FACCEJPI

Agriculture, Food Security and Climate Change



# FACCE JPI
# Strategic Research Agenda

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## FACCE-JPI Strategic Research Agenda (www.faccejpi.com)

The FACCE-JPI Secretariat would like to thank the people who have contributed to this document and in particular, the members of the FACCE-JPI Governing Board (GB), Scientific Advisory Board (SAB) and Stakeholder Advisory Board (StAB). We also thank the experts who attended the Scientific Advisory Board meetings, ERA-NET representatives and participants of the strategic workshops, mapping meetings and other FACCE-JPI activities. Finally, we thank all the Coordination and Support Action partners – past and present – who have contributed to the progress of FACCE-JPI.

The basis of the document is the Scientific Research Agenda, elaborated by the SAB in 2010 and adopted in February, 2011. The first version of the Strategic Research Agenda was adopted by the Governing Board in October 2012. Given the evolving nature of the Strategic Research Agenda, it was refreshed in 2015 following mapping meetings (2011-2013), various workshops and a detailed analysis of all the core themes by the SAB. Research priorities have been revised following input from the SAB, StAB and GB.

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**Core theme 5:**

# Foreword

Photo:Luke / Janne Lehtinen

The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) began in 2010 with the goal of providing coherence in research programming across Europe to meet the societal challenge of jointly ensuring food security, adaptation to climate change impacts and mitigation of greenhouse gases emissions (sometimes also referred to as Climate Smart Agriculture). In light of the changing European and global context, this Strategic Research Agenda (SRA) has been updated.

Europe has to meet this triple challenge for its own agriculture and its own food security, and furthermore has a responsibility, particularly given the quality of its research, to ensure that the global agendas for Sustainable Development Goals and for action on Climate Change have the means to be implemented.

The European Union has already taken a number of steps in recent years to promote sustainable development and reduce its emissions of greenhouse gases. In this context, the European Council launched FACCE-JPI in October 2010. This initiative brings together 21 Member States and Associated Countries. It is guided by two main priorities:

• To foster collaboration among national research actors to work toward alignment of research programming. Let's be clear: the challenges of food security, climate change, and depletion of resources are so important that they cannot be addressed at the national level alone. Even if the work in different countries gives rise to numerous advances, it is imperative to establish a genuine European coordination around a common vision and shared objectives and instruments.

• To develop innovation at the service of society. Marked by strong transdisciplinarity, the work carried out in this initiative involves stakeholders so as to be able to also address economic and social issues, without being limited to the purely scientific ones.

The FACCE-JPI permanent governance was adopted in February 2012 and aims to ensure its durability and to maintain the flexibility and the possibility to adapt to changes in the speed of the joint programming process. The Governing Board (GB) develops strategic goals of the JPI with advice from the Scientific Advisory Board (SAB). Civil society (NGOs and consumers), farmer organisations, industries, European Technology Platforms and administration, and European and International programmes/initiatives are represented by a Stakeholder Advisory Board (StAB) allowing them to participate in the development of the JPI. For the general public, the FACCE-JPI website provides useful information on the progress of this initiative.

The existing Strategic Research Agenda has been updated to incorporate new knowledge and emerging European and global issues and to take into account the international agendas on Sustainable Development Goals and Climate (see below), reflecting FACCE's willingness to be a player in this new period. Similar to the first version, the updated SRA structures the current and future actions around five major interdisciplinary scientific themes. These 5 Core research Themes were endorsed by the Governing Board in 2010. This refresh therefore ensures the SRA's coherence and consistency with current research areas. Although the research priorities within them have been updated, the 5 Core Themes remain the focus of the Strategic Research Agenda, namely:

- Sustainable food security under climate change,
- Environmentally sustainable intensification of agricultural systems,
- Developing synergies and reducing trade-offs between food supply, biodiversity and ecosystem services,
- Adaptation to climate change,
- Mitigation of climate change.

In five years, FACCE-JPI has already resulted in several concrete achievements, which are outlined later in the document. Whether on adaptation to climate change, water use, crop management or the protection of biodiversity, FACCE-JPI identifies innovative solutions applicable at the European scale down to the local level. The FACCE-JPI Knowledge Hub MACSUR is an important example of an innovative means of aligning national research around the theme of modelling climate change impact on European agriculture (see page 15).

Our joint programming initiative aims to provide expertise and tools for decision support in the areas of agriculture, food security and climate change to European policies and initiatives such as the Common Agricultural Policy, the European Innovation Partnership on Agricultural Productivity and Sustainability, the Bioeconomy strategy and the emerging strategies on Food and Nutrition Security and on Agricultural Research and Innovation, as well as on the European Climate and Energy policy. Solutions, methods and tools developed in and for Europe are also relevant at a global scale: for instance metrics of greenhouse gases reduction in the land use sector, or social and technical innovations jointly enabling mitigation and adaptation, that, even if specific to the European context, constitute a contribution to innovation and transformation pathways in other contexts. In addition, FACCE-JPI aims to: stimulate national research agendas; align research programmes; foster European and global collaborations between researchers, funders and policy makers; stimulate knowledge transfer, education and training; and catalyse the delivery of strategic

[1] The role of research in Global Food and Nutrition Security – Discussion Paper'. Expo 2015 EU Scientific Steering Committee: http://europa.eu/expo2015/sites/default/files/files/FINAL_Expo-Discussion-paper_lowQ(1).pdf

[2] Towards a long-term strategy for European agricultural research and innovation by 2020 and beyond – Background paper'. Expo 2015: http://ec.europa.eu/newsroom/horizon2020/document.cfm?action=display&doc_id=9741

[3] United Nations: The 2030 Agenda for Sustainable Development

[4] SDG n°2 is defined as "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture"

plans. It is intended that this integrative approach will facilitate broad policy support and facilitate more integrated research approaches to tackle the inter-related challenges of FACCE-JPI.

A new period for our societies in Europe and worldwide began in 2015. A new Sustainable Development Agenda was launched with 17 Sustainable Development Goals (SDGs) following the Millennium Development Goals (MDGs – 2000 to 2015). One of the aims of this new agenda is both to be more efficient in attaining food security for all (therefore learning from limitations and inadequacies of past actions in this field ) and to better integrate the social and ecological dimensions of sustainability (inequalities, biodiversity degradation and greenhouse gases emissions as well as the impacts of future climate changes). This new agenda is universal, a compelling project for all countries to transform our societies and economies to reach all 17 SDGs proposed in the Sustainable Development Agenda.

A new period for international cooperation on climate change also began in 2015. All governments are expected to develop policies to combat climate change and limit future climate risks and to account for them in an international framework. Within this framework, learning processes and international cooperation should increase the individual national ambitions of these policies. The capacity of our societies to produce and access food under a changing climate, and the necessity to mitigate climate change in order to avoid disruptive change, were already stated as central in the initial text of the UN Framework Convention on Climate Change (UNFCCC). The 21st conference of the parties to UNFCCC (COP21), gathered in Paris in December 2015, with the intention of setting the foundation of a new universal regime, with mitigation and adaptation on an equal footing. This endeavour is strongly supported by FACCE-JPI, as such a framework is necessary to re-build cooperation and coordination between all countries on ambitious climate policies. However, the ambition of current policies, as exemplified in the INDCs (Intended, Nationally Determined Contributions, stating the contribution of each country to address climate change), published before COP21, is insufficient to reach the objective of maintaining global temperature increase well below +2 °C and to pursue efforts to limit the temperature increase to 1.5 °C compared to pre-industrial levels. The Paris Agreement recognised the fundamental priority of safeguarding food security, and the specific vulnerability of food production to the adverse impacts of climate change: food security and agriculture issues are likely to have an increasing role in national and international climate agendas although different countries vary in their approach (adaptation / mitigation) to these problems.

These international agendas and their corresponding national policy objectives will remain mere declarations if the means for their implementation are not explicitly and actively developed. Research and innovation will play a critical role at different stages of the process where experimentation and collective learning are fundamental: setting national or global objectives; designing policy options and solutions for different stakeholders at different scales; monitoring and evaluating the effectiveness and the performance of these solutions and policies; questioning the framing of problems and solutions in order to design better policies. As the international scientific conference "Our common future under climate change" (July 2015) illustrated, many research communities are already involved in such new agendas, centred on solutions and their implementation. There is a variety of roles for research in such agendas, including but not restricted to the co-construction of solutions with stakeholders.

While these agendas set the policy context for the period 2015-2030, each of them already implies urgent action. Food security is already one of our greatest societal challenges. Although our planet produces enough food for all its inhabitants, its distribution is unbalanced. Nearly 800 million people are chronically undernourished, while another 500 million are obese. Meanwhile, climate change is already affecting agriculture and natural resources are dwindling. Even if the ambition of action is increased after COP21, there remains the prospect of further climate change, biodiversity degradation, and the increasing pressures on natural resources due to a the global population projected to rise beyond 9 billion people by 2050 and increasing incomes leading to changing diets. This prospect highlights why these international agendas need to emphasise both short and long term actions to ensure global food security while respecting the imperatives of sustainable development.

We would like to express our sincere thanks to all who have contributed to this progress, in particular the Secretariat, and we look forward to the future development of our initiative that will mark a milestone in the construction of a genuine European Research Area on Agriculture, Food Security and Climate Change.

[5] The UN-FAO World Food Summit 1996 created a definition, which is used in the context of the JPI: 'Food Security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life'.

**Niels Gøtke**
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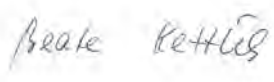
**Margaret Gill**
Chair of the Scientific Advisory Board



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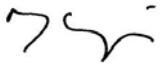

**Marion Guillou**
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# Introduction

Photo: Luke / Janne Lehtinen

## The need for research[6]

Today's agriculture and the food systems that it underpins are at a crossroads (18). Food security – the availability of and access to sufficient and healthy foods and good nutrition at all times – is central for the well-being of people and nations. Until recently, it was expected that despite climate change and increasing world population, there would be several decades with food surplus - and low prices - ahead (11). Nevertheless, food insecurity has increased in the context of the inter-linked food and economic crisis of 2008 and actions taken so far are not sufficient to reduce the chronic food and nutrition security problems, even in the range of halving the number of food insecure people as was aimed for in the MDG agenda for 2015 (19).

A key challenge is to sustainably 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 (16). Climate change is already negatively impacting food production (4, 12), while the agriculture, land use and forestry sectors contribute almost one third of total greenhouse gas emissions and have a high potential for mitigation (11). As Beddington et al. (1) stated - business as usual is not an option – but what are the alternative options?

A number of recent studies (1, 11, and 15) have indicated the need for increasing research efforts in the area of agriculture, food security and climate change. International research programmes (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 (17). The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) has been working over the past five years to define the critical research elements needed for a European response to the challenge of food security under changed conditions of demand, supply and risks. FACCE-JPI seeks to achieve, support and promote integration, alignment and joint implementation of national resources under a common research and innovation strategy to address this large challenge. Cross-border collaboration offers the opportunity for more efficient utilisation of scarce resources and JPIs bring a new dimension to European research through alignment of national activities across participating countries; working together around a common vision and strategic research agenda and pooling limited resources: avoiding duplication, filling gaps and creating critical mass (FACCE-JPI Common Vision, 2012).

## The food security and environment nexus

As illustrated by its inclusion with a high priority in the text of the United Nations Framework Convention on Climate Change, nothing is more important to humanity and the stability of societies than a reliable and affordable supply of food. Agriculture and land use change push against several planetary boundaries including greenhouse gases, biodiversity, nitrogen and phosphorus pollution and water availability (10, 16). An estimated one third of the world's cropland is losing topsoil faster than new soil is forming and many of the world's poor live on degraded land (13). Land use change resulting from expansion of agricultural land significantly contributes to $CO_2$ emission (11). Unprecedented water shortages are also increasingly apparent in many parts of the world, including southern Europe (9) and an increased frequency of temperature and precipitation extremes has caused widespread agricultural production losses in the last decade (4). Across the 17 Sustainable Development Goals, the pressure on land, water and ecosystems (through the production of biomass to jointly achieve food security, energy access and climate change mitigation) could be unsustainable in both Northern and Southern countries. Therefore, a transversal analytical capacity to evaluate trade-offs between development goals is necessary (20). In many European countries, the growth trends of the yields of major crops, especially wheat, have declined over the past two decades (14). 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 (11) and to large carbon losses from ecosystems (3), 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 European agricultural ecosystems are likely to contrast 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 (2).

## The role of Europe

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 (8). Europe is seeking to put in place an innovative bioeconomy in support of a "green growth" strategy that would combine economic growth, natural resource preservation, greenhouse gas reduction, and highly efficient resource utilisation in well-integrated value chains (7).

Europe has been one of the first regions in the world to develop climate policies, particularly tackling the energy sector. However, the agricultural sector has for the moment not been targeted directly by EU mitigation policies such as the EU Emission Trading Scheme. This is due not only to the economic vulnerability and the political sensitivity of the sector, but also to the technical difficulties in addressing very scattered emission sources and the complexity of soil carbon

[6] See reference 18
[7] http://www.faccejpi.com/Document-library/Vision-papers

storage. Nevertheless, not only does the European Union's own production result in significant emissions, but as a net importer of primary agricultural products, it causes significant emissions elsewhere (5). However, judicious use of the European land resources supported by agricultural sciences could adapt production to climate change and lower emissions domestically and internationally. Europe is well placed to address these issues since it recognises the significance of global climate change. Europe could therefore provide a space for change, testing an implementation of novel strategic concepts based on new bio-physical and socio-economic research (see also reference 18). Europe's contribution can therefore be fundamental to illustrate, inspire or influence transformations of food systems in other regions of the world. It would therefore be a critical contribution to the solutions agenda to implement the SDGs and increase the ambitions of governments in the framework decided at COP21 in Paris.

Moreover, there are significant national R&D investments in Europe in the different areas of the JPI. A report by the Joint Research Centre[8] of the European Commission indicated that in 2009, the total estimated public national R&D investment of all EU Member States on agriculture, food security and climate change as a whole[9] is around €1,535 million, while the total estimated public national R&D investment of all JPI members (including Associated Countries) amounts to around €1,583 million.

However, and although they pertain to topics of great societal importance, these resources are to a large extent engaged independently from one another, or at least with no European-scale strategy. Such a strategy is the goal which was set for JPIs by the European Commission in July 2008: to pool these national resources to create critical mass and consistent funding for research, align national research programmes, reduce overlaps, fill gaps and list EU-wide relevant priorities.

## FACCE-JPI

The Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI) was among the first JPIs to be launched by the European Council (October 2010). Its foundations were set up in the discussions carried out in SCAR collaborative working groups and brought forward through a Franco-British initiative to establish what FACCE-JPI is today: an initiative bringing together 22 countries[10] that are committed to building an integrated European Research Area addressing the challenges of agriculture, food security and climate change. Through their representatives on the FACCE-JPI Governing Board (GB; see Annex 4.2), these countries have agreed on a common vision to address these major societal challenges[11]. The JPI is providing coordination between the member states in their programming of research to achieve the FACCE-JPI vision (see below).

To achieve this goal, a strong interdisciplinary research base, encompassing economic and social aspects in addition to scientific ones, is required. This implies the need for a creative approach towards aligning national programmes. The interrelated challenges addressed are European and global and require the effort of multiple actors and stakeholders at regional, national and European levels. Input is provided by policy makers, the scientific community as well as stakeholders. The latter provides the JPI with advice through their representatives in the FACCE-JPI Stakeholder Advisory Board (StAB; see Annex 4.4).

To respond to the interconnected challenges of sustainable agriculture, food security and impacts of climate change, the Strategic Research Agenda includes five evidence-based interdisciplinary Core research Themes proposed by the Scientific Advisory Board (SAB; Annex 4.3):

1 • Sustainable food security under climate change.

2 • Environmentally sustainable intensification of agricultural systems.

3 • Developing synergies and reducing trade-offs between food supply, biodiversity and ecosystem services.

4 • Adaptation to climate change.

5 • Mitigation of climate change.

Core Theme 1 is the overarching theme, with Core Themes 2 to 5 addressing specific aspects as shown in Figure 1. Additionally, there are strong links between themes, in particular between Core Themes 2 & 3 and Core Themes 4 & 5.

This Strategic Research Agenda has been designed to set out clear policy-relevant research priorities on agriculture, food security and climate change in Europe, and to list the strategic actions involved to achieve these goals and align current and future national research programmes.

**FACCE-JPI VISION:** An integrated European Research Area addressing the challenges of Agriculture, Food Security and Climate Change to achieve sustainable growth in agricultural production to meet increasing world food demand and contributing to sustainable economic growth and a European bio-based economy while maintaining and restoring ecosystem services under current and future climate change.

**FACCE-JPI MISSION**: to achieve, support and promote integration, alignment and joint implementation of national resources in Europe under a common research strategy to address the diverse challenges in agriculture, food security and climate change.

[8] K. Haegeman, Agriculture, food security and climate change-Public national R&D investment, research programmes and transnational collaboration in Europe, JRC-IPTS, version 02-09-2010.

[9] It is important to recognise that there is fairly large uncertainty in these numbers, and the authors analysed the three areas of the JPI, and not the points of intersection which are treated by FACCE-JPI

[10] Austria, Belgium, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Italy, The Netherlands, Norway, Poland, Romania, Spain, Sweden, Switzerland, Turkey and UK; New Zealand is an Associate Member from 2016; see also Annex 4

[11] http://www.faccejpi.com/Document-library/Vision-paper

## Trans-thematic areas: Clusters

The aim of the clusters is to provide an integrative approach to identifying research priorities and correspond to the three target scales at which FACCE outputs can be delivered, i.e. farming systems, landscape and value chains. These clusters (Figure 1) are:

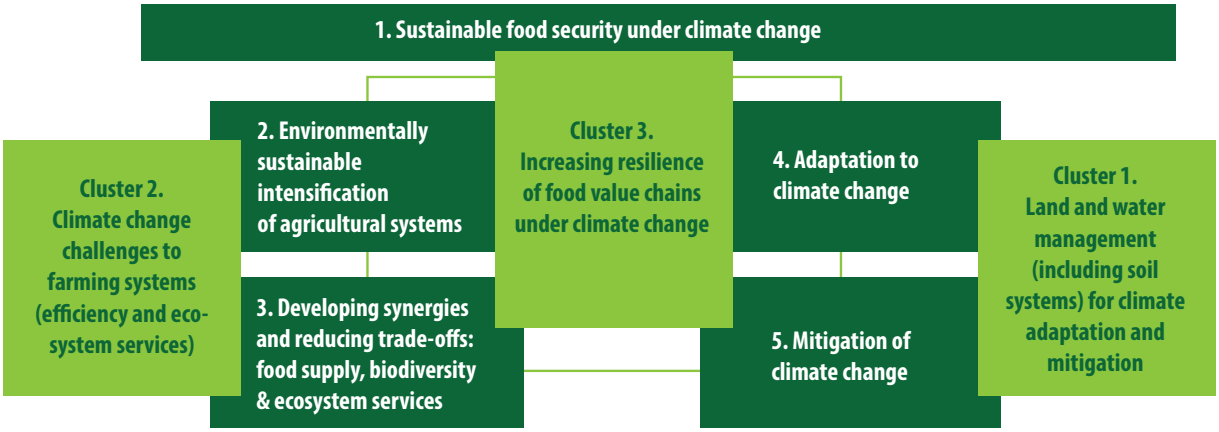
1. Land and water management (including soil systems) for climate adaptation and mitigation. Land, soil and water resources are key to achieving the various objectives included in the sustainable development agenda, but the importance of the different cumulated needs (food, energy, water, but also reduction of greenhouse gas emissions, and other ecosystem services) might be at risk if water and land resources are not managed carefully, trade-offs analysed, and governance institutions put in place (20).This cluster links Core Themes 4 and 5, with relevance to Core Theme 3. It pays special attention to soil and water quality, multidisciplinary approaches and efficient management, taking into account the different biogeographical scenarios in Europe.

2. Climate change challenges to farming systems (efficiency and ecosystem services). Farming systems are evolving under the influence of a variety of drivers, including economic competition, supply chain prescription, technological progress, and also changes in climate and ecosystems. The economic viability of such evolution pathways is a key variable to be assessed, as well as social and ecological sustainability. Implementing the agendas of sustainability defined in 2015 (SDGs, Climate change) cannot be achieved if the capacity of farming systems to create or adopt innovations, and to change, is not carefully addressed. This cluster draws on Core Themes 2 and 3, and includes: a) the multiple functions required of land under climate change and b) increasing the efficiency of agricultural supply chains under climate change. This cluster is production-oriented.

3. Increasing resilience of food value chains under climate change. Drivers of change or barriers to change in agricultural systems are often situated downstream in the food value chain. Achieving food security in a changing context can only be achieved if the determinants of food security all along food value chains are carefully considered. The contribution of food systems to economic development can best be assessed through a value chain analysis. The resilience of well-structured food supply chains is recognised to be critical for the stability of incomes for all stakeholders in the chain, which is particularly important to consider in a sector where recent crises show the importance of urgent short term action to help economic agents overcome the crisis on markets while at the same time preparing long term economic viability and overall sustainability. Core Theme 1 is the core of what FACCE-JPI is trying to achieve, with resilience embedded in each of the core themes. This cluster therefore interfaces with all Core Themes and is presented as consumer/demand-oriented.

It is intended that this integrative approach will facilitate broad policy support and enable more integrated research approaches to tackle the interrelated challenges of FACCE-JPI.

**Figure 1. The 5 Core Themes and the 3 Trans-thematic clusters**



# Achievements
## – Addressing global issues through coordinated national efforts

Photo:Luke / Janne Lehtinen

FACCEJPI

# Strategic Research Agenda

FACCE-JPI seeks to mobilise the research community across Europe to work together to meet the grand societal challenges by:

- Improving the alignment of national and European research programmes,
- Increasing high quality transnational research activities within food security, agriculture and climate change, and
- Improving the societal impact on the challenge of food security, agriculture and climate change.

FACCE-JPI has been working over the past five years to define the critical research elements needed for a European response to the challenges of food security and agriculture in the context of climate change.

## Alignment

FACCE-JPI ensures coordination and alignment of 22 participating countries to co-design a common research agenda. The FACCE-JPI Strategic Research Agenda (SRA) was launched in December 2012. It is an important milestone in the FACCE-JPI history and a crucial document steering future joint activities and ensuring strategic orientation of FACCE-JPI issues.

FACCE's SRA has influenced national and European programming. It has been taken into account in national strategies in different member countries. FACCE-JPI is regarded as an important partner of the European Commission (EC). In addition to aligning with existing ERA-NETs, FACCE-JPI has also proposed new ERA-NETs e.g. FACCE ERA-NET PIus on Climate Smart Agriculture, FACCE SURPLUS (Sustainable and Resilient Agriculture for food and non-food systems) and ERA-GAS (monitoring and mitigation of agricultural and forestry greenhouse gases).

## Research

In five years, FACCE-JPI has already initiated a number of research activities. These have strengthened cross-border collaboration in Europe. Moreover, all joint action projects (now around 50) have been reviewed by international panels of experts to ensure high quality research. Whether on water use, crop management or the protection of biodiversity, FACCE-JPI identifies innovative solutions applicable at a European scale down to the local level. FACCE-JPI takes an interdisciplinary approach to address research priorities whilst embedding the climate agenda in all actions. FACCE-JPI has also facilitated a common understanding and definitions of terminologies relevant to FACCE-JPI.

In FACCE-JPI's actions, it is estimated that, as at December 2015, approximately €120M are mobilised. Several new actions, with an estimated investment of €50M, are under development. FACCE-JPI has secured funding from the European Commission for two successive Coordination and Support Actions to ensure the efficient coordination and networking of projects, programmes and policies.

• FACCE-JPI has helped to increase the visibility of European research on agriculture, food security and climate change at a global level by fostering collaborations beyond Europe and through linkages to international activities, e.g., a joint call with the Belmont Forum and a multipartner call with some members of the Global Research Alliance on Agricultural Greenhouse Gases. FACCE-JPI has also established links at international level with AgMIP (The Agricultural Model Intercomparison and Improvement Project), as is further explained below. FACCE-JPI has also raised the profile of the socio-economic dimension of its Strategic Research Agenda by embedding economic and social aspects into the FACCE-JPI research priorities.

• FACCE-JPI has organised European-wide scientific events including the 'Great Debate on the Battle to Feed a Changing Planet' in July 2012 and a joint FACCE-JPI/HDHL/EC[12] event, the 'Grand Debate on Nutrition Security - a whole system approach' in May 2015 at EXPO Milan. The outcomes of this event served as the FACCE-JPI-HDHL contribution towards a European strategy on Food and Nutrition Security and fed into the EC public consultation on 'The role of research in global food and nutrition security'.

FACCE has initiated a large number of activities and joint actions that are described in each core theme. One example is the pilot action, the Knowledge Hub called MACSUR. Its achievements are highlighted below.

## Societal Impact

Although the delivery of societal impact is a long term process, FACCE actions have been put in place that will contribute to societal impact in the long term. Examples include projects in the multi-partner call on agricultural greenhouse gas research which address measuring and mitigating greenhouse gas emissions from agriculture or projects from the "Climate Smart Agriculture" ERA-NET which address how crops and animals can adapt to climate change.

[12] JPI HDHL: Joint Programming Initiative – A Healthy Diet for a Healthy Life www.healthydietforhealthylife.eu

## MACSUR: Research Informing Policy

MACSUR's foremost charge is improving the methodology for integrative inter-disciplinary modelling of European agriculture. In addition to technical changes, improvements include the involvement of stakeholders for setting research priorities, scenarios (if-then evaluations), and model parameters to more realistic or region-specific values. The Knowledge Hub currently brings together 265 members from 18 countries and has generated 300 scientific papers, over 500 presentations and 20 workshops and conferences. Scientific results are communicated in conferences and workshops, where policymakers take part by invitation or because of professional interest. These events also provide opportunities for direct dialogues between policymakers and scientists. The primary form of output of the research network is scientific publications that are cited in policy documents by relevant administrative departments, ministries, intergovernmental agencies, and directorate-generals, and non-governmental interest groups. MACSUR members also contribute directly to policy documents as authors, e.g. the EEA's indicator report on CC impacts or the IPCC's 5th assessment report's chapter on food security.

Several MACSUR members serve on scientific advisory boards, e.g. on research programming or on sectoral policy development, or meet with national representatives in other roles. MACSUR coordinators and other members are invited to report on progress in MACSUR in national boards and international agencies. Dialogues arise also informally, e.g. during other events but are nonetheless suited to convey condensed information of scientific results to policymakers. In addition, MACSUR and MACSUR members provide input to polls and questionnaires by national and international agencies on topics relevant to MACSUR.

Other forms of communication are specifically targeted to policymakers. Newsletters inform about progress in MACSUR, leaflets provide an overview of results after three years at European and national levels. MACSUR scientists present overviews of results to the FACCE Governing Board. A workshop for decision makers was offered in May 2015 in Brussels to EU and national representatives. In the workshop key research results were presented, leading to a panel discussion about research needs.

Overall, MACSUR as an entity uses several ways to inform policy about scientific results and research needs. In addition, individual scientists in MACSUR interact with policymakers in formal and informal ways to convey condensed information about CC impacts on agriculture to policy.

Photo:Luke / Janne Lehtinen

# FACCE-JPI Strategic Goals

Photo: Jean Weber

The interactions between agriculture, food security and climate change have been envisioned by the SAB highlighting the intersections, which are at the heart of the FACCE-JPI (Figure 2). The complex system formed by each of these components and by their interactions is under multiple pressures from external drivers. These include the rising food, feed, fuel and fibre demand, globalisation and global environmental changes and are moreover constrained by planetary boundaries such as land and water limits. Contributing to the SDGs, which means, inter alia, responding to these growing and interlinked demands in an integrated and sustainable way, necessitates thorough analyses and evaluations of trade-offs, possible mutual benefits and innovations.

To meet these challenges, research undertaken should be mission-oriented, with three complementary and interactive goals:

I. Provide new approaches for the sustainable growth and intensification of agriculture in Europe including transformational adaptation and increase the resilience of food systems to deliver European food security, feed, fuel, fibre as well as other ecosystem services under current and future climate and resource availability;

II. Provide an integrated impact assessment of climate change throughout the whole food chain, including market repercussions and contribute to direct reductions of greenhouse gas (GHG) emissions through carbon sequestration, fossil fuel energy substitution and mitigation of $N_2O$ and $CH_4$ emissions by the agriculture and forestry sectors, while reducing GHG emissions per unit area and per unit product associated with land use change;

III. Contribute to food security through reduction of trade-offs between food production and the preservation of biodiversity, ecosystem functions and services.

## How to meet the Challenges

To reach FACCE-JPI's strategic goals, research should be integrated on a large scale:

• A systemic understanding should be gained, by developing and integrating disciplines from climatology, to ecology, agronomy, forestry and socio-economy, through plant, soil, microbial and animal sciences, strongly connected to a foundation of agro-ecological and socio-economic modelling.

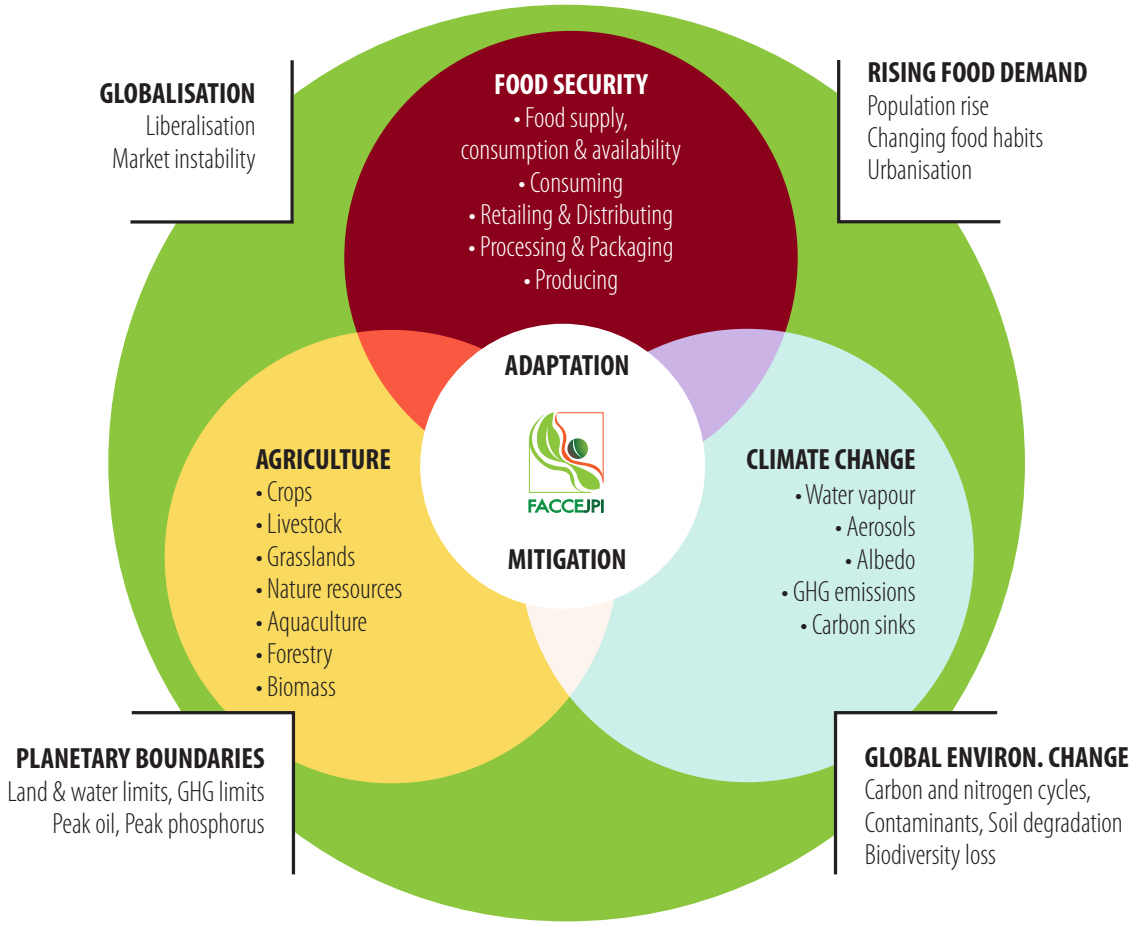
• Key European infrastructures need to be strengthened in order to integrate scenarios, observations, experiments and models and develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties. Because of the need for both urgent action and consideration of long term consequences, projections and scenarios enabling the exploration and assessment of long term transformation pathways are critical for the implementation of the post-2015 agenda.

• Economics of adaptation/mitigation strategies should be analysed so that current food security is improved while taking into account: i) uncertainties in the projections of climate change and impacts, ii) the valuation of ecosystem functions and services and their resilience.

• It is important to identify research priorities to develop synergies and reduce trade-offs between food production, biodiversity and ecosystem services (biodiversity, landscape conservation etc.). Specific solutions should be developed and implemented at the ecosystem and policy levels. Both are very relevant in order to identify possible action to implement the SDGs in an integrated manner, and to assess and compare their performance with regard to these different objectives. These solutions, particularly concerning adaptation to climate change, should be based on detailed analysis and improved understanding of regional impacts of the adaptive options and their feasibility at local and farm levels. Workable adaptation options will be developed in close collaboration with decision-makers and stakeholders involved in the research and development process.

• Breakthrough innovations (technologies and methods) in the areas of crop, livestock, fuel and fibre production, of land, water and genetic resource management and of biodiversity conservation and use have been analysed by the SAB (Table 1). The behavioural, organisational and knowledge innovations needed for effective implementation will also be considered. When mature, these innovations will be considered for integration in production systems and in policy measures.

**Figure 2. A vision of research areas in the FACCE-JPI showing drivers (in white) and highlighting interactions between agriculture, food security and climate change.**



## Focus on data, models and technologies to enable research and development

**Clear breakthroughs in science and innovation are underway but lead to massive amounts of data (e.g. remote sensing, genomics etc.) to large investment needs (e.g. biorefineries), and to large changes in need for capacities (e.g. capacity building for understanding interactions between food security, climate change and agriculture, sustainable intensification).**

**Computer modelling is an important tool in researching the uncertainties around future scenarios of agriculture, food security and climate change. FACCE-JPI has already invested in the knowledge hub MACSUR to bring expertise in this area together from across Europe and to link it to international initiatives. Crop modelling is well advanced, while trade and livestock modelling are at an earlier stage. Robust models depend on the quality of the data and the challenges in data acquisition and analysis are immense. Scientific and technological advances (e.g. genomics) have led to large amounts of data becoming available and hence tools and innovative technologies are required for data collection and analysis. Ensuring the interoperability and accessibility of databases is very important and requires data to be produced using compatible protocols and data standards. In addition, metadata is very important for a common access and usability of primary research data. Metadata is defined as a systematic method for describing data and thereby improving access to them i.e. data that defines and describes other data. [13]**

**Innovative technologies for agriculture, the environment and the bioeconomy underpin progress in research (see Table 1). To address the key challenges of rising food, feed, fuel and materials demand, alongside globalisation, rapid environmental change and societal challenges, the potential role of new and emerging technologies offers considerable opportunities. FACCE-JPI is exploring those opportunities, looking at technologies from the agri-environmental sector as well as technologies from other sectors that could be tested and further developed for the benefit of agriculture and food security in the face of climate change.**

**Funding via different instruments is required to assemble and align technologies, support trans-disciplinary networking activities and the exchange of information at the national and EU level. FACCE-JPI should therefore focus on assembling existing technologies better and improving use of innovations that are mature but not yet widely adopted to study these questions, e.g. remote sensing. The delivery of targeted funding to bring together a combination of technologies and disciplines across Europe in FACCE-JPI's context should be considered and well organised e.g. through technology-oriented calls. In order to achieve maximum impact, technological innovation and alignment need to be embedded in all FACCE-JPI actions, and more broadly in social, organisational and institutional innovation.**

**Several European initiatives, research infrastructures, research organisations and institutes are all key players in developing innovative approaches, applications and tools. FACCE-JPI can therefore add value by collaborating with relevant players.**

**Several technologies have been mapped to core themes and are listed in Table 1. The mapping resulted from in depth discussions of the FACCE-JPI SAB, StAB and external experts with complementary knowledge and perspectives (see Annex 4.3).**

[13] OECD glossary of statistical terms

Photo: Bertrand Nicolas

**Table 1:** A non-exhaustive list of new applications of existing and emerging technologies and new opportunities for agriculture, the environment and the bioeconomy mapped to the five Core Themes of FACCE-JPI

1. Remote sensing (satellites and drones, LIDAR remote sensing) applied to agriculture, precision irrigation and energy efficiency, forestry and the environment (CT2 to CT5)
2. Automation and robotics: precision agriculture (including precision irrigation and energy efficiency) and precision livestock breeding (CT2 mainly)
3. Sensors and networks for high throughput environmental monitoring: greenhouse gas emissions, air quality, water quality, soil quality (CT2, CT4 and CT5)
4. Information and communication technologies (e.g. smartphone application for field diagnosis and geo-localisation of a plant disease) (CT2, CT3 and CT4)
5. Genomic selection and marker assisted selection of plants and animals and of genetic resources, innovative use of gene technology and new techniques like gene editing (CT2, CT4 and CT5)
6. High throughput phenotyping of plants and animals (CT2, CT4 and CT5)
7. Environmental genomics: barcoding of species, new generation sequencing applied to animal and plant health (emerging diseases) (CT3 to CT5)
8. Meta-omics (including metagenomics of soils, rumen etc.), environmental genomics, metabolic profiling (CT3 to CT5)
9. Biocontrol of pests and plant diseases including vaccination, plant defence stimulation, use of auxiliaries, etc. (CT2, CT3, and CT4)
10. Predictive modelling: applied to the management of production (agriculture, forestry etc.) and natural resources, to ecosystem services (CT1 to CT5)
11. Upscaling of biobased raw materials: products of agricultural origin, forest, aquatic, including microalgae, co-products, by-products and wastes from industrial processing of organic materials and from urban organic wastes (CT1 and CT5)
12. Modelling the systemic role of biorefineries in agricultural landscapes, based on a comprehensive valuation of each of the fractions collected from the plant, by-products and wastes and on the recycling, reuse etc. including livestock and aquaculture (CT1 and CT5)
13. Renewable energies (wind, solar, etc.) in farms and in rural landscapes (CT5)

## Underpinning considerations:

The issues outlined below are of importance to a number of core themes and should be considered alongside the text that covers the individual core themes over the following pages:

• **The Bioeconomy (See Annex 3 for a glossary of terms).** The drive to decrease global dependence on fossil fuels is stimulating interest in non-food uses of biomass. The concept of the 'bioeconomy' seeks to incorporate these new opportunities without prejudicing the challenges of food security or the development of strategies to mitigate and adapt to climate change (corresponds to Core Themes 1, 4 and 5). The bioeconomy addresses synergies and complementarities between the different uses of biomass and climate change (Core Themes 2 and 3). The opportunity for FACCE-JPI lies in linking together agriculture and industrial sectors, working at the interface of agricultural sectors, and in taking an integrated systems approach to climate change adaptation and mitigation, fossil-fuel substitution and economic performance. When establishing a bioeconomy, vital aspects such as food security and climate change mitigation need to be considered.

• **Ecosystems and biodiversity.** Climate change affects ecosystems and biodiversity in an interconnected manner. Thus a holistic approach should be taken towards increasing food security while avoiding ecosystem damage and reducing trade-offs. Methods should be developed for assessing and valuing biodiversity and ecosystems services across different agroecosystems (corresponds to Core Themes 3 and 4).

• **Socio-economic factors.** Societal factors underpin every aspect of agriculture and food security and play a critical role in both mitigation and adaptation to climate change. Therefore it is necessary to foster participation and involvement of all stakeholders of society including farmers and consumers for the delivery of societal benefits. It is important to better understand how different mechanisms and policies and consumer behaviour influence climate change. On the economic side it is advisable to address adaptation matters using cost-benefit analysis and cross sectorial approaches.

• **Policies.** Appropriate policies and their implementation are crucial for attaining FACCE-JPI goals. Development of these policies requires integrated knowledge of what is currently happening and how this might be influenced by climate change. All themes have a role to play in generating this knowledge, with integration occurring particularly in Core Themes 1 and 5.

• **Scenarios.** Scenario analysis is the underlying approach to explore impacts of global change and possible options for adaptation. Scenarios are also necessary to explore possible transformation pathways to reach jointly the different SDGs in a sustainable way, linking short term action with long term consequences and changes. Consistent scenario frameworks covering both climatic and also socio-economic drivers are needed to improve coherence in research activities across themes. Newly developed global RCPs (Representative Concentration Pathways), SSPs (Shared Socio-Economic Pathways) and RAPs (Representative Agricultural Pathways) need to be made applicable for Europe and its different regions to enable consistent integrated studies across scales (from local, to regional, to continental) and themes.

• **Barriers.** One of the core issues of the sustainable development agenda that has been agreed on in 2015 is the question of implementation. How to reach the very ambitious objectives set in the SDG agenda for every country, including European countries? How to ensure that the ambition of national climate policies (both on mitigation and adaptation) can be rapidly increased in order for the planet to remain under the 2°C pathway? Solutions are already being developed; many technical, and social or organisational innovations already exist but need to be upscaled. However, the transfer of measures (including technologies and practices in support of adaptation and mitigation) can be hampered by barriers. Understanding these barriers and identifying ways to overcome them is essential for improving the effectiveness of adaptation and mitigation measures. Barriers can be technical, economic, political, cultural, social, behavioural and institutional. Barriers differ among sectors. For example in agriculture, key barriers can be government subsidies, lack of technology, capacity and skills, or property rights. Identifying and overcoming barriers should be considered as integrated parts of climate change impact studies.

• **Global, regional and local strategies.** European biogeographical regions, with their own geographic characteristics, demand specific vulnerability assessments of agricultural and natural systems, biodiversity, hydrology and water supply and socio-economic sectors in relation to climate change. Global, regional and local strategies need to be developed for climate change adaptation and mitigation for different types of production systems (Core Themes 4 and 5).

## Revisiting the core themes

The revised Strategic Research Agenda builds on the original one and structures the current and future actions and priorities around five Core Themes. Policy-relevant research and development priorities have been developed further in the update of the Strategic Research Agenda. These priorities are described further in each Core Theme section.

For each Core Theme, the main research issues and ongoing FACCE-JPI actions that address the core theme are described (see also Annex 5 for more information on FACCE actions). A list of research priorities is then given. Following the five core themes, cross-cutting priorities are described (p. 41). These may address two or more core themes. The specific challenges, and the scope and expected impacts of these priorities were informed by the following reports and papers (among others): the 4th SCAR Foresight exercise report[14], the JRC Foresight on Global Food Security 2030[15], a discussion paper on the role of research in global food and nutrition security[16] and a DG-Agri background paper on European agricultural research and innovation strategy[17]. Following selection by the GB, a subset of these priorities have been included in the 2016-2018 Implementation Plan.

These priorities focus more on impact-driven research and as such new sections entitled 'Expected outcomes and impact' and 'Opportunities for cooperation' have been included for each of the priorities in the Core Themes.

'Expected outcomes and impact' refers to the direct outcomes of the research and innovation within this priority, and examples of the potential longer-term impact that the research would have on particular beneficiaries e.g. consumers, private sector stakeholders and public policy, at the national, European and international levels. Outcomes and impacts can be achieved by development of joint actions and activities and alignment of national programmes, in partnerships with stakeholder organisations.

'Opportunities for cooperation' provides a non-exhaustive list of other research initiatives with which FACCE-JPI could align to help deliver the intended impacts. Although not individually listed, cooperation with relevant European Technology Platforms (ETPs) and Public-Private Partnerships (PPPs) is inherent throughout the Core Themes, and will be primarily achieved through the StAB.

[14] 'Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy – A Challenge for Europe'. 4th SCAR Foresight Exercise: https://ec.europa.eu/research/scar/pdf/ki-01-15-295-enn.pdf#view=fit&pagemode=none

[15] 'Global Food Security 2030 – Assessing trends in view to guiding future EU policies'. JRC Science and policy reports: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC94867/lbna27252enn.pdf

[16] 'The role of research in Global Food and Nutrition Security – Discussion Paper'. Expo 2015 EU Scientific Steering Committee: http://europa.eu/expo2015/sites/default/files/files/FINAL_Expo-Discussion-paper_lowQ(1).pdf

[17] 'Towards a long-term strategy for European agricultural research and innovation by 2020 and beyond – Background paper'. Expo 2015: http://ec.europa.eu/newsroom/horizon2020/document.cfm?action=display&doc_id=9741

# Core theme 1:
# Sustainable food security under climate change

## Scope

**This core theme includes:**

**I. Identifying key vulnerabilities of the European food system to climate change**

- **Integration of biophysical and socio-economic models to analyse the potential impacts of changes in agricultural policies and in other parts of the bioeconomy sector in Europe, under different climate change scenarios;**
- **Integrated risk analysis of European agriculture (and food systems, including food supply and value chains) under climate change: test responses to volatility both from natural and market phenomena;**
- **Understanding Europe's role in international markets and its impacts on price volatility and global food security;**

**II. Identifying policy options to increase resilience of European food systems under climate change**

- **Develop contrasted scenarios (with or without climate change adaptation) including recognition of public perceptions on how food is produced and policy dialogue;**
- **Modelling the impact (economic, social and environmental impacts as well as impacts on global food security) of changes in the bioeconomy sector in Europe under different policy options;**
- **In partnership with the private sector, identifying options (policy and technological) for helping food systems (throughout the value chain and to the consumer) become resilient to external shocks resulting from climate change;**
- **Combine observations, experiments and modelling through the development of appropriate European research infrastructures.**

### This core theme highlights the following dimensions of this challenge:

Approaches to understand food systems under a range of plausible future scenarios require **integration of aims and methods** and joint discussions between policymakers, science funders and researchers. In particular: i) integration of research on the economics of food systems (prices, drivers, markets, etc.) and climate change scenarios; ii) integration of primary production and post-harvest aspects.

As there are strong links between local, regional and global food markets, regional impacts of climate change on land use and primary production will have unprecedented effects on global supply/demand. In order to identify key vulnerabilities and measures to address them effectively, further research on climate change impacts on the European food production as well as on the broader food system including food marketing and trade is needed.

**Scenario building and modelling.** There is a need to increase the effective use of qualitative and quantitative modelling and standardised scenarios to better understand better the effects of consumer behaviour throughout the food chain. This requires a more integrated approach to analysing environmental consequences of food consumption decisions including life cycle analysis, dietary choices, the complementarity between foods and food nutrition. Policymakers should be involved to advise on which scenarios would be most useful and on whether policy options are feasible and practical.

**Impact assessment of policy instruments and regulatory measures.** Research on how development and evaluation of policy instruments takes place and how to improve ex-ante impact assessment at various scales is highly recommended. Also, an appropriate regulatory framework is critical to face the challenges derived from climate change. There is nevertheless a need to guard against regulation stifling innovative technological options that would improve food security under climate change.

As **consumer's choices and behaviours** have an important impact on all the segments of the food chain, it is crucial to develop methods to quantify the relationships, as changes in consumer habits may have market repercussions (e.g. changes in food demand and availability). The role of access to information to enable consumers to make informed choices also needs to be studied. This can only be accomplished through integrated socio-economic approaches, which should include studies on the effectiveness of legislation in changing consumer behaviour.

**Reduction of food waste** has been identified as a potential contributor to reducing global food insecurity. However, empirical data on the impact of managing food loss is lacking. A good assessment requires looking at food losses in different parts of the food chain (farm level, post-harvest level, transport, processing, markets and consumers). Post-harvest losses are higher in developing countries, while waste in the retail trade and associated with the home is more prevalent in developed countries.

**A sustainable bioeconomy** requires the development of integrated, systems-based approaches to land management and to the recycling of organic by- and co-products and of organic wastes. The focus should be on multipurpose biorefineries that can contribute to this integration while creating economic and environmental added-value e.g. to solve the protein deficit in Europe.

## FACCE-JPI Actions addressing Core Theme 1

MACSUR (Modelling European Agriculture with Climate Change for Food Security (www.macsur.eu) – a Knowledge Hub of FACCE-JPI (for a description of instruments invented or used by FACCE, see Annex 6), is a novel instrument that was created for the pilot action of FACCE-JPI (see also p. 15) It was launched in 2012 for 3 years and has been extended for a subsequent 2 years following its positive evaluation. It has been greatly successful in fostering transnational cooperation, collaboration and communication between the research communities in thematic clusters (crop, livestock systems and trade) to achieve better integration of existing models on climate change impacts on European food security. Below are some highlights of MACSUR:

- Total estimated funding volume of €19M with an in-kind contribution of €7M
- Brings together 265 researchers in 70 institutions from 18 countries
- Interdisciplinary model prediction with survey of 86 crop, 20 grassland, 8 farm and 26 economic models
- Knowledge exchange and impact with 200 peer reviewed publications, some used in the IPCC 5th Assessment report. The work of the Knowledge Hub has achieved recognition through citations in high-impact journals e.g. in Nature. 20 workshops and 10 training courses have been carried out with 500 presentations given. Approximately 20 new research projects have come out of MACSUR as new research questions have been identified through the Knowledge Hub
- Memorandum of Understanding with AgMIP (the Agricultural Model Intercomparison and Improvement Project)
- Capacity building by bringing together 265 staff supported over 3 years and 14 supervised theses

A second FACCE action addresses CT1: an international call was organised by FACCE together with the Belmont Forum[18] on Food Security and Land Use Change. In addition to FACCE partners, 6 countries from the Belmont Forum participated (Australia, Brazil, India, Japan, South Africa and the USA). Three short-term community building projects were funded as well as four Medium to Long-Term Integrated Projects. Several of these projects address questions related to land use and food security in Africa and thus represent a unique opportunity for FACCE-JPI.

[18] http://belmontforum.org/belmont-forum

## Priorities to be addressed:

| | |
|---|---|
| **Core Theme 1** | **• Climate change risk assessment for agricultural production systems (plant and livestock), and food supplies**<br>- Expected outcomes and impact: Enhanced evidence on potential extent of the risks to production systems from climate change and the costs of a range of options to mitigate these risks. This will inform national policymakers and the EU to make appropriate investments to mitigate risks.<br>- Opportunities for cooperation: Climate JPI, JRC, AgMIP (The Agricultural Model Intercomparison and Improvement Project), OECD TempAg, SUSFOOD 2 ERA-NET |
| | **• Climate change risk assessment for value chains, prices, international trade and food security, including changes in consumer behaviours and wastes**<br>- Expected outcomes and impact: Enhanced evidence on potential extent of the risks to value chains from climate change and the costs of a range of options to mitigate these risks. This will inform national policymakers and the EU to make appropriate investments to mitigate risks and also inform the private sector and consumers to enable them to make informed choices.<br>- Opportunities for cooperation: Climate JPI, JRC, HDHL (A Healthy Diet for a Healthy Life) JPI, AgMIP |
| | **• Reducing volatility in agricultural production and food markets in the bioeconomy to stabilise food security in the context of climatic variation**<br>- Expected outcomes and impact: Tools to inform the development of innovative policy instruments and mechanisms to stabilise food production, income and prices.<br>- Opportunities for cooperation: EIP-AGRI, FAO, IFAD, OECD, Agricultural Market Information System (G20 initiative) |
| | **• Assembling existing (and emerging) technologies for primary production, fostering the adoption of improved technologies that are (on the edge of being) mature but not yet widely adopted**<br>- Expected outcomes and impact: Better understanding of the dynamics that drive technology uptake. Inform national policymakers and the EU in establishing an "enabling environment" for innovation with the aim of having a more competitive European agricultural sector.<br>- Opportunities for cooperation: ICT AGRI ERA-NET, EIP-AGRI, ESFRI-related infrastructures |
| | **• Identification of the impact of food losses in the whole chain, and identifying interventions to decrease the waste**<br>- Expected outcomes and impact: A better understanding of where food is lost throughout value chains. This will increase the effectiveness of governmental intervention strategies to reduce waste in the food chain and re-use valuable resources.<br>- Opportunities for cooperation: FAO, Food KIC, SUSFOOD2 ERA-NET |
| | **• Pathways of economic development in Europe of non-food use of biomass, consequences for food supply and for land use change, biomass production, carbon sequestration, and prices and trade**<br>- Expected outcomes and impact: A better understanding of the risks and opportunities for the development of the bioeconomy in Europe. This should inform policymakers and help them design pathways to economic development that balance growth in the bioeconomy with food security.<br>- Opportunities for cooperation: JRC, JTI on Bio-Based Industries, SCAR |
| | **• Coordinating policies to support food and nutrition security in the context of climate change**<br>- Expected outcomes and impact: Improve future interventions which simultaneously consider the intended and unintended impacts of potential policies on public health, incomes and climate change.<br>- Opportunities for cooperation: JPI HDHL, SUSFOOD 2 ERA-NET |

**Three cross-cutting priorities also relate to this Core Theme (further elaborated on p. 41):**

- **Identification of the impact of urbanisation on organisation of food chains, and identifying new connections between water, food, energy and logistics to realise climate-robust and input-efficient production chains**
- **Identifying the potential role of big-data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/ knowledge policies)**
- **Explore and exploit refinery concepts for the multiple use of biomass under climate change, taking economic and environmental implications into account**

# Core theme 2:
# Environmentally sustainable intensification of agricultural systems

## Scope

**This core theme includes:**

- **Providing improved farm management and intensification practices that increase resource use efficiency and economic returns at the farm level and meet the goals of low environmental footprint alongside enhanced food security under current and future climate and resource availability;**
- **Understanding recent yield trends in Europe, taking into account changes in costs and prices and research investments as well as changes in environment, management and genotypes;**
- **Benchmarking efficiencies of resource use (water, land, nitrogen, energy) across Europe under diverse Genotype x Environment (including climate) x Management combinations and assessing total factor productivity;**
- **Integrated crop health management and integrated animal health management in the context of climate change;**
- **Low input, higher efficiency seeds and breeds i.e. producing more with less inputs;**
- **Knowledge-based IT innovations in agriculture;**
- **Improved understanding and control of soil functioning and biotic interactions at field to landscape scales.**

### This core theme highlights the following dimensions of this challenge:

The development of **innovative farming systems** that combine economic, social and environmental performance supported by targeted research at the interface between ecology and agricultural science and applying the ecological theory to the design and management of sustainable agroecosystems.

**Agro-ecological engineering approaches** will have to be further developed, in particular through the increased use of genetic and species diversity at field and landscape scales. Particular attention will be paid to the ecology and sustainable management of soil and water resources (including restoration technologies) in the context of the costs and benefits to farmers, and to the risks of contamination of the environment and along the human food chain.

Further research into **rhizospheric processes and their socio-economic feasibility** is required to explore the biological potential of the rhizosphere for sustainable intensification e.g. to increase protein levels of products.

Advances in **engineering coupled with IT** have the potential to allow farmers to reduce inputs while increasing productivity and resilience. This interface forms a target area for research.

**Advanced plant and animal breeding** (e.g. genomic selection, phenotyping) can be increasingly applied to increase the efficiency of water and nutrient use for both crop and forage production under both optimal and sub-optimal resource availability.

The design of **integrated management strategies for plant and animal health** to increase ecosystem services in agricultural production systems has a strong potential to reduce the use of pesticides and veterinary products while remaining technically and economically successful. There is a need for novel methods to monitor pests and diseases to be deployed to reduce impacts on crops and livestock systems and deploy resistance genes in a timely manner, while preventing their decay through crop and breed diversification. Further research is required to increase understanding of the benefits and costs to farmers of mobilising ecosystem services to sustainably intensify agricultural systems.

Identifying when and how **locally intensive agricultural practices** can best be integrated into a more diversified landscape matrix to reduce their environmental impacts including management of marginal land.

## FACCE-JPI Actions addressing Core Theme 2

The ERA-NET Cofund on "sustainable and resilient agriculture for food and non-food systems" (FACCE SURPLUS) has launched a call which brings in the bioeconomy aspects of agriculture. It addresses three subthemes: Spatial targeting of land use to increase biomass production and transformation, stimulating the growth of systems for the efficient utilisation of green (plant) biomass cascading through novel transformations; Developing markets for a wide range of products and services generated through integrated food and non-food systems; and Sustainable intensification of integrated food and non-food systems of agriculture, by developing integrated, systems-based approaches to land management. Projects were evaluated prior to a funding decision in December 2015 (see also Annex 5).

At this time, FACCE-JPI is developing a Knowledge Network on the development of options for sustainable intensification of European crop and livestock systems. A first workshop was held in February 2015. Further scoping is underway currently.

FACCE-JPI has also had a first workshop in August 2015 to explore the possibility of setting up a "Thematic Annual Programming" (TAP) network on Agricultural Soil Quality. A TAP network aims is to "coordinate the objectives, methodologies, outputs and outcomes of national research projects (financed by national funding agencies) on one specific research topic {...}". There was support for this instrument but further scoping of the research area is still needed.

Finally, FACCE-JPI is working closely with a new ERA-NET Cofund on Sustainable Animal Production (SusAn). This ERA-NET will address the complex animal production landscape through joint European research within a framework which supports the three pillars of sustainability - economy, environment and society - and targets opportunities for innovative research spanning all areas of animal production such as health and welfare, feeding and nutrition, reproduction, breeding and genetics, housing, nutrient management and economics.

## Priorities to be addressed:

| | |
|---|---|
| **Core Theme 2** | • **Identifying crop yield potentials and yield gaps across regions in Europe under current and future climate scenarios. Implications for input use and management. Include considerations on quality of crop products**<br>- Expected outcomes and impact: Maps of yield potential and gaps for different crops across regions in Europe. This will inform farmers and breeders in developing effective crop management strategies to increase production<br>- Opportunities for cooperation: EIP-AGRI, OECD TempAg, Wheat Initiative |
| | • **Identifying animal production potential and production gaps across regions in Europe under current and future climate scenarios. Implications for input use and management. Include considerations on quality of animal products.**<br>- Expected outcomes and impact: Better understanding of the constraints to animal production potential and realisation across regions in Europe to inform farmers and breeders in developing effective livestock systems to increase production.<br>- Opportunities for cooperation: EIP-AGRI, SusAn ERA-NET, FAO |

**Six cross-cutting priorities also relate to this Core Theme (further elaborated on p. 41):**

- **Cooperation with ICT: smart farming and food security**
- **Sustainably increasing productivity, resilience and resource use efficiencies (including soil and water) at the agricultural system scale, across regions in Europe, based on improved use of genetic resources and advanced management technologies ('management by measurement') in the context of climate change**
- **Identification of the impact of urbanisation on organisation of food chains, and identifying new connections between water, food, energy and logistics to realise climate-robust and input-efficient production chains**
- **Identifying the potential role of big data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/knowledge policies)**
- **Explore and exploit refinery concepts for the multiple use of biomass under climate change, taking economic and environmental implications into account**
- **Plant and animal production systems for better human nutrition and resilience to climate change**

# Core theme 3:
# Developing synergies and reducing trade-offs between food supply, biodiversity and ecosystem services

## Scope

**In the context of climate change, this core theme includes:**

- **Providing new approaches to the increased use of functional biodiversity in agricultural systems (e.g. intercropping, mixtures, conservation agriculture...);**
- **Developing methods for assessing and valuing biodiversity and ecosystem goods and services (e.g. carbon sequestration, water storage...) in intensive agricultural systems;**
- **Developing approaches for developing synergies and reducing trade-offs between agriculture and ecosystem services in a variable environment (climate change, price volatility...) at both farm and landscape scales;**
- **Developing a solid knowledge basis for the provision of public goods by European agriculture, so that ecosystem services are delivered efficiently and effectively.**

**This core theme highlights the following dimensions in the context of climate change:**

Methods for developing a **typology of interactions** between agricultural systems biodiversity (including agricultural biodiversity) and ecosystem services need to be developed and improved, taking into account the variability in the physical and biological environment and in land management at a range of spatial scales (e.g. farm, landscape and region).

Further understanding of the **trade-offs and synergies between agricultural practices, various forms of biodiversity and ecosystem services** is required. Designing agricultural systems to provide a basket of ecosystem services according to demands by e.g. farmers and consumers could be studied by reverse engineering methods in a range of regional contexts. Increasing the use of functional biological diversity, of multi-component farming systems, of regulating services (e.g. auxiliaries, disease control by mixing cultivars...), of landscape scale management may foster the development of high nature value agricultural production systems, while increasing their resilience to climatic variability and extremes (see CT4). Additionally, it is necessary to understand the trade-offs between varying productive uses of biomass in relation to biodiversity and ecosystem services. Implementation of the Bioeconomy Strategy for Europe will increase the potential uses of biomass. The consequences of this need to be explored and related to the production potential of biomass which will vary according to mitigation/adaptation strategies to cope with climate change. In this regard, adaptation strategies (risk assessment, regionalisation...) and mitigation initiatives (biogas, carbon sequestration, improved nitrogen fertiliser management...) are crucial to adjust the trade-offs to future needs due to a changing environment.

It will be important to test whether agricultural systems with high functional biodiversity are more resilient to climatic variability and extremes than systems with low diversity. The potential contribution of such systems (e.g. conservation agriculture, agroforestry, etc.) to greenhouse gas mitigation (e.g. through carbon sequestration) is also an important link to CT5.

**Land use planning strategies** need to be evaluated, by comparing the 'land sparing' and 'land sharing' paradigms. Land sparing assumes that 'intensive agricultural production will preserve ecosystems elsewhere', while land sharing assumes that 'multifunctional agricultural systems can accommodate production, biodiversity and ecosystem services'. A European modelling of trade-offs in land use/management at a range of spatial and temporal scales is an overarching need.

Evidence-based assessments of the **socio-economic and environmental impacts of agro-environmental schemes** are required, given the prominence of these measures in the Common Agricultural Policy and a number of EC directives that directly affect agriculture, biodiversity and ecosystem services. This work will contribute to our understanding of how to incentivise appropriate landscape design, and to increase resource use efficiency and ecosystem services through policy options to reduce trade-offs between food supply, biodiversity and ecosystem services in Europe.

**The impacts of agricultural commodity trade patterns** on biodiversity and ecosystem services outside of Europe are important to consider. For instance, food insecurity and tropical deforestation may both increase in response to high food price levels. Analysing incentives and barriers to enhancing biodiversity and ecosystem services (including in soils and water) and identifying institutional solutions to preserving adjusted net savings from nature capital stock, is also a research goal. This is particularly critical for the implementation of the SDG agenda at the global scale, as European decisions on agriculture and trade affect the realisation of the SDGs in other countries.

## FACCE-JPI Action addressing Core Theme 3

A call with the ERA-NET BiodivERsA that opened in 2013 has funded 10 projects related to "Promoting synergies and reducing trade-offs between food supply, biodiversity and ecosystem services". Two themes were addressed:

1) To what extent can biodiversity better support agro-ecosystems / agricultural production systems in terms of multi-functionality and outcomes in a global change context? The proposed research on this theme is expected to help developing innovative agricultural landscapes and systems delivering ecosystem services and preserving biodiversity, as well as enhancing biodiversity-based adaptation of agriculture to climate change and extreme events.

2) Which policies and governance systems can promote the emergence and support of agro-ecosystems / agricultural production systems benefiting from and beneficial to biodiversity and ecosystem services? The expected impact of the research proposed in this theme is to gain knowledge and inform relevant actors for the support of agricultural production systems benefiting from and beneficial to biodiversity and ecosystem services. This includes defining how innovative governance and economic arrangements could reduce the barriers preventing the development of productive agro-ecosystems with high nature value.

A common kick-off meeting for all funded projects was organised in April 2015. A brochure describing the call and all the projects is available on the FACCE-JPI website[30] (See also Annex 5).

[30] https://www.faccejpi.com/Media/ERA-NET-Plus-Brochure

## Priorities to be addressed:

| | |
|---|---|
| **Core Theme 3** | • **Assessing and valuing ecosystem services and their resilience in agricultural systems and landscapes under climate change.**<br>- Expected outcomes and impact: A better understanding of the value of specific ecosystem services to enhance sustainable productivity. This will assist land users and policymakers in enhancing the resilience of agricultural systems and landscapes.<br>- Opportunities for cooperation: EIP-AGRI, EIP Water, BiodivERsA ERA-NET, OECD TempAg, FAO |
| | • **Designing and assessing the impact of incentive mechanisms to support increased provision of ecosystem services in agriculture, including conditions for uptake and socio-economic elements.**<br>- Expected outcomes and impact: A better understanding of how policymakers can incentivise the use of ecosystem approaches in European production systems. In the longer term, the objective is to increase the outputs from resilient ecosystem services.<br>- Opportunities for cooperation: EIP-AGRI, Water EIP, FAO |

**Two cross-cutting priorities also relate to this Core Theme (further elaborated on p. 41):**

- **Identification of the impact of urbanisation on organisation of food chains, and identifying new connections between water, food, energy and logistics to realise climate-robust and input-efficient production chains**
- **Identifying the potential role of big data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/knowledge policies)**

# Core theme **4**:
# Adaptation to climate change

## Scope

**This core theme includes:**

- **Adaptation options to climate change and increased climatic variability throughout the whole food chain, including market repercussions;**
- **Regional strategies to adapt production systems to cope with climate change;**
- **Adapting seeds and breeds through conventional and modern breeding and biotechnology[31] to new combinations of environment and management: e.g. abiotic stress, elevated $CO_2$;**
- **Systems of climate change-sensitive monitoring of pests and diseases and developing climate-informed crop and animal protection;**
- **Strategic adaptation to climate change through improved land management and land use change;**
- **Adaptive water management in agriculture, watershed management, flood management, irrigation technologies, and water re-use;**
- **Adapting markets, institutions and insurance mechanisms to increased climatic variability and climate change.**

[31] Biotechnology here is used in a broad sense, referring to marker-assisted selection, genomic selection and genetic modification methods.

## This core theme highlights the following dimensions of this challenge:

**Adaptation to climate change** will be required even if efforts to stabilise atmospheric GHG concentrations are successful in the mid to long term due to the delayed impact of current emissions. The impacts of climate change will vary in space and time and vulnerability assessments and adaptation strategies have to take into account the uncertainties associated with climate change projections.

To achieve **climate smart agro-systems** in Europe, supported by all partners in the Food Chain (farmers to consumers), there is need for a comprehensive understanding of the effects of extremes in climate changes on farming systems. They influence the resilience, and therefore the production, and finally the economic benefits of farming systems, particularly for the middle and long term period. In this respect a better understanding of the interrelations between ecological and social systems will increase the efficiency and adaptability of farming systems to unexpected changes. Moreover, more specific research on risk assessment is needed in order to qualify and to quantify the impact of climate change on our agro-systems; an improved evidence base is crucial for demonstrating the importance of including climate change and climate adaptation in the political agendas of the EU and their Member States.

**Adaptation pathways**, including short, medium and long-term, need to be based on a detailed understanding of the risks and opportunities for agricultural and food systems in the context of climate change (see MACSUR network, CT1). Moreover, integrating adaptation (CT4) and mitigation (CT5) pathways and better understanding synergies and trade-offs is required.

In the long term, the baseline for **determining adaptation options** will vary given other components of global change, such as increasing scarcities in fossil fuels and in natural resources, and altered markets and consumers' perceptions; such changes also need to be addressed in relation with CT1.

Water and soil resources are exposed to multiple pressures under climate change. **Adaptive water and soil management methods** need to be developed at a range of interconnected scales (e.g. from the field to the watershed), taking into account the diversity of regional contexts in Europe. Connecting institutions managing water as well as agriculture to improve coordination and increase capacity to reduce vulnerability to extreme events, as well as effectively respond to them. Water storage systems could experience major changes in some Mediterranean areas, which has important implications for agricultural production planning, as well as the development of insurance systems. It is very important to strengthen strategies including water capturing, storing, and management, increasing the efficient use of irrigation for climate change adaptation. Smart irrigation systems that combine remote sensing, sensors and software to provide near real time estimates of irrigation needs; precision irrigation, deficit irrigation and fertigation technologies will need to be increasingly developed in drought areas, as well as safe technologies for water reuse. The pricing of water and its sharing among multiple users and sectors need to be studied and improved.

An increased understanding of **soil biology and soil processes**, responses to droughts, flooding and salinisation is also required. Methods for improving soil water infiltration and drainage from agricultural soils to recharge aquifers will also be increasingly required.

**Biological adaptation to climate change** is already taking place, e.g. through natural selection, biological invasions and emerging pests and diseases. Better understanding of the associated risks and developing both preventive and palliative strategies is required. Addressing food safety with respect to climate change (for example, food supply contamination with zoonotic agents and other pathogenic bacteria, mycotoxins and marine biotoxins, as well as pesticides and persistent organic pollutants) is also an important component of food security. Reducing and controlling these risks is relevant for both public health and economic reasons.

A key challenge concerns **plant and animal breeding**. Preserving genetic resources, defining new breeding targets in response to elevated $CO_2$, to abiotic (e.g. high temperatures, water deficit, ozone, salinity, etc...) and biotic stresses (e.g. from emerging pests and diseases) and developing advanced infrastructures for plant and animal breeding appears as a key priority.

There is a need to address the effects of climate change and the associated risks for **animal health** (including existing and emerging diseases). Dealing with increased risks will be dependent on efforts to adapt livestock systems, both in confined and pasture systems (the former also affected by climate change). Issues such as animal breeding for robustness, e.g. adaptation to heat and other extreme conditions, as well as breeding of plants for better nutrient composition and higher production under changed abiotic stress conditions, should be taken into consideration. Changes in animal production may affect the release of greenhouse gases and therefore interact with mitigation efforts.

In terms of **crop and forage research**, strengthening of the following aspects is crucial:

- development of climate change adaptation strategies for major cropping and forage production systems;
- diversification of crops and increased use of mixtures which may be more resilient to climatic variability;
- agronomical practices that provide soil and water conservation;
- plant breeding for adaptation (including drought tolerance, use of increased atmospheric $CO_2$, thermo-tolerance, tolerance to flooding and to salinisation);
- adapted fertilisation strategies in relation to precision agriculture;
- regional adaptation strategies.

Exploring the potential that **agroforestry** (including silvopastoralism and hedges) has for climate change adaptation deserves more attention, in particular the use of climate resilient tree and shrub species within integrated systems to provide an improved microclimate for crops and livestock and to increase resilience of agricultural systems to extreme climate events.

Insights on new and adapted farming systems and agricultural landscapes are needed to in order to facilitate **changes in land management** in regions that are likely to undergo transformation in the long term from climate change and to other components of global change (such as the increased scarcities in fossil energy and in natural resources).

**A comparison of the adaptive capacity** across varying European agricultural systems and regions needs to be mapped in order to determine adaptation hot-spots, which are systems with high vulnerability and low adaptive capacity. Measures to reduce vulnerability and enhance adaptive capacity will be essential for these areas. A clear connection with the Common Agricultural Policy, in terms of instruments, prescriptions and scenarios is required.

**Adaptation of the food supply chains** (including transportation, processing and retailing) also needs to be considered, by addressing the possible changes in the corresponding industries and their infrastructures (e.g. silos, slaughter houses, factories, etc...).

The adaptation Core Theme should be related to the development of **storylines and of scenarios**, showing a range of pathways for adaptation that will support discussions with stakeholders and decision makers. These should be closely aligned with the scenarios developed under Core Theme 1. Adaptation scenarios should also take into account the other drivers of change in food value chains (economic competition, technological progress etc.).

**Modelling approaches** are important tools for integrating across sub-themes and should be considered wherever data of sufficient quality exist. They can be used at different scales in different contexts as appropriate, e.g. to provide options to explore outcomes of policy related questions on adaptation to climate change. Modelling at a lower scale (farm to regional scale) can provide options to explore outcomes for policy related questions on adaptation to climate change.

## FACCE-JPI Actions addressing Core Theme 4

The FACCE ERA-NET Plus call, which opened in 2013 and co-funded by the European Commission[32], has funded 11 projects to address the area of "Climate Smart Agriculture". This term, as defined by the FAO, is agriculture that sustainably increases productivity and resilience (adaptation), reduces greenhouse gases (mitigation), and enhances food security and development and as such covers several FACCE-JPI core themes. The projects were designed to undertake research and innovative approaches on the adaptation of European agriculture to incremental climate change as well as to increased climatic variability. Projects were to address one or more of the four areas highlighted as key to advancing research in this area: i) genetics and breeding of animals and plants to increase resilience to climate change, ii) pests and diseases linked to climate and posing significant risks, iii) adaptive management of water and soil resources and iv) options for adapting agricultural systems.

A common kick-off meeting for all funded projects was organised in September 2015. A brochure describing the call and all the projects is available on the FACCE-JPI website[33] (see also Annex 5).

FACCE-JPI is working together with the Water JPI on the ERA-NET Cofund WaterWorks 2015 on water and agriculture and thus is at the interface of the two JPIs. FACCE-JPI will launch a joint call in the WaterWorks 2015 ERA-NET Cofund on the interaction between water and agriculture, and water use efficiency increase, soil and water pollution reduction and development of the economic and sociological dimension in water efficiency in agricultural and forestry areas.

[32] http://www.faccejpi.com/faccejpi/FACCE-Joint-activities/ERA-NET-Plus-on-Climate-Smart-Agriculture

[33] http://www.faccejpi.com/faccejpi/Media/ERA-NET-Plus-Brochure

## Priorities to be addressed:

| | |
|---|---|
| **Core Theme 4** | • **Identifying constraints to adapting agricultural land, soil and water management for a variety of local farming systems.**<br>- Expected outcomes and impact: Better understanding of the barriers to adoption by farmers of actions to adapt European farming systems to climate change. This will enable policymakers and the industry to develop mechanisms to remove the barriers, and hence deliver more resilient farming systems.<br>- Opportunities for cooperation: EIP Water, JPI Water (WaterWorks 2015), OECD, FAO, Global Alliance for Climate-Smart Agriculture (GACSA) |
| | • **Phenotyping, genotyping, breeding and reproduction for adaptation to climate change with crop, pasture and livestock species and evaluating alternative species.**<br>- Expected outcomes and impact: Accelerated identification and breeding of adapted crop and animal genotypes in vulnerable regions of Europe. Adoption of those genotypes by farmers will lead to more resilient farming systems.<br>- Opportunities for cooperation: EIP-AGRI |
| | • **Climate change induced transformation of farming systems towards alternative types of production and links with changes in logistics and relocation of industries, investments. Scale of production is also an issue that we need to link to social and economic dimensions.**<br>- Expected outcomes and impact: Better understanding of the opportunities and threats due to crop relocation associated with climate change. This will enable policymakers to develop more effective policies, including those associated with appropriate infrastructure.<br>- Opportunities for cooperation: EIP-AGRI, FAO |
| | • **Adapting specific value chains to climate change from the field to the fork with special emphasis on nutritional quality, food safety and stability accounting for consumer preferences.**<br>- Expected outcomes and impact: Assessment of the impact (incl. food safety) of climate change on value chains. This will enable governments to enhance the resilience of value chains.<br>- Opportunities for cooperation: EIP-AGRI |
| | • **Integrated crop health management under climate change, with focus on emerging pests and diseases, epidemiology and deployment of resistance genes, links to soil and landscape biodiversity**<br>- Expected outcomes and impact: Effective strategies and practices to support integrated pest/disease management in cropping systems. Uptake of these practices by farmers, which should lead to lower losses from pests/diseases.<br>- Opportunities for cooperation: ERA-NET on Integrated Pest Management (C-IPM), Wheat Initiative |
| | • **Integrated animal health management under climate change with focus on emerging pests and diseases, interactions between wild and domesticated components at landscape scale**<br>- Expected outcomes and impact: A better understanding of the risks of emerging diseases for different regions across Europe. This will enable national and European policymakers (dealing with agriculture and wildlife) to improve resilience strategies for managing the risks from animal diseases.<br>- Opportunities for cooperation: EIP-AGRI, Global Network for Animal Disease Research (STAR-IDAZ) |
| | • **Increasing economically viable input use efficiency by improving water quality and soil function, and better use of fertilisers.**<br>- Expected outcomes and impact: A better understanding of the regional variation in the relationship between water quality, soil function and input use across regions in Europe.<br>- Opportunities for cooperation: EIP-AGRI, FAO, BiodivERsA ERA-NET, JRC |

**Four cross-cutting priorities also relate to this Core Theme (further elaborated on p. 41):**

- **Cooperation with ICT: smart farming and food security**
- **Sustainably increasing productivity, resilience and resource use efficiencies (including soil and water) at the agricultural system scale, across regions in Europe, based on improved use of genetic resources and advanced management technologies ('management by measurement') in the context of climate change**
- **Plant and animal production systems for better human nutrition and resilience to climate change**
- **Identifying the potential role of big data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/knowledge policies)**

# Core theme 5:
# Mitigation of climate change

## Scope

**This core theme includes:**

- **Contributing to reductions and removals of GHG emissions through carbon sequestration, substitution of fossil-based energy and products, and mitigation of $N_2O$ and $CH_4$ emissions by the agriculture and forestry sectors, while reducing the risk of GHG emissions associated with indirect land use change;**
- **Developing cost effective monitoring and verification methodologies of field, animal and farm scale GHG budgets, possibly including indirect land use and cradle to grave life cycle;**
- **Developing verifiable GHG mitigation and carbon sequestration measures in farming systems;**
- **Developing technologies and methods to substitute fossil-fuel energy through increased use of biomass and other renewable energies in the agriculture sector also ensuring climate resilient sustainable agriculture for food and non-food systems without jeopardising food security.**

## Assessment of this core theme highlighted the following research needs:

**The consideration of agriculture, forestry and land use change in an integrated fashion when looking at biophysical and economic estimates of mitigation potential (e.g. marginal abatement cost curves)**. A possibility is to work toward a common framework for Life Cycle Analysis (LCA) of livestock and crop production systems to investigate how farming practices should be modified and at which cost or benefit, in order to maximise mitigation and increase carbon storage. Mitigation options also need to be assessed and prioritised in relation to their synergies with adaptation measures and their impact on food security.

**Mitigation options focusing on soil carbon sequestration in crop and pastoral soils**. This includes biological processes and agronomic management practices concerning soil carbon dynamics and sequestration in crops, grasslands, forests and mixed systems. The current changes in European soil carbon stocks need to be established with improved accuracy, also taking into account the impacts of land use change. Strategies that could provide Europe with a high rate of carbon sequestration in soils need to be researched and the best agricultural practices for soil carbon sequestration established at regional and system scales with priority placed on degraded soils and on organic soils. In addition, soil monitoring tools using advanced physical and biological methods need to be developed for rapid assessment of soil organic carbon stocks. The efficiency and effectiveness of remote sensing and innovative sensors needs to be evaluated. Focus is also required on the rhizospheric interactions between plants and microbial communities to harness the potential of root symbioses ($N_2$ fixing legumes, mycorrhizae and plant growth promoters). For instance, fungal carbon sequestration in soil is an emerging topic in this area.

**Mitigation options focusing on the nitrogen cycle.** $N_2O$ emission mitigation needs to be considered in the broader context of the reactive nitrogen cascade, since all reactive N forms contributing to the nitrogen cycle may lead to indirect emissions (e.g. from $NO_3^-$, $NH_3$). Moreover, mitigating $N_2O$ emissions may result in pollution swapping and in increasing ammonia and nitrate emissions. Reducing fertiliser N inputs can be achieved without harming crop productivity through a range of agronomic strategies, including avoiding excess N fertiliser use, increasing the use of legumes in crop rotations and in pastures and improving the management and application of organic N fertilisers. The potential of precision agriculture to reduce nitrogen losses and increase nitrous oxide mitigation needs to be further explored as well as the potential to better control soil processes (i.e. nitrification and denitrification) leading to $N_2O$ emissions.

**Reduction of emissions by livestock, in particular through nutrition, animal breeding and manure management systems.** $CH_4$ and $N_2O$ emissions are dependent on: i) animal species productivity; ii) the housing system; iii) manure management and treatment; iv) diet composition and feeding regimes; v) soil management. These factors are interrelated. Low emission production systems are needed. Cheap, rapid and simple measurement tools are also required.

**Developing biogas and other technologies to generate energy from animal wastes and crop residues.** Some of the barriers pertain to the use of biogas digestates as fertilisers, others to the availability of biomass to run the plant without reducing crop production. Bioenergy aspects (substitution of fossil fuels) need to be integrated to capture land based options for GHG mitigation.

**Protocols and certification for methods to assess greenhouse gas emission.** Policy measures and (new) technologies should be based on sound evidence and the best knowledge available. Results from different research projects and trials should be comparable and available, including the underlying data. Harmonisation of assessment methods and working methodologies would not only contribute to the quality and comparability of the data, but also in a better judgement of the effects of (potential) measures to reduce emission of greenhouse gases. Training and education courses as a tool to stimulate methodology convergence may be important along with the development of outreach strategies to engage with farmers to share information and motivate them to adopt mitigation options and strategies. The European research infrastructure required to monitor, report and verify (MRV) GHG emissions and removals needs to be developed. Independent verification of national inventories is needed and can be achieved through the combination of inverse atmospheric modelling of GHG flux and modelling and of soil and forest inventories using improved and transparent collection of activity data. Progress in monitoring and measuring for Europe can make a very useful contribution for the global negotiations on climate change as the metrics of GHG in the agriculture, forestry and land use sectors still need to be improved.

**Barriers to taking up mitigation actions need to be elucidated when addressing the technical, economic and market potentials of mitigation options.** Studies looking at the cost per tonne of $CO_2$ of implementing mitigation measures need to assess the costs and benefits both for the public sector (R&D, dissemination, training, regulatory measures) and for the private sector.

- When considering GHG emissions and removals, systems analysis needs to be further developed and applied to food supply and demand chains, including trade issues, processing and retailing, diets and waste, plus the complication of inter-sectoral emissions for example transport, buildings. The forestry sector raises particular issues regarding carbon storage and potential to use timber for fuel. Options

concerning forestry and biofuels need to be better integrated and also linked to the opportunities for recycling biomass waste.

- More social sciences input is needed to understand the determinants of dietary choices (e.g., meat consumption) and the role of economic and social factors (facilitating or blocking the uptake of solutions or innovations) and the role of policy options. Further development of scenarios and storylines for the world and for Europe will be required in this area.

## FACCE-JPI Actions addressing Core Theme 5

To address greenhouse gas mitigation, FACCE-JPI opened a call in 2013 that has funded 11 projects in a "Multipartner call on Agricultural Greenhouse Gas Research". In addition to FACCE-JPI partners, these projects involve partners from the Global Research Alliance on Agricultural Greenhouse Gases (GRA) (USA, Canada and New Zealand). The projects funded are expected to contribute to addressing the following points:

- promoting consistent methodological approaches for the measurement and estimation of GHG emissions and carbon sequestration to improve research coherence and the monitoring of mitigation efforts;
- improving the measurement and estimation of GHG emissions and carbon sequestration in different agricultural systems;
- proposing, testing and verifying new practices, strategies and solutions to sustainably increase the C-sequestration potentials of agricultural soils while maintaining or even enhancing crop productivity, soil biodiversity and fertility;
- improving knowledge sharing, access to, and application by farmers of GHG mitigation and carbon sequestration measures, required for best management practices and technologies.

An ERA-NET Cofund on monitoring and mitigation of agricultural and forestry greenhouse gases (ERA-GAS) has been positively evaluated by the EC and corresponds to a topic suggested to the EC by FACCE-JPI. The ERA-NET will cover aspects of monitoring and mitigation of agricultural GHG, including such aspects as reducing uncertainties and improving national agricultural GHG inventories (e.g. with ICOS(*)), the role of climatic variability and agricultural and forestry practices for GHG emissions, the technical and economic potential of $CH_4$ and $N_2O$ mitigation, carbon sequestration and reduced emissions from energy use and pre-chain inputs, emissions/removals certification, economic and policy measures, including trade, barriers to implementation, life cycle assessment.

* Integrated Carbon Observation System

Photo:Luke / Janne Lehtinen

## Priorities to be addressed:

| | |
|---|---|
| **Core Theme 5** | • **Alternative land use systems (agroforestry, hedges, mixed farming systems) and land and soil management systems (soil conservation, legumes and soil biology) for building above and below ground carbon stocks and increasing biomass production for food and non-food uses.**<br>- Expected outcomes and impact: A better understanding of the carbon balance of alternative land use systems, including agro-forestry. This will enable national policymakers and the EU to develop policies which will incentivise the adoption of land use systems that benefit carbon sequestration.<br>- Opportunities for cooperation: EIP-AGRI, Four per thousand (Quatre per mille) international research programme, FAO, GACSA, GRA |
| | • **Technical and economic potential of GHG abatement, including enhanced soil carbon storage, in livestock and crop systems and in integrated systems.**<br>- Expected outcomes and impact: A better understanding of how management practices of crop and livestock systems influence net GHG emissions. This will inform national and European policymakers, and the agricultural sector on how to minimise GHG emissions without negative impact on food production.<br>- Opportunities for cooperation: EIP-AGRI , GRA, GACSA, Four per thousand international research programme |
| | • **Lifecycle analysis of products and of typical diets. Alternative food systems with low carbon footprint.**<br>- Expected outcomes and impact: Increasing knowledge and analysis of the carbon footprint of a range of food systems. Better information for policy, industry and consumers should lead to better informed food choices.<br>- Opportunities for cooperation: JPI-HDHL, JRC |
| | • **National inventories improvement; Measuring, Reporting and Verification (MRV) options**<br>- Expected outcomes and impact: More cost-effective models and methods for measuring agricultural GHG emissions. More accurate measurement will enable farmers and policymakers to make a more reliable contribution to GHG mitigation targets.<br>- Opportunities for cooperation: GRA, ICOS research infrastructure (ESFRI) |
| | • **Research forest fires: Smart forest management to decrease forest fire recurrence and increase forest resilience. Preservation of biomass and soil, avoiding $CO_2$ emissions. Study of future scenarios due to spreading risk of forest fires in Europe due to climate change.**<br>- Expected outcomes and impact: A better understanding of how factors associated with climate change influence the probability of forest fires. This will help national policymakers to implement risk management strategies.<br>- Opportunities for cooperation: Future ERA-NET on forestry, SUMFOREST ERA-NET |

**Two cross-cutting priorities also relate to this Core Theme (further elaborated on p. 41):**

- **Identifying the potential role of big data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/knowledge policies)**
- **Explore and exploit refinery concepts for the multiple use of biomass under climate change, taking economic and environmental implications into account**

# Summary

## An overview of priorities of the FACCE-JPI Strategic Research Agenda

**The table below summarises all the priorities and have been defined by Core Theme (CT) and by Cluster (CL):**

| Core Theme | Priorities | Cluster(s) |
|---|---|---|
| CT 1 | • Climate change risk assessment for agricultural production systems (plant and livestock), and food supplies | CL 2 |
| | • Climate change risk assessment for value chains, prices, international trade and food security, including changes in consumer behaviours and wastes | CL 3 |
| | • Reducing volatility in agricultural production and food markets in the bioeconomy to stabilise food security in the context of climatic variability | CL 3 |
| | • Assembling existing (and emerging) technologies for primary production, fostering the adoption of improved technologies that are (on the edge of being) mature but not yet widely adopted | CL 1, 2 and 3 |
| | • Identification of the impact of food losses in the whole chain, and identifying interventions to decrease the waste. | CL 3 |
| | • Pathways of economic development in Europe of non-food use of biomass, consequences for food supply and for land use change, biomass production, carbon sequestration, and prices and trade. | CL 3 |
| | • Coordinating policies to support food and nutrition security in the context of climate change | CL 3 |
| CT 2 | • Identifying crop yield potentials and yield gaps across regions in Europe under current and future climate scenarios. Implications for input use and management. Include considerations on quality of crop products | CL 2 |
| | • Identifying animal production potential and production gaps across regions in Europe under current and future climate scenarios. Implications for input use and management. Include considerations on quality of animal products | CL 2 |
| CT 3 | • Assessing and valuing ecosystem services and their resilience in agricultural systems and landscapes under climate change | CL 1 and 2 |
| | • Designing and assessing the impact of incentive mechanisms to support increased provision of ecosystem services in agriculture, including conditions for uptake and socio-economic elements | CL 1 and 2 |
| CT 4 | • Identifying constraints to adapting agricultural land, soil and water management for a variety of local farming systems | CL 1 |
| | • Phenotyping, genotyping, breeding and reproduction for adaptation to climate change with crop, pasture and livestock species and evaluating alternative species | CL 2 |
| | • Climate change induced transformation of farming systems towards alternative types of production and links with changes in logistics and relocation of industries, investments. Scale of production is also an issue that we need to link to social and economic dimensions | CL 2 and 3 |
| | • Adapting specific value chains to climate change from the field to the fork with special emphasis on nutritional quality, food safety and stability accounting for consumer preferences | CL 3 |
| | • Integrated crop health management under climate change, with focus on emerging pests and diseases, epidemiology and deployment of resistance genes, links to soil and landscape biodiversity | CL 1 and 2 |
| | • Integrated animal health management under climate change with focus on emerging pests and diseases, interactions between wild and domesticated components at landscape scale | CL 1 and 2 |
| | • Increasing economically viable input use efficiency by improving water quality and soil function, and better use of fertilisers. | CL 1 |
| CT 5 | • Alternative land use systems (agroforestry, hedges, mixed farming systems) and land and soil management systems (soil conservation, legumes and soil biology) for building above and below ground carbon stocks and increasing biomass production for food and non-food uses | CL 1 |
| | • Technical and economic potential of GHG abatement, including enhanced soil carbon storage, in livestock and crop systems and in integrated systems | CL 1 and 2 |
| | • Lifecycle analysis of products and of typical diets. Alternative food systems with low carbon footprint | CL 3 |
| | • National inventories improvement; Measuring, Reporting and Verification (MRV) options | CL 1 and 2 |
| | • Research forest fires: Smart forest management to decrease forest fires recurrence and increase forest resilience. Preservation of biomass and soil, avoiding $CO_2$ emissions. Study of future scenarios due to spreading risk of forest fires in Europe due to climate change | CL 1 and 2 |

## Cross cutting priorities

**The following priorities relate to two or more Core Themes:**

| Core Themes | Priorities | Cluster(s) |
|---|---|---|
| CT 2 and 4 | • **Cooperation with ICT: smart farming and food security**<br>- Identifying and mobilising the potential of ICT to the benefit of smart and resilient farming systems.<br>- Expected outcomes and impact: An overview of the current and future use of ICT-related instruments relevant for agro-food systems, a strong network of partners involved in the development of ICT in the agro-food sector, and a strategic research agenda describing ways to move forwards.<br>- Opportunities for cooperation: ERA-NET ICT-AGRI. | CL 3 |
| CT 2 and 4 | • **Sustainably increasing productivity, resilience and resource use efficiencies (including soil and water) at the agricultural system scale, across regions in Europe, based on improved use of genetic resources and advanced management technologies ('management by measurement') in the context of climate change**<br>- Expected outcomes and impact: Methods and guidelines to identify strategies for sustainable intensification of agriculture. This will support national and European policymakers in developing strategies to support sustainable increases in productivity, resilience and resource use efficiency.<br>- Opportunities for cooperation: EIP AGRI, OECD TempAg, GACSA | CL 2 |
| CT 2 and 4 | • **Plant and animal production systems for better human nutrition and resilience to climate change**<br>- Opportunities for cooperation: JPI HDHL, EIP AGRI, OECD TempAg, GACSA | CL 3 |
| CT 1, 2 and 3 | • **Identification of the impact of urbanisation on organisation of food chains, and identifying new connections between water, food, energy and logistics to realise climate-robust and input-efficient production chains**<br>- Expected outcomes and impact: Mapping of urbanisation trends across Europe and a better understanding of their impact on food chains and their vulnerability to climate change. This will inform national policymakers on how to make these food chains more resilient.<br>- Opportunities for cooperation: JPI Urban Europe, Belmont Forum | CL 3 |
| CT 1, 2, 3, 4 and 5 | • **Identifying the potential role of big data for food security with a focus on collecting data, translating data into information, and promoting and facilitating use of the information by end-users (incl. via open data/knowledge policies)**<br>- Expected outcomes and impact: A better understanding of how the use of big data can improve the processes and systems within the agrifood sector. This will enable the agrifood sector to gain early access to trends associated with climate change. The impact will be a more resilient agrifood sector.<br>- Opportunities for cooperation: ICT AGRI ERA-NET, Research Data Alliance | CL 1, 2 and 3 |
| CT 1, 2 and 5 | • **Explore and exploit refinery concepts for the multiple use of biomass under climate change, taking economic and environmental implications into account**<br>- Expected outcomes and impact: A better understanding of non-food uses of biomass, which maybe capitalised on without compromising food security. Greater awareness of such economic opportunities will benefit the whole agrifood value chain and contribute to the growth of Europe's bioeconomy.<br>- Opportunities for cooperation: JTI on Bio-Based Industries, JRC | CL 2 and 3 |

## Instruments to be used for the delivery of the FACCE-JPI Research priorities are described in Annex 6

# Horizontal programmes and activities

Photo:Luke / Janne Lehtinen

## Horizontal programmes and activities

The development of this research will require increased access to research infrastructures as well as education, training and capacity building in a number of disciplines which have been neglected over the past decades 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. Further, to achieve the objectives of FACCE-JPI, there is a need to communicate and exchange knowledge resulting from FACCE's actions in order to make it useful in addressing the societal challenge.

## Infrastructures and platforms

The research undertaken to achieve the objectives of FACCE-JPI requires strong links to world class research infrastructures, on the one hand for observation and measurements and on the other hand, for integrating and harmonising data and resources' collection and storage. Furthermore, the JPI seeks to establish standardised protocols and tools for modelling and data analysis, e.g. in the Knowledge Hub MACSUR.

As noted above, key European infrastructures need to be assembled in order to integrate scenarios, observations, experiments and models so as to develop and inter-compare agro-ecological and socio-economic projections while assessing their uncertainties. FACCE-JPI has identified and established links to existing and emerging European research infrastructures and will study the need to develop new Research Infrastructures.

## Protocols and data

There is an urgent need for harmonisation of methods and protocols as well as modelling systems and common databases. Although there has been much progress, the development of common protocols is required for obtaining comparable data, needed to achieve a first critical step towards common databases. Examples include the need for common protocols for measurements of key processes (e.g. carbon sequestration, greenhouse gas emissions) at field scale, development of protocols for climate model downscaling and the development of sound databases useful for Life Cycle Assessment in agricultural systems. These tools are essential to enhance sharing and dissemination of information and new knowledge.

## Sharing databases and modelling platforms

In addition to the harmonisation of methods and protocols, the success of FACCE-JPI depends on the sharing of data and databases, with clear rules concerning intellectual property management. Mapping of existing databases could be a first step. Before resorting to new tools, existing databases such as the ICT-AGRI tool MKB (Meta Knowledge Base) could be shared. Sharing could be accomplished through research consortia or projects, workshops and networks.

In order to share data and databases, common formats are necessary. Another issue is the "homogenisation" of datasets and their quality control, implying the definition of clear protocols for data sharing which reduce ambiguity or bias.

Moreover, it is necessary to harmonise modelling systems and efforts. Models, e.g. for farm systems, should be compatible with each other (compatible protocols). This subject should be addressed together with related research initiatives. Harmonising modelling systems and efforts is being addressed in the FACCE-JPI Knowledge Hub, MACSUR. Finally, there is a need to ensure that activities of FACCE-JPI and the other global initiatives like the Global Research Alliance on Agricultural GHG Research are complementary, using harmonised methods, common protocols, sharing of data and mutual information.

## Education, training and capacity building in Europe

The need for further strengthening of a number of disciplines (e.g. agronomy and animal husbandry, farming systems) has emerged in stakeholder interactions, which have also highlighted that European farmers and growers are getting older (only 7% are under 35, and 32% are over 65) and that recruitment to plant breeding courses in universities and other academic institutions throughout Europe is declining. This poses a sustainability challenge to the European plant breeding and seeds businesses. To revitalise the agricultural sector, stakeholders are advising that a new generation of researchers and trained farmers and growers is needed.

FACCE-JPI seeks to promote education and training in joint actions by encouraging mobility of researchers in Europe at all levels to foster transfer of knowledge, organising Europe-wide research seminars to foster creative thinking and cross-disciplinary exchange of ideas, and organising workshops or training programmes around particular research themes, open to young researchers. As an example, MACSUR has given rise to numerous training workshops, researcher mobility and student training (Ph.D. and M.S.).

In view of the unequal research capacities in Europe, in addition to the above-mentioned actions, FACCE-JPI seeks to build research networks and to enhance networking between disciplines and research groups, within countries and at a European level. This is already being carried out in the exploratory workshops that bring together diverse disciplines as well as in the Knowledge Hub, MACSUR.

## Communication and dissemination

FACCE-JPI seeks to foster communication between the scientific community, policymakers, stakeholders/end users and funders. A key vehicle for this is the FACCE-JPI web site: www.faccejpi.com.

In order to foster the participation in FACCE-JPI actions, the uptake of research results coming from FACCE-JPI and the policy-relevance of FACCE results, dialogue must be promoted between researchers, policymakers and stakeholders/ end-users (farmers, agri-food industry) throughout the research cycle from planning to utilisation.

## Research community

FACCE-JPI recognises the need to communicate within the research community on FACCE-JPI actions and outputs. There is a need to publicise the JPI and its activities among researchers, through international conferences or seminars, through the web site and newsletter and through social media. The SAB has a key role in the communication and interactions with the research community and, when appropriate, in seeking their input. It is particularly important that FACCE-JPI actions are announced widely, and in advance, to the relevant researchers, and that their participation is encouraged.

## Stakeholders

A need to communicate and form links with stakeholders, in the broadest sense, is highlighted. The co-construction of knowledge, innovation and solutions with stakeholders is a possible way to ensure the usefulness and the uptake of research.

As FACCE-JPI intends to influence research programming, the interaction with stakeholders upstream of the development of programmes through the Stakeholder Advisory Board (StAB), comprised of representatives from around 20 European and international organisations, ensures that research and its expected impacts are defined in convergence with stakeholders' strategies and needs. Through the StAB, links are being made to farmers, the agri-food industry and the supply chains (livestock, crop and food value chains).

Further interaction with additional stakeholders will be carried out through consultations or through targeted workshops, as appropriate

## Policy dialogue

The problems related to agriculture, food security and climate change require a European-wide long-term research base. The post-2015 climate and SDG agendas, as well as the response to economic crises in the sector, will require the development of dynamic national and European policies. This research will inform national and European policymakers and will highlight current and emerging issues. It is critical that policy be evidence-based. It is thus necessary to strengthen the policy-driven research and research supporting regulation on JPI issues, e.g. for a knowledge base underpinning the Common Agricultural Policy. FACCE-JPI will examine the best policy mechanisms to achieve its objectives.

After 2015, a particularly important focus will be not only the definition of objectives, but the effective implementation of actions and policies to reach them. The research from FACCE-JPI will contribute to the formulation and implementation of EU and national policies concerning food security and climate change: organising such a policy dialogue (e.g. through cross representation at meetings including policymakers) will undoubtedly be necessary for FACCE-JPI research to have an impact on the global challenge. The question of how the research produced will be taken up by policymakers, researchers, land managers and others is important and greater emphasis could be given to research focusing on the best policy mechanisms to achieve the objectives set out by FACCE-JPI. Different steps in policy development could benefit from FACCE-JPI research: better formulation of objectives, identification of potential policy options, comparison of the performance of these options on different sets of criteria, analysis of the conditions of implementation and deployment of these solutions, and evaluation of past policies to adjust new measures to be taken.

On the other hand, the research areas covered by the JPI deal with large uncertainties and thus it is important to consider how to communicate uncertainty to policymakers who generally want to know the 'right' answer or the 'correct' number. Another point concerns the effects and consequences of different agreements, policies and laws on agricultural production and land use: it will therefore be particularly important that research developed in the framework of FACCE-JPI does not focus only on sectorial policies for food security, climate change and agriculture, but takes into account the variety of other drivers of change in food and agriculture systems. The relevance of FACCE-JPI research for these other areas of policies (e.g. trade, development, environment, competition) will be assessed during the policy dialogues.

Concretely, FACCE is considering an action in the mid-term to address coordinating policies to support food and nutrition security in the context of climate change[23]. This action, to be carried out in cooperation with the JPI Healthy Diet for a Healthy Life (HDHL), would evaluate the effectiveness of existing policy interventions, and this knowledge will be used to improve future interventions which simultaneously consider the intended and unintended impacts of potential policies on public health, incomes and climate change. In addition, future research needs in relation to gaps in existing knowledge required for effective policy development will be defined. The results will deliver improved human and environmental health across Europe, as well as increase the competiveness of Europe by ensuring that policy implementation relating to climate change goals, labelling or pricing is appropriate and evidence-based.

## Funders

Through the participation of representatives of funding agencies in the Governing Board and FACCE-JPI actions, a dialogue with funders has been firmly established. Other local, regional, national and international initiatives exist or are going to be created, whose objectives overlap those of FACCE-JPI. These challenges have to be considered on a global basis, namely because of the very strong interrelation between regional climates, but can only be effectively handled on a more local basis. Where relevant, the use of regional initiatives is essential for tackling these challenges in addition to cooperation with global initiatives. This implies a need to define a strategy for involving national and sub-national funding agencies in addressing efforts in the context of the FACCE-JPI issues. Further, FACCE-JPI must incite all EU researchers and funding agencies to develop research activities that are consistent with FACCE-JPI priorities, protocols and approaches.

## Knowledge exchange and uptake for innovation

Beyond the communication described above, interactions need to be promoted between researchers, farmers, and the farming industry, the private sector and consumers, in order to provide new opportunities for innovation. FACCE-JPI not only focuses on research but also on innovation. Here, the importance of Small and Medium Enterprises (SMEs) and industry in the agriculture and food sectors has to be stressed, including their role in fostering societal innovation and shaping consumer behaviour. Instruments to improve access to innovation as well as specific innovation activities are essential in this domain.

Specifically, the need to link outcomes of climate change risk assessment to the researchers/practitioners who will need to respond (e.g. crop breeders, disease researchers, land management expertise) was highlighted as a priority by members of the StAB, and is being implemented through MACSUR. There is a need for integration of innovative and sustainable agricultural dynamics in the upstream and downstream sectors. Specific means include institutional innovation, "research actions", i.e. the co-construction of new production systems with farmers and transposition of existing innovations (i.e. reuse or generalisation, with possible adaptation of innovative approaches which already exist) and setting up a catalogue of techniques available online (not restricted to techniques presently in use, but encompassing the whole "book of blueprints" which constitutes the original concept of a production function in economy).

## Evaluation and monitoring

Individual joint actions and any corresponding funding procedures are being monitored and evaluated as part of a defined Monitoring and Evaluation framework[24] to ensure optimal implementation in the FACCE-JPI process as well as informing future activity. For each joint action, the procedures for setting up the action are evaluated (e.g. availability of information on the call, electronic submission system, eligibility check, evaluation process, informing of evaluation outcomes) as well as the progress of the accepted projects (scientific and financial reporting, scientific outcome in the form of papers, patents, etc. plus impact on the societal challenges). Moreover, the JPI process is being monitored and evaluated to ensure that FACCE-JPI is fulfilling its objective of aligning national research programming in Europe and contributing to a European Research Area to bring greater impact of European research towards addressing the societal challenge of food security in the face of climate change. The pre-identification of expected impacts for each core theme will enable a better assessment of such impacts. The impact of FACCE-JPI on policy-making in Europe will also be assessed. A set of indicators has been developed that take into account FACCE-JPI objectives, activities, outputs, outcomes and impacts. The FACCE-JPI Advisory Boards (SAB and StAB) as well as external experts will be called upon to participate in evaluation activities.

## Conclusion

Joint Programming is a pioneer concept. After 5 years of existence, FACCE-JPI has succeeded toward its goals of aligning national and European research programmes, increasing high quality transnational research activities within food security, agriculture and climate change and has put into place actions that will improve the societal impact on the challenge of food security, agriculture and climate change.

This updated SRA paves the way for the next round of FACCE work aimed at shaping the European Research Area, enhancing European competitiveness by pooling national resources and avoiding fragmentation and duplication of research efforts and providing the research base needed to inform European policies on issues of great societal importance, in the short and long term.

The SRA will be implemented through the successive Implementation Plans of FACCE-JPI, which will address the research priorities using existing and new instruments, always looking for new ways to work together so as to address the societal challenge.

Joint Programming is an evolving process. FACCE-JPI has already achieved a great deal, and this refreshed agenda marks a milestone in the continued process toward addressing these challenges as well as a fully integrated European Research Area.

[23] See http://www.faccejpi.com/faccejpi/Document-library/Outcomes-of-the-Grand-Debate for full paper

[24] http://www.faccejpi.com/faccejpi/Document-library/Monitoring-and-Evaluation-Framework

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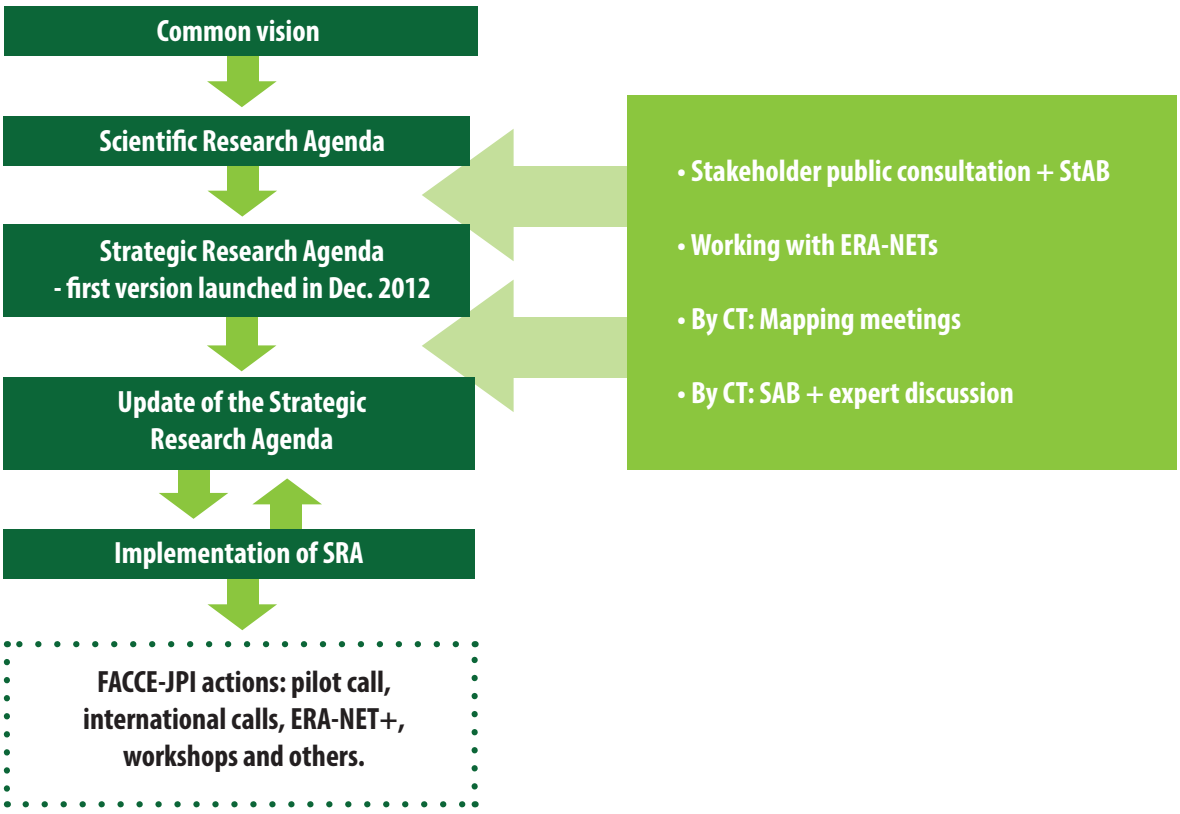
# Annexes

## Annex 1: Methodology – inputs to the Strategic Research Agenda

A number of activities aim to progress the FACCE-JPI process and to move towards a transdisciplinary, participative approach. Its research scope, first designed in the Scientific Research Agenda[25], was complemented by the analysis of current and future national research programmes through a series of mapping meetings on the 5 core themes in 2011 - 2013 and by the regular input of stakeholders (Figure 3). FACCE-JPI works together with other European initiatives to ensure coherence and contribute efficiently to achieving the European Research Area (ERA). Finally, this agenda will be further supported by activities on infrastructure and platforms, capacity building, education and training, knowledge exchange and communication and dissemination (see p. 43).

**Figure 3. FACCE-JPI activities contributing to the SRA and its update**



## Scientific Research Agenda

A board of internationally renowned scientists (Annex 4.3) are elected to constitute the SAB. The initial task of the SAB in 2010 was to develop a Scientific Research Agenda for FACCE-JPI. The Scientific Research Agenda designed by the SAB defined five Core Themes which were adopted and taken forward in the FACCE-JPI mapping process and which (with some modification) continue to structure future joint actions.

A set of criteria has been developed in order to select the core research themes of the FACCE-JPI. According to these criteria, core themes should:

- Be evidence based,
- Be highly effective at European level,
- Have high expected returns,
- Reflect priority needs of Europe and/or regions of Europe,
- Reinforce Europe's contribution to global public goods,
- Be interdisciplinary,
- Influence the development of the research agenda,
- Be complementary, with clear links and synergies within and across themes.

The full scope of the JPI was described (see Annex 2). The Scientific Advisory Board has elaborated on the Core Themes and research priorities and these inputs are included herein. The Scientific Research Agenda formed the scientific basis of the subsequent Strategic Research Agenda.

## Mapping Meetings

An innovative system of mapping and foresight meetings on ongoing and future research projects and programmes was carried out on each of the core themes defined in the Scientific Research Agenda between 2011 and 2013. During these meetings, posters were prepared by each member country presenting their current and future national programmes as well as their participation in European and international actions. Mapping meetings were complemented by desk studies and bibliometric analyses. The meetings brought together funders and research policymakers as well as scientific experts to analyse the current research and to make recommendations for future research and policy and the means to implement them[26].

**Mapping of core themes helped to identify:**

1 • Topics on which much research is being done in many JPI countries. These topics are of interest for future alignment, joint actions or instruments.
2 • Topics on which research is carried out in a small number of JPI countries. These latter are topics for novel alignment activities (e.g. geographic, thematic).
3 • Topics which are in the Strategic Research Agenda but on which there is little or no research or there is need for new investment. These topics could give rise to news topics in Horizon 2020 as collaborative projects, joint calls or ERA-NETs.
4 • Emerging topics. FACCE-JPI organised workshops to further explore these topics.

A "broad based" meeting concluded the 5 thematic mapping meetings to maximise their outcomes, build synergies with alignment and implementation working groups and to evaluate both the methodology and the process. FACCE-JPI's work continues to identify instruments and methods to realise alignment of national activity.

## Stakeholders

In order to gather stakeholder views on FACCE-JPI plans and activities, an online questionnaire, structured around the five core research themes of the FACCE-JPI, was used as the basis for a consultation exercise with stakeholders across Europe in 2012. For the elaboration of the 2013 Strategic Research Agenda, input from the consultation was used to validate and in some cases expand the subjects to be addressed in the core themes and to highlight supporting activities required by the JPI.

Stakeholder input has continued throughout the FACCE-JPI process through the Stakeholder Advisory Board (StAB; Annex 4.4). A group of European and international stakeholders corresponding roughly to 5 broad categories (Civil society, including NGOs and consumers, Farmers, Industry, Administration, including European Technology Platforms – ETPs and international and European research), themselves representing a great number of other organisations from very various backgrounds, meet to provide advice on the alignment of FACCE-JPI activities to stakeholder needs and to increase the impact of JPI actions for stakeholders and end-users.

## Strategic Research Agenda

Using the Scientific Research Agenda as a basis, and taking into consideration outputs from the mapping meetings, the SAB analysed all core themes in more detail, bringing in scientific experts to identify gaps and decide priorities for each theme. These are presented with each Core Theme above. The priorities have been updated for this revised version of the Strategic Research Agenda to focus more on impact-driven research.

[25] http://www.faccejpi.com/Document-library/Scientific-Research-Agenda; see also Annex 2.

[26] The reports from the mapping meetings can be downloaded from http://www.faccejpi.com/Document-library/Mapping-meeting-reports

## Annex 2: Scope of FACCE-JPI

### Agriculture.

Agriculture can be defined in a broad sense as the production of food, feed, fuel and fibre by land based systems. Thus, the sector includes annual and perennial crops, grasslands, livestock and forestry, rural landscapes; land use, biodiversity and ecosystem services. Freshwater and marine aquaculture are also included because feed production is required as input to these systems. Marine fisheries are not considered within the scope, since these will be addressed by the 'Healthy and productive seas and oceans' JPI. Competition for land will grow and it is important to focus on the sustainable intensification of production and, at the same time, consider ecosystem services that agriculture can offer, as well as linkages with the broader bioeconomy[27]. Bioenergy, biofuels and biomaterials are included as they will become even more important as prices of fossil-based energy and raw- materials rise and as the environmental and security risks associated with dependence on fossil fuels are recognised.

### Food security.

Agricultural production is not the only component determining people's food security. The UN-FAO World Food Summit 1996 created a definition, which is used in the context of the JPI: 'Food Security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life'. The JPI will highlight supply and utilisation of food with less research on processing, packaging, distribution, retail and economic access. The JPI will also embrace the safety aspects of food security, as defined above, and the agricultural and food policies that impact on food safety and nutrition. Further, the JPI will map and monitor emerging technologies that impact on agriculture and food security. However, FACCE-JPI will not include issues covered by the 'Healthy Diet for a Healthy Life' JPI, such as: the determinants of diet and physical activity; eating habits and diet advice and diet-related chronic diseases.

### Climate change.

The future of agriculture and of food security will take place under climate change and under other global environmental changes[28].The JPI, while considering climate change in a global and regional context, must develop scientific understanding to assist European Union farmers in adapting locally to climate variability and climate change, and to ensure that EU farming and food systems contribute to reducing greenhouse gas emissions. The link between the global, European and local farm levels necessitates that scaling issues are addressed early on in the programme. Collaborations with the climate research community[29] need to be organised. Since many mitigation efforts can also assist in adaptation it is important to integrate the two, taking into account regional variation across Europe. Links will be made to the Climate JPI as well as the Global Research Alliance on Agricultural Greenhouse Gases to avoid overlaps and provide complementarity.

### Water.

Special attention should be paid by FACCE-JPI to water management in agriculture, since about 70% of the global freshwater pre-empted by human use is allocated to agriculture. Adaptive water management in the context of climate change, increasing demands from non-agricultural sectors and limited water supply needs to be developed by research targeting water use efficiency in both rain-fed and irrigated agriculture and reduction of yield loss from water deficits. Links will be made to the Water JPI to avoid overlaps and provide complementarity.

### Land use.

Today, approximately 12% of the Earth's land area is under intensive crop production and close to 20% is pasture and rangeland used for livestock production. Future land use on Earth must accommodate multiple competing demands for food and fibre, energy, services, infrastructure and conservation by some 9 billion people – on a non-expandable global surface. There is a need for integrative, systems-level research approaches by the JPI to address changes in land use both in Europe and at a global scale, in link with climate change and with food security.

### Scope of the economic and social approaches.

Integration of economic approaches and expertise will be important in developing FACCE- JPI. Economics is of importance for identifying research priorities and innovation opportunities, as are social attitudes, consumer preferences, risk management, international trade, employment and institutional issues, etc, given their direct relevance to climate change and food security. Other social sciences (such as sociology, policy sciences etc...) may also be required. This will necessitate a sound consultative process across disciplines.

### Scenarios of global change and time horizon.

Current climate research efforts (Intergovernmental Panel on Climate Change, 5th Assessment Report) start from atmospheric GHG con-

[27] The usual definition of bioeconomy includes biorefinery as part of agricultural processes which can be included in the FACCE JPI. However, the corresponding industrial processes are not within the scope.

[28] Rate of biodiversity loss, saturation of the nitrogen and phosphorus cycles, stratospheric ozone depletion, global freshwater use, change in land use, atmospheric aerosol loading and chemical pollution (Rockström et al., Nature, 2009)

[29] World Climate Research Programme (WCRP) of the World Meteorological Organization (WMO), International Council for Science (ICSU) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, 'Connected Climate Knowledge for Europe' JPI.

centration pathways to generate new socio-economic and climate scenarios, which can be used for integrated assessments of impacts, adaptation, mitigation and vulnerability. The proposed Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) will develop biodiversity scenarios beyond those initiated by the Millennium Ecosystem Assessment. For agriculture and food security, important areas include the development of contrasted future agricultural scenarios and storylines, upgrade of models (including biophysical, biological, economics) and ensemble modelling for risk assessment. Most climate modelling considers timescales of 50-100 years, but increasing attention should be given to shorter-term seasonal/decadal predictions. Therefore a JPI time horizon of a few decades is proposed, perhaps until 2050. Time horizons will also dictate the geographical scope needed – for example 2050 would need a global horizon, but shorter timescales over the next 3-5 years could focus on the EU.

**Geographical scope**.
The focus is on Europe, but Europe is part of a global system of food production and consumption. The research agenda of Europe in the food, agriculture and climate change domains has impacts on the global research capacities and creates potentially important spill-over effects to other regions of the world. Thus, the JPI must consider Europe's role in a global context and how the global context will affect Europe. For FACCE-JPI it is proposed to cover the role of Europe for sustainable resource (land and water) use and for European and global food security. A complementary focus on food security and climate change impacts on surrounding regions (e.g., the Mediterranean Basin) and outside Europe (e.g., in Sub-Saharan Africa) is recommended and could be carried out through collaborations with other countries and with international programmes, such as such as the Climate Change, Agriculture and Food Security (CCAFS) programme of the CGIAR. The JPI will greatly advance the study of agriculture in developed countries for global food security and this will complement CGIAR international efforts which are currently centred on developing countries.

## Annex 3: Glossary of terms

**Bioeconomy:**
Bioeconomy encompasses the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy.[30]

**Sustainable Intensification:**
Sustainable intensification can be defined as producing more from same area of land while reducing negative environmental impacts and increasing contributions to natural capital and the flow of environmental services.[31]

**Food security:**
Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[32]

**Climate Smart Agriculture:**
Climate Smart Agriculture (CSA), as defined and presented by FAO at the Hague Conference on Agriculture, Food Security and Climate Change in 2010, contributes to the achievement of sustainable development goals. It integrates three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars: 1) sustainably increasing agricultural productivity and incomes; 2) adapting and building resilience to climate change; 3) reducing and/or removing greenhouse gases emissions, where possible.[33]

**Resilience:**
Resilience is defined as the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organisation, and the capacity to adapt to stress and change.[34]

**Ecosystem services:**
An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. Ecosystem services are ecological processes or functions having monetary or non-monetary value to individuals or society at large and thus are the benefits people obtain from ecosystems. There are I) supporting services such as productivity of biodiversity maintenance, soil formation, photosynthesis, and nutrient cycling, II) provisioning services such as food, fibre or fuel, III) regulating services such as climate regulation or carbon sequestrations, and Iv) cultural services such as tourism and spiritual and aesthetic appreciation. [35]

**Adaptation:**
Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation.[37]

**Mitigation:**
Mitigation is an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and to enhance greenhouse gas sinks.[38]

[30] European Commission (2012) Innovating for Sustainable Growth: A Bioeconomy for Europe

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# Annex 4: FACCE-JPI Governance and membership

## Annex 4.1: Permanent governance

For the permanent governance document, please refer to the FACCE-JPI website: http://www.faccejpi.com/Governance

## Annex 4.2: GB membership (as of October 2015)

Chair: Niels Gøtke (DK)
Vice-Chair: Annette Wijering (NL)

| Country | Last name | First name | Affiliation |
|---|---|---|---|
| Austria | Fuhrmann | Elfriede | Federal Ministry of Agriculture, Forestry, Environment and Water Management |
| Belgium | Vuylsteke<br>Marlier | Anne<br>Julie | Flemish Government, Department of Agriculture and Fisheries Département des Programmes de Recherche |
| Cyprus | Antoniou<br>Chrysafi | Leonidas<br>Rebecca | Research Promotion Foundation<br>Research Promotion Foundation |
| Czech Republic | Jerabek | Ladislav | Ministry of Agriculture of the Czech Republic |
| Denmark | Gøtke<br>Kristensen | Niels<br>Erik Steen | Ministry of Science Technology and Innovation<br>Aarhus University |
| Estonia | Kaare | Külli | Estonian Ministry of Agriculture - Research and Development Department |
| Finland | Peltonen<br>Ellmén | Mikko<br>Ulla | Ministry of Agriculture and Forestry, Department of Agriculture<br>AKA - Academy of Finland |
| France | Houllier<br>Heral | François<br>Maurice | INRA<br>ANR |
| Germany | Kucharzak<br>Stalb | Ramon<br>Hartmut | BMBF<br>Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV) |
| Ireland | Howell<br>O'Mara | Richard<br>Frank (Prof.) | Ministry of Agriculture<br>TEAGASC |
| Israel | Perl<br>Kapulnik | Avichai<br>Yoram (Prof.) | Ministry of Agriculture and Rural Development<br>Agricultural Research Organization from the Volcani Center |
| Italy | Montedoro | Marina | Ministero delle Politiche Agricole e Forestali |
| The Netherlands | Wijering<br>Löffler | Annette<br>Huub | Ministry of Economic<br>Affairs Wageningen UR |
| Norway | Langthaler<br>Ribe | Gundrun<br>Harald | The Research Council of Norway, Dept. Agriculture and Marine Issues<br>Norwegian Ministry of Agriculture and Food |
| Poland | Rzepecka | Monika | Ministry of Science and Higher Education |
| Romania | Belc<br>Alexandru | Nastasia<br>Monica | National Authority for Scientific<br>Research National Authority for Scientific Research |
| Spain | Melgarejo<br>Minguez | Paloma<br>Inés | Instituto Nacional de Investigación y Tecnología Agraria y Alimentaría (INIA)<br>Technical University of Madrid |
| Sweden | Källman<br>Svensson | Stefan<br>Jan | Ministry for Rural affairs<br>Formas |
| Switzerland | Walther<br>Aeschlimann | Pascal<br>Andreas | Swiss National Science Foundation<br>Forschunganstalt Agroscope |
| Turkey | Adali | Cinar | Scientific and Technological Research Council of Turkey |
| UK | Willis<br>Roper | Tim<br>Mike | BBSRC<br>Defra |

### Observers

| | Last name | First name | Affiliation |
|---|---|---|---|
| European Commission | Constantin<br>Cavitte | François<br>Jean-Charles | European Commission<br>European Commission |
| SCAR | Collins | Mike | SCAR Representative, Department for Environment, Food and Rural Affairs (Defra) |

## Annex 4.3: SAB membership (as of October 2015)

Chair: Prof. Margaret Gill, University of Aberdeen, UK
Vice chair: Dr. Harry Clark, New Zealand Agricultural Greenhouse Gas Research Centre, NZ

### Current members

| Name | Affiliation |
|---|---|
| Prof. Anne Marte Tronsmo | Norwegian University of Life Sciences, Norway |
| Prof. Fabio Fava | University of Bologna, Italy |
| Prof. Frank Ewert | University of Bonn, Germany |
| Dr. Harry Clark | New Zealand Agricultural Greenhouse Gas Research Centre, New Zealand |
| Prof. Margaret Gill | University of Aberdeen, United Kingdom |
| Prof. Marketta Rinne | The Natural Resources Institute Finland (Luke), Finland |
| Ms.Leslie Lipper | Food and Agriculture Organization of the United Nations, Italy |
| Prof. Peter Gregory | East Malling Research, United Kingdom |
| Prof. Rattan Lal | The Ohio State University, USA |
| Prof. Reinhart Ceulemans | University of Antwerp, Belgium |

### Former members

| Name | Affiliation | Years active |
|---|---|---|
| Prof. Kenneth Cassman | University of Nebraska, USA | Jun 2010-Apr 2012 |
| Prof. Frits Mohren | Centre for Ecosystem Studies, Wageningen University, The Netherlands | Jun 2010-Apr 2012 |
| Prof. Bernd Müller-Röber | Potsdam University's Institute of Biochemistry and Biology, Max Planck Institute of Molecular Plant Physiology, Germany | Jun 2010-Apr 2012 |
| Prof. Johan Rockström | Stockholm University, Sweden | Jun 2010-Apr 2012 |
| Dr. Henning Steinfeld | Food and Agricultural Organization (FAO) | Jun 2010-Apr 2012 |
| Prof. Elias Fereres | University of Cordoba, Spain | Jun 2010-Jun 2013 |
| Prof. Stephen P. Long | University of Illinois, USA | Jun 2010-Apr 2012 |
| Mrs. Rajul Pandya-Lorch | IFPRI, USA | May 2011-Mar 2014 |
| Prof. Pirjo Peltonen-Sainio | MTT Agrifood Research, Finland | Jun 2010-Sep 2014 |
| Prof. John R. Porter | University of Copenhagen, Denmark | Jun 2010-Mar 2014 |
| Prof. Thomas Rosswall | CGIAR Program 'Climate Change, Agriculture and Food Security' | Jun 2010-Apr 2012 |
| Dr. Joachim von Braun | University of Bonn, Germany | Jun 2010-Jun 2013 |
| Prof. Jean-François Soussana | Institut National de la Recherche Agronomique (INRA) Paris, France | Jun 2010-Jun 2015 |
| Prof. Dirk Inzé | Ghent University, Belgium | May 2014-Jul2015 |

## Experts invited to SAB meetings (as of October 2015)

| Experts invited | Affiliation |
|---|---|
| Prof. Abad Chabbi | AnaEE coordinator, INRA, France |
| Prof. Alberto Fereres | Spanish Research Council, Spain |
| Dr. Anni Huhtala | Government Institute for Economic Research, Finland |
| Dr. Beatrice Darcy-Vrillon | INRA, France |
| Dr. Cesar Revoredo-Giha | Scotland's Rural College, UK |
| Prof. Cynthia Rosenzweig | The Agricultural Model Intercomparison and Improvement Project (AgMIP) |
| Prof. Emilio Montesinos | University of Girona, Spain |
| Dr. Erik Mathijs | University of Leuven, Belgium |
| Prof. Graham Leeks | Water JPI |
| Prof. Helen Sang | University of Edinburgh, UK |
| Dr. Juan Antonio Navas Cortes | Institute for Sustainable Agriculture, Spain |
| Prof. Mario Caccamo | NIAB, UK |
| Dr. Martin Banse | Johann Heinrich von Thuenen-Institute, Germany |
| Prof. Martin van Ittersum | Wageningen University, The Netherlands |
| Prof. Nuria Duran-Vila | INIA, Spain |
| Prof. Pere Puigdomenech | Centre for Research in Agricultural Genomics, Spain |
| Dr. René Klein Lankhorst | Wageningen UR, The Netherlands |
| Prof. Richard Tiffin | University of Reading, UK |
| Prof. Tim Benton | University of Leeds, UK |
| Dr. Werner Kutsch | ICOS Director General, Finland |
| Dr. Xavier Le Roux | University of Lyon, France |

## Annex 4.4: StAB membership (as of October 2015)

Chair: Beate Kettlitz, Food Drink Europe

Vice-Chairs: Marco Schlüter, IFOAM; Jan Venneman, EFFAB

| Organisation's name | Contact | Position |
|---|---|---|
| COPA-COGECA | Christiane Möllhoff | Senior Policy Advisor |
| European Initiative for Sustainable Development in Agriculture (EISA) | Patrick Wrixon | President |
| FoodDrinkEurope | Beate Kettlitz | Director Food policy, science and R&D |
| European Crop Protection Association (ECPA) | Jean-Charles Bocquet/ Aurelie Dhaussy | Regulatory Affairs Manager |
| Plants for the future (ETP) | Silvia Travella | Coordinator |
| Farm Animal Breeding and Reproduction Technology Platform (FABRE-TP) (ETP) (EFFAB) | Jan Venneman | General Secretary, FABRE-TP |
| TPOrganics (ETP) | Marco Schlüter | Director of the secretariat |
| Water Supply and Sanitation Technology Platform (WssTP) (ETP) | Antonio Lo Porto | Director |
| European Federation of Biotechnology | Marc van Montagu/ Marc Heijde | EFB President / Scientific Advisor |
| The Animal Task Force (ATF) | Florence Macherez | Secretariat General |
| Global Research Alliance on Agricultural Greenhouse Gases (GRA) | Bruce Mc Callum | Representative of the Alliance Secretariat |
| European Federation of Food Science & Technology (EFFoST) | Dietrich Knorr | President |
| European Regions Research and Innovation Network (ERRIN) | Francesca Ricardi di Netro | Veneto Agricoltura |
| European Forum for Agricultural and Rural Advisory Services (EUFRAS) | Michael Kuegler | EUFRAS contact point |
| Food and Agriculture Organization of the United Nations (FAO) | Jeroen Dijkman | Senior Officer |

## Annex 4.5: Secretariat membership (as of October 2015; see www.faccejpi.com for details)

| Organisation | Participation in CSAs |
|---|---|
| INRA | Coordinator, FACCE CSA, FACCE EVOLVE |
| BBSRC | FACCE CSA, FACCE EVOLVE |
| BLE | FACCE CSA, FACCE EVOLVE |
| DASTI | FACCE CSA |
| IBA | FACCE CSA, FACCE EVOLVE |
| INIA | FACCE CSA, FACCE EVOLVE |
| Jülich | FACCE CSA, FACCE EVOLVE |
| Luke | FACCE EVOLVE |
| MIPAAF | FACCE EVOLVE |
| Teagasc | FACCE CSA |
| Tübitak | FACCE CSA |
| WUR | FACCE CSA, FACCE EVOLVE |

## Annex 5: Summary of FACCE joint actions by Core theme

### Core Theme 1

**Knowledge Hub MACSUR**

"A detailed climate change risk assessment for European agriculture and food security"

- Started in June 2012 for 3 years, extended for a further 2 years following successful evaluation
- Three subthemes: Crops, livestock and trade
- €19M estimated total budget including €7M new money
- 265 research groups from 18 countries participating
- MoU with the international project AgMIP
- Outcomes of MACSUR used in the IPCC 5th Assessment Report

**Joint action with the Belmont Forum**

Collaborative Research Action on "Food Security and Land use change"

- Launched in 2013
- 14 countries participating including Australia, Brazil, India, Japan, South Africa and the USA
- €10M estimated total budget
- Three community building projects and four medium- to long- term integrated projects selected

**Exploratory workshop on "Food safety implications of climate change and climate variability.** Sept. 24-25, 2014, Bucharest Romania

### Core Theme 2

**ERA-NET Cofund FACCE-SURPLUS**

"Sustainable and Resilient agriculture for food and non-food systems"

- Launched in 2015,
- 15 countries participating
- €17M estimated total budget

**Planned action: Knowledge Network on Sustainable Intensification of European crop and livestock systems**

### Core Theme 3

**Joint call between FACCE-JPI and ERA-NET BiodivERsA**

"Promoting synergies and reducing trade-offs between food supply, biodiversity and ecosystem services"

- Launched in 2013
- €10M total budget
- 10 projects on-going

### Core Theme 4

**ERA-NET Plus 'Climate Smart Agriculture'**

"Adaptation of agricultural systems in Europe"

- Started in January 2015
- 18 countries participating
- €16M total budget
- 11 projects funded

**Planned action: ERA-NET joint call together with WaterWorks 2015 on agriculture and water**

**Planned action: Thematic Annual Programming (TAP) Network on Agricultural Soil Quality**

### Core Theme 5

**Multi-partner call on agricultural greenhouse gas research mitigation**

"Mitigation of greenhouse gases"

- Launched in 2013
- In collaboration with non-European GRA countries (Canada, USA, New Zealand)
- Estimated total budget of €5.5M
- 11 projects on-going

**Exploratory workshop on "Animal Health and Disease and Greenhouse Gas Mitigation**, May 21, 2014, Madrid, Spain

**Planned action: ERA-NET on "Monitoring and mitigation of agricultural and forestry greenhouse gases" (ERA-GAS)**

## Annex 6: Instruments for the Delivery of the FACCE Research Priorities

The FACCE-JPI Strategic Research Agenda is being delivered through a series of Implementation Plans.

Through an iterative process, involving the Governing Board, the Scientific Advisory Board and the Stakeholder Advisory Board, research priorities are identified for the short term and included in the Implementation Plan (IP). The first IP covered 2014-2015 and the new IP for 2016-2018 has been prepared.

Through the FACCE-JPI IPs, participating countries are continuing to find new ways to work together to achieve harmonisation and streamlining of national research. FACCE-JPI is not solely about new joint calls for proposals, but aligning already funded national projects and programmes towards the achievement of the common FACCE-JPI Strategic Research Agenda. FACCE-JPI has used a combination of these approaches to work towards the top-level aim of JPIs which is to ensure the European Research Area is achieved through national efforts in key societal challenges in addition to EU programmes.

To deliver the FACCE-JPI Research Goals, additional programmes will continue to be developed through joint actions in which several countries in variable geometry participate voluntarily and on the basis of their respective political and financial commitments and strategies. FACCE-JPI defines such new programmes through dialogue among participating countries. As explained above, when mutually beneficial, collaboration with other European and international initiatives will also be explored.

### Instruments for Delivery

FACCE has developed several new and innovative instruments for alignment.

**Knowledge Hub:** The aims of a Knowledge Hub are to increase and facilitate cooperation between excellent researchers and research institutions; bring international impact, develop research capacity, provide learning and training activities and in the long-term to provide efficient scientific support for strategic and political decision-making.

A successful example of this is illustrated in the FACCE pilot action, a Knowledge Hub (MACSUR), which is an innovative, tailor-made instrument associating three complementary dimensions: networking, research and capacity building (see also p. 24 for more information on MACSUR). The Knowledge Hub is an instrument for alignment, in which many participants are already (nationally) funded to carry out (national) research. This has also necessitated some additional research funding in some countries, which is of course beneficial. FACCE-JPI will continue to identify research communities that would benefit from being brought together through Knowledge Hubs.

**Thematic Annual Programming Network:** Another instrument, the "Thematic Annual Programming" (TAP) Network is being developed. Based on the analysis of existing research and need for alignment across Europe, topics would be defined which are shared across many countries. Then national programme managers would be invited to meet with each other, scientific experts and the SAB to define topics to be shared by any new national programme in this area. An item text (e.g. one page) will be included in each national programme participating (on a voluntary basis). Then, after launching national programmes, a meeting would be organised with all projects working on a given item to discuss objectives, methods and expected outcomes. As part of this coordination, it might be possible to e.g. organise a database from project outputs (to be agreed and planned in advance) funded by the JPI. Following a pilot of this type, programme managers would be invited to evaluate the effectiveness of this approach. A first meeting for a TAP on Agricultural Soil Quality was held in August 2015 and is currently being taken forward by the JPI.

**Knowledge Network:** This is a new instrument currently being developed by FACCE. While a Knowledge Hub is based on a combination of new and existing activities and is a restricted scientific community comprising one consortium focussed on a specific goal, a Knowledge Network is expected to be a broad expert community with in the centre a Committee of National Science Leads and Funder Representatives and an informal web of nodes and interactions, formed by ongoing projects, programmes and various national and international science-policy-practice interactions. The general objectives are to facilitate collaboration across Europe, to increase return on investment of public R&D funding, to create synergy and avoid duplication, and to enable complex research.

**Workshops:** FACCE has carried out a series of workshops focussing on emerging research areas, often at the intersection of two or more established research areas. For example, in 2014, FACCE organised two workshops, one on "Animal health and disease and greenhouse gas mitigation" and another on "Food Safety Implications of Climate Change and Climate Variability". It is expected that exploratory workshops might give rise to future FACCE-JPI actions.

Although FACCE has used a variety of new instruments for implementing its research actions, conventional competitive calls form the basis of many FACCE actions, including in the ERA-NETs.
In addition to joint calls carried out uniquely between FACCE-JPI members, the implementation of the Strategic Research Agenda

requires FACCE-JPI to continue to work closely with the European Commission, particularly in the elaboration of Horizon 2020 Work Programmes.

The use of existing EC instruments such as public-public partnerships (ERA-NET Cofunds or Article 185) or public-private partnerships, infrastructures, mobility and training grants will continue to enhance the ability of participants to work together in the implementation of the FACCE-JPI Strategic Research Agenda for European added value. FACCE-JPI has successfully presented topics to the European Commission for inclusion in work programmes for both FP7 and Horizon 2020 where there was evidence that new research was needed, and will continue to work closely with the European Commission.

The ERA-NET Cofund instrument is specialised to carry out transnational calls, and as such, provides a means for partial implementation of the agenda of FACCE-JPI. FACCE-JPI aims to ensure coordination with a maximum of existing ERA-NETs and new ERA-NET Cofunds so that the calls that they organise serve to implement the Strategic Research Agenda of the JPI. To achieve this, FACCE-JPI will continue to build on achievements across Europe to date, notably interactions, cooperation and coordinated approaches with various actors such as The Standing Committee on Agricultural Research (SCAR).

Following the internal evaluation carried out by FACCE, it was agreed that for each upcoming action, the following points will be considered:

- What is the added value of this action?
- How is innovation taken into account in this action?
- What technologies (new or existing) will be important for the success of this action?
- What international links could/ should be established?
- What other initiatives/research actions (e.g. ERA-NETs, other JPIs) could be linked to this action? What is the best way to do this?

## European and international collaboration

FACCE-JPI works with a number of European initiatives and projects (public to public, public-private partnerships), including ERA-NETs, aiming with these collaborations not only to take forward the research and alignment goals of FACCE-JPI, but also to support the European Research Area, increase the impact of FACCE-JPI on European policy-making and innovation, and facilitate exchange of information and mutual learning with other initiatives. FACCE-JPI works with other JPIs (in particular, JPI Climate, JPI Water and JPI Healthy Diet for a Healthy Life) and participates in activities of the H2020 projects PLATFORM and ERA-LEARN 2020. FACCE-JPI and JPI HDHL have identified two priority research areas to be developed through collaboration between the two JPIs.

As is explained in the Strategy for Cooperation and Coordination with European and International Initiatives (see www.faccejpi.com), FACCE-JPI will also seek to establish links with the other European initiatives such as the European Innovation Partnership on Agricultural Productivity and Sustainability (EIP AGRI) and the European Institute of Technology's Knowledge and Innovation Communities (KIC), in particular, the Climate KIC and the future Food KIC. FACCE-JPI will also strengthen links to existing and emerging European research infrastructures like MIRRI, ICOS, ELIXIR[39]etc., seek interactions with the European Strategy Forum on Research Infrastructures (ESFRI) and propose areas where new infrastructures or upgrades of existing ones are necessary (see also the section on "Horizontal programmes and activities"). Finally, at the European level, FACCE-JPI also plans to work more closely with the EC's in-house Joint Research Centre (Institute for Environment and Sustainability), and the Standing Committee on Agricultural Research (SCAR), which plays an important advisory role. This will be achieved through cross representation at meetings and systematic engagement as observers. SCAR is represented as an observer on the FACCE-JPI Governing Board and FACCE-JPI plans to work closely with SCAR, in particular via the FACCE-JPI Governing Board Working Group on ERA-NETs.

At the international level, FACCE-JPI recognises the necessity to work with selected global partners, Agricultural Research for Development Initiatives and third countries (i.e., non EU and non-Associated Countries) in order to help better structure research at the global level, raise FACCE-JPI's visibility and impact worldwide, and promote information-sharing with similar programmes undertaken in other regions (e.g., Africa, Mediterranean area). As is noted in the Achievements section, FACCE-JPI has already developed partnerships with international initiatives and will seek to deepen collaboration with additional partners, such as the FAO Committee on World Food Security, the CGIAR programme on "Climate Change, Agriculture and Food Security" (CCAFS; http://ccafs. cgiar.org/), and the Global Alliance on Climate Smart Agriculture (GACSA) and possibly others, in the future.

[39] ANAEE: Analysis and Experimentation on Ecosystems (http://www.anaee.com/)
MIRRI: Microbial Resource Research Infrastructure (http://www.mirri.org/)
ICOS: Integrated Carbon Observation System
(http://icos-ir.eu)
ELIXIR Data For Life (http://www.elixir-europe.org/)

FACCEJPI

# Strategic Research Agenda

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