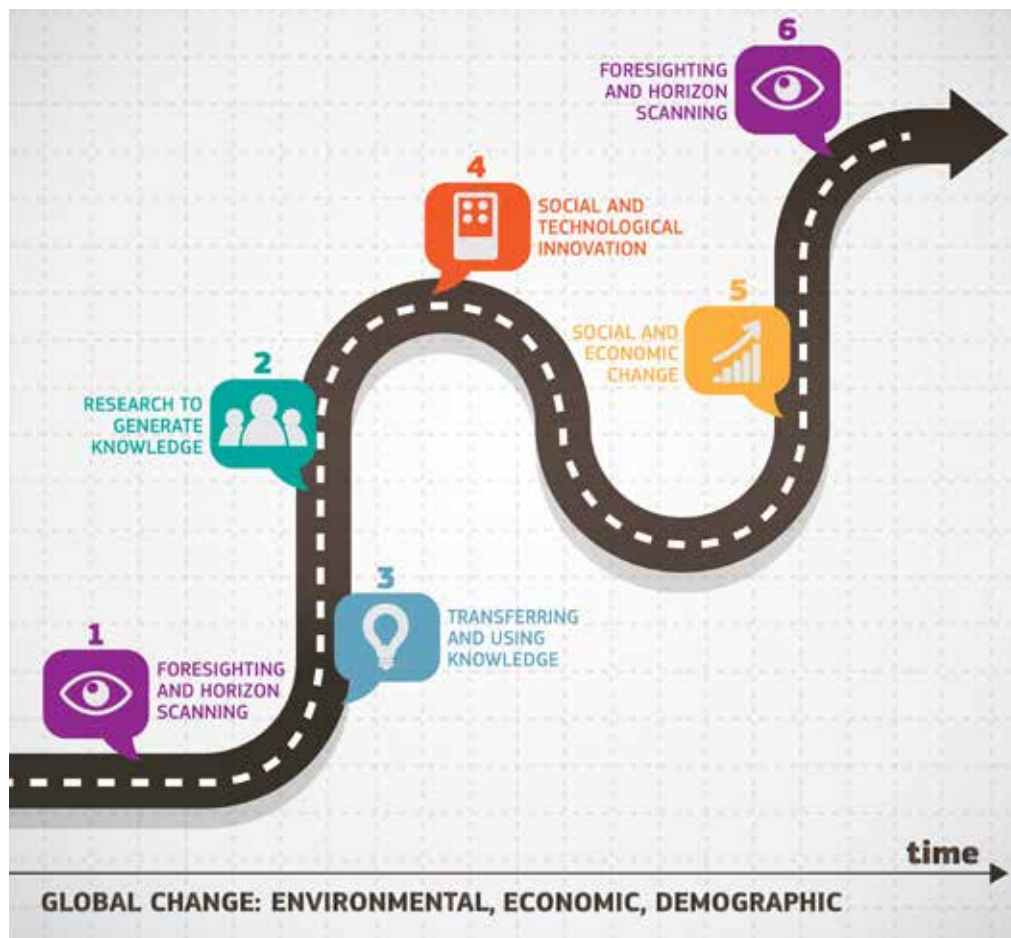
- Access to, and tenure of, agricultural land underpins production and its security in many parts of the world. Investigating how governance institutions can fully take into account the needs of those who have a stake in the land. In the developing world, this primarily concerns models of tenure (and their transformation), in the EU it is also about the public goods coming from agricultural land (themes D and E).
- Minimising costs given the growth of LSLA, and maximising the potential for benefits to investors and traditional inhabitants of the land.
- Strengthening the assessments of the relative importance of small-holding farms compared to larger commercial entities so to ensure a fair place to each of these approaches to farming for the future of agriculture in the developing world.
- Understanding, at country and regional level, the specific causes of food insecurity in order better to develop targeted solutions.
- Food sovereignty implies that citizens should have the right to shape the food system they want, even though the (economic) power often resides in a few large institutions. Identifying to what extent, and in what way, food sovereignty can align with institutional power is needed. Although food sovereignty is often seen as less relevant in the developed world, the current rejection of GM food production by some EU citizens can be seen as an issue of food sovereignty. How best to resolve such issues is an active area of research.
- Developing interventions to enhance access to nutritious food for the EU's poorest.
- Investigating what reduces the vulnerability of subsistence farming systems?

## STRUCTURAL ISSUES THAT APPLY ACROSS ALL THEMES

In addition to the cross-cutting research issues, like adapting to and mitigating climate change, there are a number of cross-cutting structural issues to enhance the utility of knowledge-generation within the EU. These issues can be characterised as being inter-linked to make a virtuous spiral (Figure 2). Initially, strategic analysis of the future (foresighting) sets the research needs. Research is then undertaken, by

member states, by the EU and globally, to generate knowledge. This research needs to address the triple “bottom lines” for economic, public health and environmental benefits, and therefore has to be interdisciplinary and undertaken within a systems approach. Research effort across different countries should be better aligned to ensure complementarity of efforts.

Figure 2



The knowledge generated then should be utilised by creating technological and social innovation (in part through education and communication). Innovation then, in turn, creates social and economic change. This coupled with global development and environmental change happening through time, then requires the forecasting to be updated. These issues are explored in turn below.

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## SETTING THE AGENDA: FORESIGHTING AND FUTURES' RESEARCH

The world is changing very fast given demographic change, population, and economic growth, coupled with climate change and a range of geo-political issues. Strategic research takes time to deliver outcomes, so delivering research to underpin future innovation needs is aided by scoping what these may be. This requires using (and further developing) methodologies for looking ahead, via developing scenarios, foresighting and horizon scanning. This is not in order to predict the future, but to look at plausible futures as a guide to developing either strategies for planning or finding solutions that "fit most scenarios". Such approaches can also help avoid closing down future options if the world ends up not as we imagine it. Given the EU's academic expertise, its cultural and geo-political heterogeneity and strengths in integrating across disciplines and countries, there is considerable scope for further enhancing our world-leading expertise in this area.

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## ADDRESSING MULTIPLE GOALS: STIMULATING INTERDISCIPLINARY AND STRATEGIC RESEARCH AND ACTION

"Food and nutrition security" can be considered as a "meta-challenge" as it necessarily covers health, production, environment, trade, economics and international development. Finding the right balance across the three areas of economic, environmental and public health requires new ways of thinking. Additionally, the food system is highly dependent on water, energy and land use. These complex interactions are sometimes termed the "nexus" problem. For example, agriculture impacts on water use and quality and there is the risk of trading off increasing agricultural output against decreasing water availability or quality with environmental or social impacts. These interactions lead to a need to balance across food, water, land, and energy, rather than simply thinking about maximising food production. The breadth of the intellectual challenge requires greater interdisciplinary thinking than has hitherto been the norm, and requires significant cooperation across the EU (and beyond) as no single country can invest sufficiently to fully address the challenge. This suggests the need for more strategic approaches to building interdisciplinary research programmes, and aligning national and international efforts.

Just as research typically exists in disciplinary silos, policy is often also disconnected. Economic policy may not align well with environmental, climate-change, energy or health policies. Industries are also inherently narrow, with a focus, for example,

on food, water, energy, or biofuels. As much as interdisciplinary research is needed, it is also important to encourage innovation to bring a better balance between the production of food (and its economic potential), its impact on and competition for water resources, and the sustainability of ecosystem services that are public goods. This will require greater sophistication in the regulatory and policy environment. However, policy, to be effective also needs to be simple and transparent. This presents a paradox. Research has an important role to play to embrace the complexity of the food system, but it should also help find routes through the complexity to develop simple, effective and joined-up policy.

An important part of sustainable economic development is via facilitating the “bio-economy” — the emerging cross-cutting economic sector that produces, transforms, and uses bio-based materials. This is inherently trans-disciplinary, but, if not well promoted, it may generate new competition between biomass and food, and between production of bio-based material and other environmental services. However, there are important synergies between technologies and creation of new links in and between value chains (e.g., production of biochemicals alongside production of biofuels, use for waste, bio-based products in chemical and building materials industries). The essence of such transformational strategies are not only technological (new science) and behavioral (adjusted consumption), but also institutional, i.e., providing the regulatory framework and long-term incentives for industry and consumers, both at national and international levels. Sharing new bioeconomy knowledge from science systems of rich countries with developing countries and support for adaptation to local circumstances is an opportunity for collective action.

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## INVESTING IN AND ALIGNING RESEARCH

Each country exists in a globalised world and is affected by drivers beyond its borders, and therefore is a stakeholder in the global challenge; yet no single country has the resources to fully research (and understand) the issues around global food and nutrition security. EU research investments, such as Horizon2020<sup>73</sup>, are a crucial component of generating knowledge that is both of national and supra-national interest. Furthermore, significant value added can be gained by coordinating and aligning national and EU research strategies. Finding ways to identify common research priorities on a global scale is important to avoid competition with other countries globally, or wasted effort by not aligning similar investments or missing strategically important knowledge gaps on the assumption that “some other country is doing that”. Within the EU, alignment is brought about via the Joint Programming Initiative<sup>74</sup> (such as FACCE: Agriculture, Food Security and Climate Change and HDHL: Healthy Diets for a Healthy Life) and ERA-NETs<sup>75</sup>, aided by the Standing Committee on Agricultural Research (SCAR<sup>76</sup>). Internationally a range of other instruments (e.g. Future Earth, OECD, G20-sponsored projects) is available. Some member states have innovative partnerships for aligning research and interdisciplinary analysis across areas, such as the UK’s cross-government Global Food Security Programme. These mechanisms need to be developed at national and supra-national scales (within the EU and between the EU and partners in other regions) fully to gain collective value from each research investment.

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## TRANSFERRING RESEARCH KNOWLEDGE INTO INNOVATION AND PRACTICE

Research creates the most societal benefit when the knowledge is used. Across the world, governments grapple with the “valley of death” between research undertaken and its uptake into innovation and use. Facilitating the green innovation economy requires building bridges across this valley. This may require greater linkage between stakeholders who are end-users and research providers. Such linkage needs to be encouraged throughout the research process (including in the co-design of research programme, and participation in steering research which can help provide “pull” for the use of the knowledge). Although in stimulating knowledge-into-use stakeholders are primarily identified as associated with industry, with the driver being economic growth arising from using research. Civil society also has a stake that may be non-financial, and may be associated with the development of social rather than technological innovation.

A recurrent challenge to the research and innovation system is stimulating two-way knowledge flow, allowing practitioners to access knowledge for implementing the “best practice” and allowing researchers to understand and address practitioners’ needs. New research is not always needed as what we already know can be a platform for innovation if the knowledge is easily available and accessible. Enhanced knowledge structures and systems that allow data to be comprehensively shared can help deal with this. These structures

and systems can also allow development of decision tools and allow information to be accessed by end-users. This may include developing “honest knowledge brokers” or “trusted intermediaries” to ensure end-user trust in the information. It may also include enhanced efforts for user-involved research, such as developing networks of farmers involved in on-farm research and innovation and aiding them in the role of knowledge champions<sup>77</sup> for peer-to-peer learning.

The EU has already had significant impact in developing the innovation culture. For example, the European Technology Platform *Food for Life*<sup>78</sup> was launched in 2005, and is an industry-led public-private partnership aiming to foster research-into-innovation in the food sector.

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## EDUCATION AND ENGAGEMENT WITH THE PUBLIC

Food is a wonderfully integrative issue as it covers a broad range of academic and applied issues, and promoting understanding of the food system, and respect for food, within school and university education would lead to positive societal outcomes. The challenges in meeting food and nutrition security involve societal choices about pathways to achieve goals (for example, there is increasing discussion about changing diets for public health and environmental benefits), and many of these choices require social innovation and attitudinal change across society. This, in turn, needs greater public understanding of the issues around food production, environment, nutrition and health.



# PART 2

## FROM ANALYSIS AND DISCUSSION TO RECOMMENDATIONS

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# INTRODUCTION

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The material in Part 1 was first published as a “discussion document” at the start of the Expo. The subsequent discussions (including an online consultation) was broadly supportive of both the analysis and the issues raised (see Annex 2 for details). Informed by these discussions, it is possible to formulate some concrete recommendations for the EU.

Rather than revisit and prioritise the research areas discussed across the 7 themes – all of which are important, with “leverage points” highlighted below – this part concentrates instead on issues concerning how research knowledge is generated and used. The focus is primarily on understanding the complex food system in order to address the SDGs and broader challenges of developing a sustainable<sup>79</sup> food system that delivers food and nutrition security. The opportunities from addressing these goals provide the potential for significant benefits for human well-being, for economic prosperity, for meeting environmental goals especially the reduction in greenhouse gas emissions and biodiversity<sup>80</sup> loss and for reducing the pressure on the food-water-energy nexus.

Dealing with the challenges demands significant changes: politically, from industry and from societies around the world. To date, policy frameworks at national and international level to promote public health, to manage land- and water-use sustainably, to improve the efficiency of food production, to reduce greenhouse gas emissions, to address food security and to reduce poverty and promote economic growth have largely been developed in isolation. Responsibility for each policy area tends to fall within the remit of a distinct government ministry or public interest group.

In order for governments to develop strategies that harness the opportunity for realising multiple benefits, it will be important to break down such policy silos and to foster multi-sectoral, multi-interest and cross-government dialogues that allow for the cross-pollination of expertise and policy experience. In turn, this further requires breaking down academic and disciplinary silos and developing more holistic, integrated “systems views”. For example, there is an important, and often under-recognised, interplay of the land, water and atmosphere<sup>81</sup> that collectively provides equitable climate, access to fresh water, the foundations of livelihoods and access to food (not only crops and livestock, but also fish and seafood providing a significant component of animal protein for over 4 billion people<sup>82</sup>). In addition, many rapidly growing mega-cities are coastal, relying as much on the oceans as the land for food, livelihoods and habitation. Despite this interplay between land, water and atmosphere, academic discussions typically fragment along disciplinary lines.

Up until now, such integrative dialogues – especially at the policy level - have been hindered by a number of issues. One has been dealing with the complexity, not just of individual aspects such as nutrition, safety, or sustainability, which are each multi-dimensional, dynamic and interactive and thus complex, but of the totality of the food system. Another has been whilst recognising that consumer demand drives the food system there is a wariness of intervening in an issue as personal as diet, whether for promoting health or lowered environmental impacts, given our individual and cultural attitudes. As a result, debates, policy and recommendations, often develop

in isolation: until recently, advice on human nutrition largely ignored advice on what can be sustainably be produced leading to notions of “sustainable diets” differing from “healthy diets”, creating significant confusion for consumers aiming “to do the right thing”. Likewise, on the production side, the impetus has been to produce more, whilst in parallel, on the consumption side, the debate around tackling waste has been growing. Whilst these debates have been independent, they should not be; producing more without tackling the causes of waste may simply lead to more waste, whilst conversely, reducing waste may reduce the need to produce more.

The Scientific Committee cannot emphasise enough the urgency and importance of addressing the challenges of sustainable food and nutrition security. In today’s world, more people than not are likely to suffer ill-health via having poor diets (the twin burdens of under-nutrition and over-consumption of calories), with the often life-long consequences this has. Similarly long-term, developing new ways of producing food that are climate smart and lower environmental impacts may take decades to go from lab to field at scale; and the greenhouse gases emitted from agri-food today will take 30-40 years to impact fully on the climate. Action is needed now to create positive change for the decades ahead.

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## THE ROLE OF RESEARCH AND RESEARCHERS

The challenges of creating a sustainable food system that provides food and nutrition security for a significantly larger population, whilst the climate changes, requires significant structural and systemic change. A forthcoming report from Chatham House (on reducing global GHG emissions by dietary changes<sup>83</sup>) highlights the need for a societal change in attitudes to food in order to improve global public health and drive sustainability. In the report, evidence is presented that there is low awareness, across the world, of the breadth of the issues around food and its environmental impact. The report argues that public awareness is the first and necessary step in producing systemic change as it creates the space for policy and industry intervention. Further, evidence suggests that independent researchers (i.e. those not funded by interest groups) remain a main source of public trust in developing understanding of complex and contested issues. These same researchers also provide a pivotal role in reducing the “known unknowns<sup>84</sup>” to “known knowns” and thereby creating the grounds for innovation to effect change. Of course, research also provides space for discovering the “unknown unknowns”. In order to systematically address these challenges, it was suggested above to develop models of governance for delivering sustainable agriculture and nutrition from local to supra-national scales, and that this entails appropriate design of the research – policy interface.

This leads to four recommendations to use research funding and capability to target the levers of change<sup>85</sup>. At its core, this

requires better integrated thinking across traditional silos. This demands “**systems thinking**” – across the whole food system and more widely how food interacts with water, energy, land, biodiversity and climate and their intrinsic feedback loops. The core of the “integrated thinking” is research and the active agents, and human capital, are researchers who, in addition to creating new knowledge, perform the roles of experts, horizon scanning, early warning and stimulating innovation (*Recommendation 1*).

In turn, such thinking and analysis can be used to effect societal change, and policy coherence, by raising awareness of the issues and, **developing debate and engagement**, to obtain social license (*Recommendation 2*).

These social and political licenses in turn will open up new opportunities for business innovation which will reinforce the speed of change through **innovation and impact** (*Recommendation 3*).

The fourth recommendation is concerned with the global institutional framework required to synthesise complex knowledge and stimulate problem-solving new research, and suggests moving **towards an International Panel on Food and Nutrition** security (IPFN) to create the political license to tackle these challenges (*Recommendation 4*).

The core of the “integrated thinking” is research and the active agents, and human capital, are researchers who, in addition to creating new knowledge, perform the roles of experts, horizon scanning, early warning and stimulating innovation.

# RECOMMENDATION 1:

## SYSTEMS THINKING

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### THE CHALLENGE: SCOPING THE KNOWNS AND THE UNKNOWN THROUGH SYSTEMS THINKING

The challenges of meeting sustainable food and nutrition security, in the face of adverse environmental change, are considerable (see Part 1). The time is also limited: given the drivers of demand growth, global ill-health from poor diets, and the impact of agriculture and fisheries' intensification and extensification on the environment, action is needed now to enable a response-at-scale over the coming decades.

Innovations<sup>86</sup> driven from mono-disciplinary or mono-sectoral perspectives may compound, rather than reduce, the challenges. For example, in the past, the use of salt or sugar to increase shelf-life and taste has helped the development of the food system, but, it turns out, to have substantial negative health consequences. Focussing on single attributes or targets, for example yield or disease resistance, can lead to systems, practices or products with lower quality and which may be associated with environmental damage such as nutrient surpluses and damage to water quality and biodiversity. Many potential solutions aimed simply at increasing production have the potential to impact negatively on other parts

of the system via trade-offs. In addition, many parts of the systems are potentially more strongly connected in a sustainable bioeconomy than has been recognised in the past, and this provides scope for positive interventions. Understanding the trade-offs between different interventions and their systemic impact is a first step to identify points of leverage for change. Sectoral approaches therefore must be set within an interdisciplinary understanding.

*In-depth analysis of the whole food system is needed to identify the "leverage points" that will create the synergies and maximum positive impact on the challenges requires.* Such systems research remains a relatively new way of doing research and needs greater support. Any leverage points identified as areas where innovation may result in change will also require funding, so investments in different areas of research need to be tensioned against each other. Promoting inter- and trans-disciplinary research (Recommendation 3) is not to argue mono-disciplinary research is not needed. Following identification of a leverage point, relevant innovations may well sit within single disciplines, and of course, "discovery science" is always needed to build the foundations of knowledge. Nonetheless it is suggested that strategic research is most likely to provide impact when it is set within an interdisciplinary framing.

Greater systems' thinking requires interdisciplinary<sup>87</sup> – and inter-sectoral – expertise, and often analysis that transcends academia and involves stakeholders in society or industry (this is trans-disciplinary research and is addressed more directly in Recommendation 3). It also requires

incentivisation to reduce disciplinary, sectoral and geographic boundaries. This can come about through promoting greater research at a systems level (e.g. within Horizon 2020 and the Joint Programming Initiatives), rewarding “discipline hopping”, promoting more inter-disciplinary degrees and training and so on. However, this will require both a change in the level of encouragement of more systems research and a broadening of the approach.

A greater “pull” to developing a broadly based systems research culture can come from policy communities demanding inter- or trans-disciplinary answers to policy questions<sup>88</sup>. One useful exercise, for example, is undertaking inclusive, cross-sectoral, cross-disciplinary foresight and horizon scanning exercises that scope out collective and integrated views of the future and the potential routes to meet the challenges<sup>89</sup>. Such exercises have the potential to drive changes in thinking if they engage a sufficient range of stakeholders from policy, industry, civil society and academia.

With such inclusive foresighting the challenge space is articulated. When well done, it provides further incentives for action-oriented research. For example, several recent reports have highlighted the systemic risk coming from changing weather patterns. These risks affect production, transport and logistics and the international supply chain. To address how best to manage these risks requires expertise jointly from climate science, agricultural science, sustainability, transport, ocean science, trade, food safety, industry and policy. A foresighting exercise on this topic could identify leverage points, as well as trade-offs<sup>90</sup>, that may reduce the systemic risk in a way that any one discipline may not. Once the leverage points have been identified, targeting research and innovation effort is likely to be more effective.

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## THE RECOMMENDATION: ENHANCE SYSTEMS RESEARCH

- Innovate to create a culture of systems thinking embedded in universities, government and industry. For example by framing disciplinary challenges within inter- or trans-disciplinary thinking. In particular:
  - foster more broadly based systems research through investments in research through programmes, projects and encouragement for interdisciplinary training, and discipline hopping
  - in conjunction with Recommendation 4, develop a funded programme of foresighting/horizon scanning exercises that are systemic and not sectoral to set the challenges jointly across policy, industry and academic communities and across sectors.
  - reflect the leverage points identified by such inclusive foresighting programmes in research funding programmes and, where appropriate via partnership with national and regional funders in the EU and internationally

## RECOMMENDATION 2: DEVELOP DEBATE AND ENGAGEMENT

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### THE CHALLENGE: SET OUT THE ISSUES: INFORM AND EMPOWER ENGAGEMENT AND ACTION

A more widespread understanding of the role of food in nutrition, equity and environmental impact will play a critical and preparatory role for the systemic changes necessary to develop sustainable food and nutrition security.

Policy or industry-led interventions are less resisted when the public, including food-chain actors and stakeholders, is aware of, and engaged with, the policy rationale and of the benefits to be reaped for the public good. Enhancing public awareness and engagement serve to cultivate the conditions for citizens and consumers to make individual changes to their behaviour, stimulating the development of new markets, and create the political space for the full range of government intervention necessary to bring about the scale of change required.

Such engagement can come about through a variety of means. These can vary from in-depth participation of a few citizens in research projects or dialogue, involvement of many in citizen science and interactive

projects to awareness-raising campaigns targeting the population. For formal education, incorporating food systems into the curriculum or developing a greater understanding through other forms of engagement are possible. For example, the European Commission established the European School Fruit Scheme to increase the consumption of fruit and vegetables amongst children, for the dual benefits of improving nutrition and supporting local agriculture. This scheme supports Member State governments to develop national and regional strategies with health and education authorities to provide fresh and processed fruit and vegetables in schools, and to develop accompanying awareness-raising campaigns.<sup>91</sup> Another potential route is to develop EU-wide or for member states to be encouraged to produce national dietary guidelines (NDGs) which integrate nutritional and environmental aspects, and for these to be highlighted for public and industry discussion.

As the researcher community are widely trusted as independent experts, academics play an important role in developing the trust underlying effective communication and dialogue. However, for such communication to be effective, the messages have to be simple and synthetic and highlighting key leverage points for systemic change. This requires developing messages through systems analysis and consensus building (see Recommendations 1 and 4). At the moment, some inertia is created when individual studies, produced by individual academic groups, become noteworthy for highlighting heterodox views leading to significant confusion in citizen's minds



(e.g. as to the benefit of eating X vs Y, or that, for example, a particular way of farming is “better” or “worse” than another). Needless to say, how best to undertake systems analysis to identify and effectively use the levers for change is, in itself, an area of social science research endeavour.

The benefits of improving public engagement will arise from the opportunities it creates for beneficial change. For example, positive public attitudes to changing technologies, pro-healthy diets and behaviour, pro-environmental production and consumption will, in turn, drive the market and open up opportunities for new and innovative goods and services.

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## THE RECOMMENDATION: DEVELOP DEBATE AND ENGAGEMENT IN THE “SUSTAINABLE FOOD CHALLENGE”

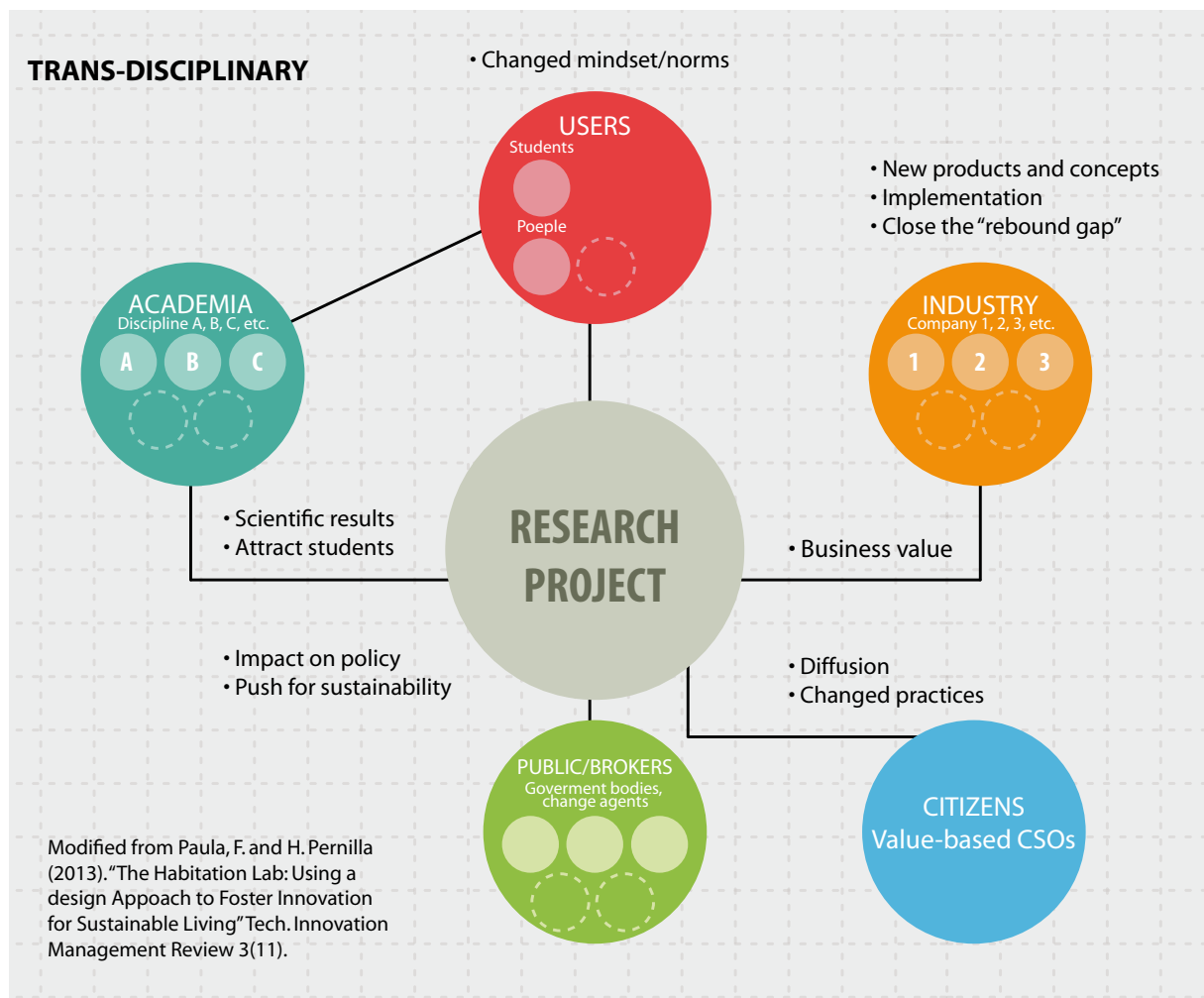
- Using syntheses developed by inter- and trans-disciplinary and systems analysis (Recommendation 1), **create increased societal awareness of, and engagement in, the importance of food for a healthy life and environment**, and the challenges to develop a sustainable food system in the face of climate change. These debates can be engendered via multiple mechanisms to engage both children and adults.
- It is implicit that changing attitudes and behaviour at a population level requires significant research across the spectrum of social and human sciences. Thus, in addition to the need for engagement and dialogue with the public, there is an academic need to understand how behaviour can be changed effectively.

## RECOMMENDATION 3: INNOVATION AND IMPACT

### THE CHALLENGE: CREATE POSITIVE INNOVATIONS QUICKLY

Impacting on the challenges requires innovation in science, policy, regulation, institutions, social attitudes as well as industry. Broadly, for innovation to have an impact, it requires social license (do people want it in the form proposed?) (addressed in Recommendation 2) and a supportive fundamental research base (from natural and, often, social sciences in tandem,

Figure 3



addressed in Recommendation 1); including a sound independent evidence base that an innovation or change is necessary<sup>92</sup>.

Given the urgency of the issues the traditional linear model of the “innovation pipeline” is not fit-for-purpose because fundamental research followed by applied research followed by uptake driving change at scale is inefficient and takes too long. Instead, following the identification of a leverage point for positive change, research aiming to deliver impact or innovation should be undertaken in partnership with stakeholders who would welcome innovation in that space (Figure 3). Such stakeholders can help steer and guide the “upstream science” in such a way as to deliver solutions with speed and utility. This is transdisciplinary research, and has been significantly fostered via EC research and innovation instruments in recent years.

However, given the scale of innovation needs, there is a requirement for (a) more transdisciplinary research<sup>93</sup>, (b) that is built on broader-based systems analysis, and (c) that maintains the perceived independence of the research (see Recommendation 2), as solutions perceived to be for the benefit of industry risk some mistrust that they also provide public benefit. Responsible Research and Innovation (RRI)<sup>94</sup> requires that researchers, citizens, policy makers, business, third sector organisations and so on work together during the research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society (Figure 3). Ensuring public trust requires RRI fully to engage with civil society throughout, and to ensure innovation is not seen only as for the benefit of business.

The EU has developed a range of important instruments for fostering innovation. For example, the recent development of European Innovation Partnerships (EIPs), promises success, in particular, at driving

innovation applicable to industry. However, some of the innovation needs may require institutional, political or social innovation which may impact on economic growth indirectly (e.g. via reducing healthcare or environmental costs) rather than directly by creating new markets for products; and such innovations also need stronger support. Additionally, many of the leverage points may require action targeted outside the EU, and it is therefore crucial that partnerships with stakeholders (and funders) internationally are welcomed.

Fostering an innovation environment requires incentives (for researchers and for some businesses) and also takes time. One way of doing this is to explicitly build indicators of impact into the research design and reward process. Such incentives create a pull to stimulate early engagement in innovation, and can arise from ensuring the transmission of ideas into practice takes a greater part in research projects, and it may justify dedicated innovation funding. It can also come through incentivising engagement in other ways. For example, as for Denmark’s Innovation Fund and France’s ANR, the UK’s Research Excellence Framework<sup>95</sup> judges both academic excellence and academic impact on society and this is significantly changing academic culture towards ensuring research is used more widely. A further incentive is to develop the infrastructure for innovation, which perhaps crucially relies on processing, analysing, sharing and accessing data. Encouraging open access data, whilst investing in the infrastructure to allow its use (repositories as well as bandwidth) is key.

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## THE RECOMMENDATION: DRIVING THE INNOVATION ENVIRONMENT

- Traditionally, innovation arose from applied research and was undertaken by different communities from the “blue-skies” researchers, with little connectivity between them. Although this culture is changing, **stimulating innovation through trans-disciplinary research should remain a high priority for the EC, within a responsible research and innovation framework** (Figure 3). Innovation needs to be defined as broadly creating a positive effect on society, whether through increasing economic growth, improving public health or environment, or any other route. Dedicated innovation funding should remain available, and all research instruments should require the “impact and innovation agenda” to be addressed. The EU should also work with Member States to encourage researchers, whatever their funding, to “make a difference”.
- This, in turn, raises a separate research question about impact attribution. With some innovations (e.g. a new product) the impact of its development can be assessed in terms of sales. With other innovations (social, political, institutional) the impact is much more difficult to assess (for example, attributing the impact of policy on raising people out of hunger<sup>96</sup>). To manage investments in innovation requires better ways to measure their impacts.

# RECOMMENDATION 4: TOWARDS AN INTERNATIONAL PANEL ON FOOD AND NUTRITION SECURITY (IPFN)

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## THE CHALLENGE

Establishing and maintaining the socio-economic, public health, environmental and political conditions that allow food and nutrition security is a high priority of societies and decision makers. Achieving food and nutrition security will not only require strong commitment by policy makers but also solid scientific knowledge and transparent public discourse on instruments, synergies, trade-offs and risks. Even beyond 2030, the stability of the global food system will remain being exposed to environmental and health risks, population pressure, constraints in production, disruptions in trade or conflicts. Moreover, food systems are increasingly embedded in the larger economic and ecological context of the bioeconomy, and food and nutrition systems issues need to be assessed in the sustainability framework of the water, food and energy nexus. Tackling the food and nutrition science agenda is not a project or a study, but calls for a permanent mechanism that draws systematically on the global science capacities in new ways currently not available.

Scientific knowledge is a global public good, provided by a large diversity of individuals, local, national and global research institutions and financed at different scales by governments, donors, private

enterprises or international organizations. An optimal provision of public goods requires coordination<sup>97</sup>, and needs to ask: How much knowledge should be provided? Who provides knowledge? What are research gaps and priorities? The current institutional arrangements for the policy and science interactions are not equipped to comprehensively address the huge task of guiding toward a world without hunger and malnutrition. An approach toward design such policy-science interaction, partly based on established building blocks of international organizations and science networks is proposed here. Some initiatives actually are already moving in this direction. To move the process forward more swiftly and in a less *ad hoc* way needs a high-level initiative.

The framework proposed here for improved policy and science interaction in food and nutrition security builds on the experience of the *Intergovernmental* Panel on Climate Change (IPCC). For a number of reasons it is not proposed simply to copy this institutional arrangement, the suggestion is to aim for an International Panel on Food and Nutrition Security.<sup>98</sup> It should operate efficiently at low administrative and organizational transactions costs. Such an institutional innovation to synthesize and assess knowledge relevant for decision makers would bring about four important advantages compared to the current system. It would:

1. better reflect the **diversity and presence as well as lack of consensus** in international science insights and knowledge from

different disciplines and countries, and may resolve key issues with new research,

2. improve **exchange and coordination** among science disciplines and research efforts at scale as well as between science and policy domain,
3. increase **transparency** in the synthesis and assessment process based on rigorous peer cooperation and peer review, and
4. increase the **legitimacy** of assessments and recommendations to governments and society.

These four advantages are particularly important for areas with high controversies either due to conflicting scientific findings or due to controversial ethical views in assessing and valuing different measures and options to achieve food and nutrition security. The proposed design adheres to best practices related to functional separation between risk assessment and risk management, as followed in the EU.

Besides regular assessments on the state of food security research (on academic advances and deficits – not on description of developments), the strength of such an institutional arrangement would be to deal with controversial and conflict-laden assessments, for instance on nutrition interventions, market stabilization policies, technologies and innovations (potential, risks, regulation), land use change, land ownership (incl. land investments) or multi-level governance structures and responsibilities that often paralyze decision-making. Moreover, an IPFN would be the appropriate entity to assess emerging opportunities such as bioeconomy, and the role of agriculture and food systems in green growth strategies.

The institutional setting would help to improve coordination and alignment:

- within the science domain,
- within the policy domain and
- between the two domains.

Policy-makers need a solid information base for decision making and the science domain can deliver parts of this knowledge. So far, policy-makers are confronted with a huge diversity of uncoordinated voices from scientists, disciplines, academic organizations and science bodies, often articulating without peer review based quality checks when it comes to policy advice. The proposed institutional innovation would help to coordinate the actors in the science domain in order to provide knowledge to policy makers – not with one voice, but within one institutional framework that can be legitimately considered as representing the scientific knowledge. But also the science domain needs the policy domain for identifying research priorities (which are related to societal goals) and the research gaps that lead to high social costs. This agenda and priority setting cannot be done by scientists as they lack the (political) mandate. Currently, scientists are confronted with many political institutions that translate their specific political agenda into research priorities. An institutional framework would help to coordinate supply and demand of knowledge, avoid redundancies of uncoordinated research, clarify societies' demand for specific knowledge and provide transparent assessments of particular issues.

Before outlining options for the way forward, the current state of affairs in science and policy related to food and nutrition security shall be briefly visited.

## SCIENCE SYSTEMS ADDRESSING FOOD AND NUTRITION SECURITY

Science systems related to food and nutrition security are typically embedded within national science systems but increasingly with significant international linkage. There are also some existing international entities. The main building blocks are

- The university systems with food and nutrition security and public health related faculties
- National Academies and international Academy networks in general and with a focus on FN and health
- National food, nutrition, and agriculture related research and synthesis organizations<sup>99</sup>
- Private sector research (mainly in high income countries)
- The Consultative Group on International Agricultural Research Centers (CGIAR) with its programs
- The Global Forum on Agricultural Research (GFAR)
- The High Level Panel of Experts on Food Security and Nutrition (HLPE)
- The professional academic associations related to food and nutrition security, broadly defined (incl. e.g. international Nutrition, Food Science, Crop science, Soil Science, Animal science, Agricultural Economics associations etc.)

All these entities serve important roles in moving the science frontiers in food and nutrition security, and selectively engage with policy, be it on demand by policy bodies or be it by soliciting policy advice. However, they do not come together as organizations to address key policy challenges across disciplines. A particularly important role

is played by the CGIAR in development-related food and nutrition security issues, but the total science resources of the CGIAR cover not more than about 3 per cent of total world science capacities in food security; the recently established Inter Academy Partnership (IAP), a new organization of world academies brings together established global networks of academies of science, medicine and engineering into a collaboration in which academies work together to support the special role of science and its efforts to seek solutions to address the world's most challenging problems, including an initiative on food and nutrition security started in 2015. An IPFN would not duplicate any of these efforts but facilitate new divisions of tasks and efforts, and would help to overcome current duplications, as well as limited scale of science engagement. Overall transactions costs of many partial assessments would be reduced. The above mentioned entities could actually be considered as partners in a foundation process of an independent IPFN.

## POLICY SYSTEM ADDRESSING FOOD AND NUTRITION SECURITY

The policy system for food and nutrition security represents the demand side for science based insight. Food and nutrition security policies are national, regional, and international, with many interactions and externalities among these levels. The SDGs emphasize national responsibilities for action. The roles and structures of the global organizations addressing food, nutrition / health, and agricultural issues have evolved over the past six decades. International civil society and governmental organizations also play increasing roles.

- national governments, mostly with multi-level structures



- civil society organizations
- G7 and G20 initiatives
- World Health Organisation (WHO)
- Food and Agriculture Organization of the United Nations (FAO)
- World Food Programme (WFP)
- International Fund for Agricultural Development (IFAD)
- The Committee on World Food Security (CFS)
- Organisation for Economic Co-Operation and Development (OECD)
- United Nations Children's Fund (UNICEF)
- United Nations Environment Program (UNEP)
- United Nations Framework Convention on Climate Change (UNFCCC)
- Convention on Biological Diversity (CBD), and its mechanisms
- United Nations Convention to Combat Desertification (UNCCD)
- Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO)

All these organizations serve important public goods functions, and all make important contributions. Furthermore, they all draw in one way or the other on specific science communities for advice, but the science advice is thereby segmented and coherence of evidence based science advice cannot be assured, and conflicting evidence is not resolved.

Particularly relevant for policy coordination on food security is the Committee on World Food Security (CFS). In 2009 the Committee

went through a reform process to ensure that the voices of other stakeholders were heard in the global debate on food security and nutrition. The vision of the reformed CFS is to be the most inclusive international and intergovernmental platform for all stakeholders to work together in a coordinated way to ensure food security and nutrition for all. The Committee reports annually to Economic and Social Council of the United Nations (ECOSOC).

International public goods provisioning increasingly occurs also through a complex global web of government networks, where a collection of nation states communicate via heads of states, ministers, parliamentarians and the UN, and where corporations and NGOs participate in various ways. Networks of national governments and even province level governments and of cities, whose officials come together on a regular basis to exchange information, co-ordinate activities, and adopt policies to address common problems at a global scale. They already play key roles in international policy domains such as public health, crime prevention, and energy but not enough in areas of food, and nutrition. Furthermore, civil society organizations at national and international levels are engaged in the policy process and play important roles in shaping policies, such as consumer groups, environmental organizations, farmers' organizations, etc. They also play a role in shaping science policy agendas.

## DRIVERS OF CHANGE

The science- and the political systems related to food and nutrition security are both confronted with significant drivers of change, creating dynamics in knowledge and policy needs. This calls for new and more goal oriented forms of interaction between the two. These drivers include:

1. Demographic transformations with population growth, urbanization, rural aging in many parts of the developing world establish new structures and science challenges.
2. Behavioral change related to food consumption and life styles, partly resulting in the obesity and related health consequences.
3. The transformative roles of food and nutrition sciences, and food systems with new value chains, an increased role of processed food, supermarkets, integrate the food system ever more with the larger international economy in terms of labor markets, energy markets, and services, i.e. finance, and commodity markets and foreign direct investment.
4. The environmental aspects of food production and harvesting and the increased scarcities of natural resources, i.e. water systems, fertile soils and oceans, biodiversity; and the huge risks of climate change, all with science challenges of growing complexities.
5. The protracted food and nutrition insecurity in about 400 million small farm households, which form the world's largest group of the hungry and malnourished, requires social science attention in conjunction with other sciences.

Obviously, these drivers of change are interlinked. Recognizing that science has a significant role to play for international economic development is an important first step toward results oriented science policy for food and nutrition security. Investment in science systems is part of any successful development policy. The science community today must rise to the challenge to connect to the debate on human and sustainable development goals. Some initiatives have been taken recently, such as Sustainable Development Science Network (SDSN), Green Growth Knowledge Platform (GGKN), and the emerging international network on Bioeconomy. Moreover, in the past two decades, information and

communications technologies (ICTs) reduced transactions costs and improved the networking intensity in the international science systems, including with emerging economies. This will also facilitate more virtual approaches toward an international Panel on food and nutrition security, rather than any excessive meeting intensive arrangement.

### **A SCIENCE BASED ASSESSMENT MECHANISM FOR FOOD AND NUTRITION SECURITY: THREE OPTIONS**

The current and future challenges of food and nutrition security require a strong mechanism for science based assessment as a permanent institutional arrangement. An international arrangement tasked with this could be partly inspired by the Intergovernmental Panel on Climate Change (IPCC). While its medium-term focus for the coming two decades should relate to the SDGs to end hunger by 2030, it must have a long-term perspective on food and nutrition related risks and challenges beyond 2030.

An international arrangement that facilitates the peer reviewed assessments on food and nutrition security is needed for delivering evidence based analyses for action with foresight. This function goes far beyond any of the existing science advisory bodies for policy at national or international levels. The whole international science system related to food and nutrition security and food production and harvesting needs to be engaged in inclusive ways for the purpose.

As both, the science system and the policy systems of food and nutrition security sketched above, are complex and multi-layered, any choice of options for design of mechanisms for improved international science – policy interaction need to carefully consider a set of criteria such as

1. Contribution to improve the informed decision making process on food and nutrition security effectively and efficiently, in comparison with business as usual,
2. Political and organizational feasibility of action for implementation on both sides and jointly, the science component and the political / organizational component of an International Panel type mechanism,
3. Costs, including transactions costs, of implementation and of management of mechanisms.

Each of the three options considered below have their plusses and minuses in relation to each of these criteria. Table 1 summarizes

the evaluation of the different options which differ in the degree of coordination within the science bodies and between the academic and political domain. Option 1 represents working just with the current system. Implementation of option 3 would be based on design principles of the IPCC and be embedded in the UN system. Option 2 would imply less political linkages, and could be initiated by the global science community (for instance facilitated by Inter Academy Partnership and CGIAR) with support by the EU. Below, the options are explained in more detail.

**TABLE 1.**  
**ASSESSMENT OF THE DIFFERENT OPTIONS FOR SCIENCE-POLICY INTERACTION**

	POTENTIAL BENEFITS	TRANSACTION COSTS	FEASIBILITY	BEST SUITABLE FOR
<b>Option 1:</b> Working with the current system	Fast and ad-hoc small-scale assessments or reviews possible but limited potential for large-scale issues	No additional up-front costs; Redundancies and gaps due to lack of coordination remain	High (business-as-usual)	Problems of limited disciplinary or regional scope, involving little controversies
<b>Option 2:</b> Establishment of an International Panel on Food and Nutrition Security  (Science in the lead)	Better coordination and academic dispute settling than option 1.  Global mobilization of science for food and nutrition security. New problem solving research is triggered.	Lower coordination costs than option 3 (governments and International Organizations are invited and comment on findings, but no veto possible)	High political feasibility.  Participation of scientists due to ISI listed publications, strengthened networks among scientists.	Issues where decision-making depends on comprehensive science base but not necessarily on consensus
<b>Option 3:</b> Establishment of an Inter-governmental Panel on Food and Nutrition Security  (Governments and international organizations in conjunction with science bodies in the lead)	Increased legitimacy and credibility for controversial issues due to mandate by international community.  Clarity on peer review of existing research (no new research).  Enforced coordination among science and policy.	High transaction costs (time spent by researchers) due to broad participation, transparency rules and formal approval by governments.	Requires strong leadership and commitment of international institutions and governments.  Participation of scientists based on reputation and policy impact.	Problems where consensus is necessary for decision-making (UN system)

### **Option 1: Working with the current system**

- Perspective: Reliance on established and evolving science – policy interactions. Hope that global integration and enhanced science capacities in food and nutrition security in middle income countries may facilitate some gradual improvement of science based actions that may improve international actions.
- Limitations: Demand by policy for evidence based insights and science systems' supply of such insights may remain at a low level, **unless the CFS is evolving further.** International organizations and political bodies may continue to focus on defined subsets of the agendas and potentials for synergies, as well as attention to trans-sectoral nexus issues between nutrition, health, sanitation, food and agriculture will hardly be captured. Lack of legitimacy for evaluating policy options that involve normative judgements.
- Potential contribution to enhance the achievement of the food related SDG effectively and efficiently: limited potential;
- Political and organizational feasibility on both sides, the science component and the political / organizational component of an International Panel type mechanism: not only feasible but likely, as political costs of a no-action option are low in the short term.
- Costs, including transactions costs, of implementation and of management of mechanisms: no cost of implementation; continued high transactions costs of uncoordinated and duplicated science – policy interactions in multiple organizational settings.
- Implementation action: no action needed.

### **Option 2: Establishment of an International Panel on Food and Nutrition Security (Science in the lead)**

- Perspective: Not following the IPCC approach and design. Establishment of a standing mechanism for science and policy related to food and nutrition security to assess the state of scientific evidence on a set of well-defined policy challenges. Strong peer review based assessments. Policy bodies and civil society would be invited to comment on assessments that also reflect controversies (no need for consensus reports). Would bring relevant science communities world-wide together with some focus. Evidence base around controversial food issues would be openly stated, no principle to reach consensus needed, but identification for needed science on controversial issues.
- Limitations: Governments and international organizations would pick and choose as fit their circumstances and priorities. Civil society and media might engage more for identified opportunities and for avoidance of emerging risks related to progress in the SDG on end hunger.
- Potential contribution to enhance the achievement of the food related SDG effectively and efficiently: some potential.
- Political and organizational feasibility on both sides, the science component and the political / organizational component of an International Panel type mechanism: feasible if proper incentive systems would be created for the global science communities related to food and nutrition security to actually participate (reputation, funding). Political costs of the option are low. Private sector and NGOs might support the process if they expect to influence assessment.
- Costs, including transactions costs, of implementation and of management of mechanisms.<sup>100</sup>

- Implementation action: Starting the mechanism on the science side; political side is actively observing. Selected UN Agencies (possibly WHO and FAO) **through the CFS** share observer roles and provide feedback to the science forum's assessments. National Governments are also serving as observers of the assessments and provide feedback.

### **Option 3:**

#### **Establishment of an Intergovernmental Panel on Food and Nutrition Security (Governments and international organizations together with science bodies in the lead)**

- Perspective: Basically following the IPCC design and approach. Establishment of a standing forum for science and policy related to food and nutrition security to assess the state of scientific evidence on a set of well-defined policy challenges. Strong peer selection governs the peer-review based assessments. Formal interaction to conclude assessments with policy bodies. Would bring relevant science and policy communities world-wide together with a clear focus on solutions for food and nutrition security.
- Limitations: taking more time to establish such mechanism and assessment processes are also slower than on informal basis, even after governments and international organizations might agree on it. Because more policy driven in terms of themes, civil society and media would engage much more for identified opportunities and for avoidance of emerging risks related to progress in the SDG on end hunger and improved nutrition.
- Potential contribution to enhance the achievement of the food related SDG effectively and efficiently: significant potential; also potential to overcome controversies that paralyze decision-making.
- Political and organizational feasibility on both sides, the science component and the political / organizational component of an International Panel type mechanism: political feasibility may be constrained by international organizations' turf interests. Political organizations such as G20 with EU could play a catalytic role for initiation (EU experience with JPIs on food security and on nutrition, etc.). Some private sector and NGOs might oppose the process because of formal rules based on scientific principles; other might support the process (depending on their *expectations on the outcome* of the assessments). Scientists willing to contribute if demanded by international community, academic quality is good and report has impact.
- Costs, including transactions costs, of implementation and of management of mechanisms: cost of similar to option 2, plus indirect costs of political coordination (full plenary UN-type meetings, additional coordination requirements within national governments & ministries); rigorous transparency and review rules increase time and burden researchers have to spend for contributing to assessments. Much reduced transactions costs due to less uncoordinated and duplicated science on specified themes.
- Implementation action: Starting the mechanism simultaneously on the science and political side. Positioning with UN Agencies (possibly WHO and /or FAO **and through the CFS**) sharing lead roles could facilitate more global legitimacy on the policy sides, but probably entail a lengthy process. Feedback to the science body's findings are encouraged beyond government by civil society. To enhance knowledge transfer, a first assessment report by IPFN could include climate-change related food and nutrition topics with some former authors / co-chairs of IPCC reports to benefit from their experience.

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## THE RECOMMENDATION: TOWARDS AN INTERNATIONAL PANEL ON FOOD AND NUTRITION SECURITY

The food and nutrition security issues loom large and need action. Science must play a key role to offer global and context specific local solutions. If steps in the direction of improved science – policy interaction are not taken, incoherent and uncoordinated actions for food and nutrition security, often lacking scientific evidence base, will continue to hamper needed progress toward a world to “end hunger, achieve food security and improved nutrition and promote sustainable agriculture”(SDG 2).

The IPCC can serve as a useful role model and reference point, but its strong emphasis on consensus is owed to the global public good characteristic of the climate problem which requires strongly coordinated decision making within the UN system. Food and nutrition, though being a global issue, provides much more scope for local, national and sectoral decision making. The need for a comprehensive science base and an objective science-policy dialogue as well as improved coordination to close research gaps is at the moment more important than to achieve consensus in all areas.

Considering the political and administrative (transactions) costs of the options 2 and 3, an Intergovernmental Panel on Food and Nutrition Security (option 3) is a long term scenario at best. Rather option 2 should be pursued for the time being, and option 3 kept as a future scenario.

Coming to a meaningful implementation of the option 2 will require science policy leadership. Leadership for change could come from the science community. Political and some financial support would be needed by the UN and the G20. The EU is well placed to play the essential catalytic role to further develop the proposed initiative, and by so doing exercise global leadership and and be strongly seen to be addressing the SDGs.

To move the process forward toward option 2 initially may need a high-level, broad based, legitimized time-bound dialogue forum that embraces the whole set of food and nutrition security challenges, and addresses the organizational implications. Following political decisions based on a comprehensive implementation plan, the setup of the system could be done step by step, managed by a small task force supported by a secretariat.

# CONCLUSION

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The Steering Committee of the EU scientific programme for EXPO 2015 has reviewed the challenges associated with the broad topic of food and nutrition security, and presented four recommendations. These recommendations, if accepted, would place Europe at the heart of leading the necessary changes in the food system using the research agenda to provide evidence and drive innovation. The recommendations cover the way knowledge is generated and used for innovation (systems approaches in inter-and trans-disciplinary projects), using the

evidence to engage with the public to help ,motivate social change, and to show global leadership in facilitating the development of an institutional structure to synthesis complex evidence and make it broadly available to drive policy development that is needed to address the SGDs. The potential of the European Union to be at the forefront of change towards a sustainable system that provides food and nutrition security for all is tremendous, and the global need for leadership is likewise considerable.



## STEERING COMMITTEE FOR THE EU SCIENTIFIC PROGRAMME FOR EXPO 2015

**The Steering Committee of the EU scientific programme for Expo 2015** is a joint initiative of the European Commission and the European Parliament and was launched on 21<sup>st</sup> March 2014.

Given the political importance of the Expo theme, this Committee was set up in order to ensure that the European Union takes the opportunity offered by the platform of Expo 2015 “to establish its role as a key player in this global debate [...] and to work towards fruitful collaboration on these matters with other stakeholders, both public and private” (COM(2013) 255 final).

Franz Fischler was nominated as its chair by former Commissioner Maire Geoghegan-Quinn. Its eleven scientific experts have been selected in a broad and comprehensive process by a selection panel, which was nominated by the EU Expo Commis-

sioner General, David Wilkinson in December 2013. The three members of the panel were Pamela Byrne, Pier Sandro Cocconcelli and Harry Kuiper. Based on the agreement between the chair and the EU Expo Commissioner General the committee also includes stakeholder participants from the United Nations, OECD, the private sector and civil society. Subject to the agreement with the chairman the committee can invite external experts to specific meetings whenever necessary.

The secretariat of the steering committee is provided by the EU Expo 2015 Taskforce and based in the Joint Research Centre, the European Commission’s in-house science service. Working in close cooperation with policy Directorates-General the JRC’s mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

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# EXPO 2015: A UNIQUE DISCUSSION PLATFORM

## INTRODUCTION TO THE SCIENTIFIC PROGRAMME

A prime objective of the EU participation in Expo 2015 was to foster global research and policy development through international academic conferences, workshops, exchanges of best practices and joint declarations on actions by stimulating a policy debate among the 148 participating countries and international organisations.

Given the relevance of theme for many EU policies, half of the College including VP Mogherini, Georgieva and Šef ovi visited Expo on various occasions. From the side of the Parliament, 85 MEPs including President Schulz and delegations from five EP Committees (ITRE, AGRI, PECH, DEVE, INTA) visited Expo, as well as the Presidents of the Committee of the Regions (CoR) and European Economic and Social Committee (EESC) with several of their members. More than 200 events took place in the framework of the EU Expo Scientific programme, either in the EU Pavilion, in JRC Ispra, Milan universities and other locations in the city centre organised by a great number of Commission services (JRC, AGRI, MARE, DEVCO, GROW, SANTE, RTD, DGT, ENER, ECHO), the European Parliament, the EESC and the CoR. These reflected the wide EU interest and commitment to the theme of Expo. Among other stakeholders, the EU Pavilion also provided a basis for official delegations of EU Member States which did not have their own pavilion and was also host to external countries and institutional business organisations such as Confindustria, Coldiretti and others for events linked to EU policies, but also cultural events such as the promotion of Aarhus as EU Culture capital in 2017.

The scientific programme started with a conference “Towards an agenda for global food and nutrition security” on 8 May in Milan bringing together key stakeholders from within and outside Europe to discuss in three panels the seven research challenges presented in the discussion document and the documents emphasis on the importance of systems approaches.

Thirty-five events were organised under the special patronage of the EU Scientific Steering Committee for Expo, either because of their particular importance to the Expo theme, or because the Committee felt they added usefully to the event programme. Each of these events was attended by a ‘rapporteur’ (either a Scientific Steering Committee member or a scientist of the JRC) with the objective of gaining new insights to further develop the discussion document. The following section outlines the main matters which emerged from this reporting back along with the public consultation.

## FEEDBACK FROM THE ONLINE CONSULTATION

In order to give interested stakeholders an opportunity to contribute their views on the discussion document – without having to go to Expo - an online consultation on the document took place between April and September. This was launched on 13 April 2015. Participants were asked:

- should Europe play a key role in research and development (R&D), science and technology(S&T) and innovation for global food and nutrition security?
- to rank in order of importance the seven challenges identified by the scientific steering committee as well as highlight additional big research challenges;
- to comment on the need for more cross-cutting trans- and interdisciplinary research; and,
- how global food and nutrition security could be achieved through better mechanisms enhancing research into use.

By the final day of the consultation, 1 September 2015, 306 contributions were received, including 30 qualitative responses. These contributions came from a wide variety of respondents from universities and research institutes mostly across Europe and a few from private individuals.

## BROAD CONSENSUS ON THE NEED FOR TRANS- AND INTERDISCIPLINARY RESEARCH

There was broad consensus on the need for more trans- and interdisciplinary research given the complexity of the global food system, 93% of respondents agreed with this statement. When asked how could this approach to research be organised and supported several respondents cited the following options through inter-disciplinary groups; through establishing an interdisciplinary food authority; and through establishing public private partnerships.

## MEASURES TO TRANSFER RESEARCH INTO USE

The majority of respondents (82%) agreed that global food and nutrition security can be achieved through better mechanisms enhancing research into use. Respondents also highlighted that there is increased public demand for evidence-based policy, this demand should somehow be met. There is a need for some kind of formal linking between policy and science and the answer to this could be modelled for example on the Inter-Governmental Panel on Climate Change (IPCC) model or the Consultative Group on International Agricultural Research (CGIAR). For the majority of respondents the most important routes that can be used to transfer knowledge into use were through education and communication.

## FEEDBACK FROM THE EVENTS

The opening of the scientific debate at the Expo conference on 8 May, focused exclusively on the content of the discussion document, and it received very encouraging reactions. The overall importance of research to achieve global food security was confirmed and participants called for new funding sources for food systems research, a specific EU platform for collaborative/international research in agriculture, other bio-resources and food sciences with open access data, an open place for experimentation and improving agricultural statistics. Also it was stressed that we have to constantly review our mechanisms for defining research priorities and the importance of business-science cooperation to advance food security. Beyond the event on the discussion document, events attended by the rapporteurs have not specifically had food

security research as such as a topic, but covered a broad range of topics related to the Expo theme. It was clear however the cross-cutting issues mentioned in the discussion document had wide support.

## **STIMULATING INTERDISCIPLINARITY**

As outlined in the discussion document, the discussion in various events confirmed that global food and nutrition security is a “meta-challenge” that cannot be tackled by only one discipline but needs to be approached holistically. There were many terms used to convey this message: ‘comprehensive’, ‘holistic’, ‘integrated’, ‘food systems approach’, and even a ‘one-health approach’ (considering human, animal and plant health). But the key was a strong consensus on the need for interdisciplinary research and a systems thinking. Claims for more research on the circular economy or bioeconomy similarly can be considered as confirmation for the need of the ‘big picture’ and to go beyond ‘silo thinking’. This need has been justified by the lack of analytical models and eventually solutions integrating economic and ecological principles in the light of climate change and scarce resources but also considering the non-economic values of agriculture and nature. Another aspect where interdisciplinary approaches might bring benefits is for developing methods to understand consumer behaviours and choices, which needs insights from behavioural sciences, economics, biology, and consumer studies.

## **EDUCATION AND COMMUNICATION**

It was stressed that there is a need to better communicate research outcomes to non-academic audiences as well as amongst the experts. In addition to this, education is important for various target groups in order to achieve food security: First of all better education of consumers will play an important role in influencing their food choices. It can also make them more sensitive towards food waste and help to reduce misconceptions with regards to the environmental impacts and the real price of food (including the environmental costs incurred in food production). But there is also a need for more education of farmers of the land and the sea<sup>101</sup>, both in the developed and the developing world, teaching them about new technologies and there is a need for capacity building in developing countries i.e. in the field of food safety. Last but not least the education system itself has to adapt fostering more integrated research and education on innovation, making the science of food more attractive and develop new offers e.g. for multidisciplinary engineers who can in the future deliver better and more integrated solutions.

## **TRANSFERRING RESEARCH KNOWLEDGE INTO INNOVATION AND PRACTICE**

A third cross-cutting issue that recurred during various events was the aspect of knowledge transfer. There was a broad consensus that there is a need to reduce the time taken to progress from research to the market, and to scale up innovation. In the conference on 8 May it was suggested that there could be a case for a dedicated innovation trust fund in Europe. Apart from this the increased exchange of knowledge and best practises between stakeholders in particular farmers, researchers, educationalists, and consumers was pointed out. Multi-stakeholder approaches are considered important. These should reflect farmers’ needs as well as those of consumers and citizens, but it is often difficult to facilitate this due to lack of the actors competences and resources to engage in research. Also there is a large gap between individual initiatives by front runners and the willingness of many stakeholders in the food sector to engage in innovative steps to improve, for example, their energy efficiency and

overall sustainability. There is also often a lack of knowledge of existing initiatives. Examples that have been given are that conventional farming could learn from the lessons of organic farming with regards to agriculture in Europe and there is the need for knowledge transfer impeding a feasible creation of value chains in Africa with little investment.

### **A NEED TO HIGHLIGHT THE IMPORTANCE OF "INFORMATION AND COMMUNICATIONS TECHNOLOGY" (ICT)**

While many of the events suggested additional examples of research areas to supplement those in the discussion document, there was one new aspect that was highlighted in several events, this is the importance of collecting, processing, analysing, sharing and accessing data (This concern was also flagged in the responses to the online consultation, see Annex II). This could be considered as an additional cross-cutting issue, given that it was mentioned in quite different contexts from nutrition and food consumption, to food safety, microbial diversity, food losses and food production sustainability. Data can also play an important role to better understand, assess and monitor resources, the impacts of agriculture on climate change and to better measure resilience. It stands in close connection with another aspect, which is the role of ICT and the digital revolution that has helped to make more data available sometimes even for (almost) free. There are many more benefits connected to this 'big data' that should be further explored such as utilising high-resolution satellite imagery, drones, robotics, and computer-based advisory tools to enhance precision agriculture, as well as crowd-sourcing to fund innovation.

## ENDNOTES

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[http://ec.europa.eu/agriculture/most-deprived-persons/index\\_en.htm](http://ec.europa.eu/agriculture/most-deprived-persons/index_en.htm)
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- 83 Public understanding and policy options for addressing greenhouse gas emissions from the livestock sector, case examples of Brazil, China, UK and US (in prep) Chatham House
- 84 Donald Rumsfeld famously partitioned knowledge into what we know (“known knowns”) what we know we don’t know (“known unknowns”) and what we don’t yet realise we don’t know (“unknown unknowns”)
- 85 To re-emphasise, the research areas needed are covered in the Discussion Document. Here we are concerned with how the cross-cutting issues of how knowledge is created and used.
- 86 Throughout we use “innovation” to mean new ways of doing things, this includes institutional, political, legislative, social change, as well, of course, as the development of new processes within industry.
- 87 Implicitly, as in the research areas above, we are inclusive across academic disciplines, whether social, natural, biological or environmental sciences.
- 88 E.g. an analysis of the innovation needs of agriculture looks very different if current market trends continue, vs if agriculture was implemented for the purposes of nutrition. If the former situation specifies the research and innovation funding, it will contribute to further systems inertia (“business as usual”), whereas if the latter specifies research needs, it would lead to greater disruptive innovation.
- 89 There exist a range of foresight reports, or research prioritisation exercises, and a joint analysis of them would be useful. Nonetheless, their conclusions crucially depend on the boundaries of the system being examined.
- 90 At a recent discussion on responses to food price spikes there was a productive conversation about whether intensification of land use when food prices were high, through land use conversion, was a useful immediate strategy to mitigate food shocks. This discussion was sparked by one economist saying “I’ll take future climate change over a current recession”. The interdisciplinary debate was very fruitful, especially in terms of highlighting the assumptions made by different disciplines, and thereby indicating the underlying knowledge needs.
- 91 European Commission (2012): Report from the Commission to the European Parliament and the Council in accordance with Article 184(5) of Council Regulation (EC) No 1234/2007 on the implementation of the European School Fruit Scheme
- 92 This is important as an innovation (in terms of novel food, or a proposed change in consumption patterns) is often justified in response to a wider agenda on food prices, global food security or environmental sustainability.
- 93 This is clearly not a recommendation for all research to fit in the mould; rather research specifically aiming at developing innovations addressing strategic challenges. There is also a need to assess the success of such investments.
- 94 <https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation>
- 95 <http://www.ref.ac.uk/>
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- 97 Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press.
- 98 A more detailed analysis of IPCC as a benchmark for IPFN is provided in a study by von Braun and Kalkuhl (2015) International Science and Policy Interaction for Improved Food and Nutrition Security: toward an International Panel on Food and Nutrition (IPFN). Working Paper, Center for Development Research (ZEF), Bonn
- 99 For example, the UK’s Global Food Security programme coordinates between public bodies with an interest in food to develop and prioritise the research agenda and deliver knowledge for use.
- 100 Direct costs for meetings of the plenary, bureau, expert panels (\$1.5-\$2.0 mln.) and for secretariat (\$2.1 mln) plus indirect costs for working time of authors and reviewers plus additional implementation costs for specific objectives; reduced transactions costs due to less uncoordinated and duplicated science on specified themes. Costs based on budget positions in the budget and expenditure arrangements of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES/3/10 [http://ipbes.net/images/documents/plenary/third/working/3\\_10/IPBES\\_3\\_10\\_EN.pdf](http://ipbes.net/images/documents/plenary/third/working/3_10/IPBES_3_10_EN.pdf)).
- 100 Agriculture, fisheries and aquaculture



Research and innovation are the most effective tools to increase global food and nutrition security. The European Union has therefore highlighted in its participation at Expo 2015 that new knowledge is central to address the pressures on the global food system and to feed a growing and more animal protein demanding population without exhausting our limited natural resources.

An independent Scientific Steering Committee was invited to follow the EU's scientific programme on Expo 2015 and to develop a European Research and Innovation agenda for Global Food and Nutrition security including clear and straightforward recommendations for European policy makers. This final document will contribute to the legacy of Expo 2015 by fostering international research and development and by presenting recommendations on how to accelerate the efforts to achieve sustainable global food and nutrition security.