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Research priorities for sustainable agri-food systems and life cycle assessment

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ABSTRACT

Recognizing that research for sustainable agri-food systems will be essential to meet global and European challenges in the coming decades, European countries participate in two Joint Programming Initiatives (JPIs): Agriculture, Food Security and Climate Change (FACCE) and Healthy Diet for Healthy Life (HDHL). Mission oriented research agendas have been developed and are focused on delivering key outputs. For FACCE these are: i) to sustainably intensify European agriculture, ii) to operate agriculture within greenhouse gas, energy, biodiversity and contaminant limits and iii) to build resilience to climatic change in agricultural and food systems. HDHL focuses on: i) determinants of diet and physical activity, ii) developing healthy, high-quality, safe and sustainable foods, iii) diet-related chronic diseases. The role of life cycle assessment (LCA) in the context of these research priorities is discussed. Bridging nature capital, on the one hand, and health issues, on the other, with the assessment of the life cycle may lead to breakthroughs in the sustainability assessment of food systems.

1. Introduction

Today's agriculture and the food systems that it underpins are at crossroads. Food security – the availability of and access to sufficient and healthy foods and good nutrition – is central for the well being of people and nations. Until recently, it was expected that, despite climate change and an increasing world population, there would be several decades with food surplus – and low prices – ahead (IPCC, 2007). Contrary to this expectation, the volatility of world food prices has increased and two out of the last three years have been characterised by large spikes in international grain prices with some grains more than doubling in cost (Von Braun, 2008).

1.1. Agriculture, food security and climate change

A key challenge is to increase the global food supply to accommodate a world growing to 9 billion or more people by 2050 while preserving a safe operating space for humanity by avoiding dangerous environmental change (Rockström et al., 2009). Climate change is already negatively impacting food production (Lobell et al., 2011; Coumou and Rahmstorf, 2012), while the agriculture, land use and forestry sectors contribute almost one third of total greenhouse gas emissions and have a high potential for mitigation (IPCC, 2007). Yet, the Earth still provides enough. While a billion people go hungry, half a billion are obese. The global calories deficit reaches only a few percents of global supply by agriculture and could be compensated by reducing food over-consumption. Moreover, 40% of the grains are used to feed livestock and an additional 6.5% for biofuels. Furthermore, 40% of the totality of global food products is either lost after harvest or wasted (Beddington et al., 2012).

A number of recent studies (Beddington et al., 2012; Paillard et al., 2011; IPCC, 2007) have indicated the need for increasing research efforts in the area of agriculture, food security and climate change. International research programs (e.g. the CGIAR research programme on Climate Change, Agriculture and Food Security, CCAFS) have been initiated to address this for the developing world. A Global Research Alliance on agricultural greenhouse gases has also been launched (Shafer et al., 2011). The Joint Programming of research Initiative on Agriculture, Food Security and Climate Change (FACCE JPI) has been working over the past two years to define the critical research elements of a European response to food security under climate change.

Agriculture is a significant contributor to land degradation and anthropogenic global greenhouse gas emissions, being responsible for 25% of carbon (largely from deforestation), 50% of methane, and more than 75% of N_2O emitted annually by human activities (Tubiello et al., 2007). An estimated one third of the world's cropland is losing topsoil faster than new soil is forming and many of the poor live on degraded land (Nkonya et al., 2011). Agricultural expansion in the tropics is mainly based on deforestation, since 80%

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of new tropical croplands are replacing forests (Foley et al., 2011), which affects biodiversity and key ecosystem services. Species-rich regions of the world are under pressure from agriculture conversion, putting at risk animal and plant species, including hundreds of medicinal plants that are the basis for global health care (TEEB, 2009). Land use change resulting from expansion of agricultural land significantly contributes to CO_2 emission (IPCC, 2007). Unprecedented water shortages are also increasingly apparent in many parts of the world, including southern Europe (Fereres et al., 2011) and an increased frequency of heat waves and precipitation extremes has caused widespread agricultural production losses in the last decade (Coumou and Rahmstorf, 2012).

In many European countries, the growth trends of the yields of major crops, especially wheat, have declined over the past two decades (Olesen et al., 2011). Moreover, the variability of crop yields has increased as a consequence of extreme climatic events, such as the summer heat of 2003 which led to 36 billion Euros economic losses for the agriculture sector in the EU (IPCC, 2007) and to large carbon losses from ecosystems (Ciais et al., 2005); the summer drought and heat in 2010 destroying vast areas of crop stands in Russia, and the 2011 spring drought in France. Future climate change impacts on the European agricultural ecosystems are likely to lead to increases in yield and expansion of climatically suitable areas in northern Europe, and more frequent water shortages and extreme weather events (heat, drought, storms) in southern Europe (Bindi and Olesen, 2011).

1.2. Diets and health

The food system in its entirety (including pre-chain inputs, agricultural production, food processing and retailing) is by far the largest industrial sector in Europe (Eurostat, 2008). European governments are struggling with the growing social and economic consequences of the alarming increase in obesity and diet related diseases, including malnutrition (Stratton, 2007) and micronutrient deficiencies and diet-related chronic diseases. Increased affluence and urbanisation tend to reduce daily physical activity and ready-to-eat foods with high energy densities tend to replace the traditional diets. In 2008, across the 27 countries of the European Union, 59% of adult men and 48% of adult women were either overweight or obese. There is growing evidence that obesity continues throughout the life cycle with associated health-related problems, such as type 2 diabetes, cardiovascular diseases, hypertension, and a range of cancers. Such lifestyle-related diseases have a negative impact on life expectancy, reduce the quality of life and lead to increased health costs (HDHL JPI, 2012).

2. Priorities in research

Recognizing that research will be essential to meet global and European challenges in the coming decades, European countries participate in Joint Programming Initiatives (JPIs). The mission of a JPI is to achieve, support and promote integration, alignment and joint implementation of national resources under a common research and innovation strategy for facing key societal challenges. Two JPIs are concerned with agri-food systems: Agriculture, Food Security and Climate Change (FACCE) and Healthy Diet for Healthy Life (HDHL). Both JPIs are developing strategic research agendas in consultation with stakeholders. A new European Era-Net, Susfood, on Sustainable Food Production and Consumption has also been launched. Its strategic goal is to maximize the contribution of research to the development of more sustainable food systems from farm to fork.

2.1. Agriculture, food security and climate change (FACCE JPI)

Twenty-one European countries contribute to the Agriculture, Food Security and Climate Change (FACCE) JPI (Soussana et al., 2012) and develop a common research and innovation strategy for facing the challenges at the intersection of agriculture, food security and climate change.

An integrated scientific research agenda has been designed and is focused on delivering key outputs: i) to sustainably intensify European agriculture to avoid increasing the demand on food production in other (e.g. developing) world regions, ii) to operate agriculture within greenhouse gas, energy, biodiversity and contaminant limits and iii) to build resilience to climatic change in agricultural and food systems. Crop and animal production systems of increased productivity with reduced environmental footprint per unit product should be developed. This will require accurate benchmarking (genotype $\times$ environment $\times$ management) of the main drivers, including socio-economics, of current agro-ecosystems, and the design, experimentation, and modelling of alternative systems. To substantiate this, a Scientific Research Agenda (FACCE – JPI, 2011) has been agreed, including five evidence based interdisciplinary core research themes, which will yield high returns with the prospect to reinforce the contribution of Europe to global public goods.

1. Sustainable food security under climate change, based on an integrated food systems perspective: modelling, benchmarking and policy research,
2. Environmentally sustainable growth and intensification of agricultural systems under current and future resource availability,
3. Assessing and reducing trade-offs between food production, biodiversity and ecosystem services,
4. Adaptation to climate change throughout the whole food chain, including market repercussions,
5. Greenhouse gas mitigation: N_2O and CH_4 mitigation in the agriculture and forestry sector, soil carbon sequestration, fossil fuel substitution and mitigating GHG emissions induced by indirect land use change.

To reach these goals a systemic understanding should be gained, by developing and integrating a large range of disciplines that must be strongly connected to a foundation of agro-ecological and socio-economic modelling. Key European infrastructures need to be assembled and developed in order to integrate scenarios, observations, experiments and models, develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties. This should result in possible pathways for innovative developments of European food systems and of a bioeconomy with a decadal time frame reaching 2030 or 2050. For instance, given the generation times involved in breeding major food crops, to have adapted commercial lines for 2030 will require at least 15 years of development.

The development of this research will require increased training and capacity building in a number of disciplines which have been neglected over the past decades (e.g. agronomy and animal husbandry, farming systems) and that need to move toward more integrated systems approaches, by better integrating developments from a range of other disciplines such as ecology, earth sciences, social sciences, applied mathematics and computing. A pilot action has been launched by the FACCE JPI concerning the modelling of climate change risks in the form of a large collaborative network (see www.macsur.eu).