Climate change impacts along the agro-food chain: End-user relevant research for food security

About you

This proposal is submitted on behalf of the leadership team of the FACCE JPI knowledge hub MACSUR (http://macsur.eu), comprising 70 European institutions in 18 countries. MACSUR brings together the excellence of research in modelling grasslands, livestock, crops, farms, and agricultural trade in order to:

- ➢ improve the modelling of climate change impacts and adaptation strategies for European agriculture
- ➢ illustrate to political decision makers how climate will affect regional farming systems and food production in Europe.

To achieve these goals, MACSUR engages in a range of activities, including work to improve modelling capacity (identifying research priorities for agricultural modelling in the context of climate change, undertaking model comparisons, initiating assessments and improvement of model linkage, scaling and uncertainty, data evaluation, enhancing links to experimental research, training young scientists) and the application of integrated modelling approaches to regional climate change challenges. These activities are underpinned through the establishment of a community of practice across a broad range of scientific disciplines. The knowledge hub started in June 2012.

Challenge and vision

The focus of our proposal (food security) has been recognised as a vital area for action at the highest level within European research, policy and stakeholder communities. The EXPO2015 EU Scientific Steering Committee presented recommendations for research and innovation in global food and nutrition security (Fischler et al. 2015). The 2015 Lund Declaration by ten European Joint Programming Initiatives calls for political commitment to the alignment of research, infrastructure, and funding to address grand societal challenges of which food security is one. Our proposal will significantly contribute to the Food Research Area announced by Carlos Moedas, Commissioner for Research Innovation and Science.

It is widely accepted that climate change impact models have enormous potential to address the grand challenges faced by Europe in relation to food, energy and economic security. There has never been a more pressing need for fundamental research linked to real world applications that mitigate the negative impacts of climate change on primary production… And here's how it could work in practice.

Climate change poses a dual challenge to food systems and agriculture. Food security, food safety and ecosystem services must be delivered under increasingly difficult conditions, with extreme weather events becoming more frequent and long-term changes in climate altering the underlying conditions for crop and livestock farming. At the same time, the emissions associated with agriculture must decrease in order to reduce the magnitude of these destabilizing climatic changes. This issue has come sharply into focus since The Paris Agreement, achieved at COP21. It sets new, tough targets for limiting global warming. EU investment in climate impact research through FP7 projects is more than 177 M€ and through H2020 over 43 M€. While this investment has already seen returns in terms of research output, there is currently a lack of joined-up thinking and coherent strategies for application (Fischler et al. 2015). What is urgently needed now is a focussed effort to determine what Paris-compliant agricultural and food system futures look like.

We envisage a future in which climate change adaptation and mitigation requirements are fully integrated into European and national policy, into the production of industrial services and products, and into advice to farmers and its practical application. This integration will be vital to ensuring food security for Europe in the long term. Effective, reliable modelling of climate change impacts and adaptation options will need to be directly connected to end-users, with stakeholders engaged at all stages of model development and application.

The future role of agricultural modelling will be to provide reliable and user-friendly information to secure ecologically and economically optimal production for food security and the maintenance of ecosystem services. Regional case studies addressing specific local concerns will use integrated crop, livestock and trade modelling approaches to deliver on-the-ground improvement in agricultural governance and practice. Harnessing the predictive power of models gives us a unique opportunity to climate-proof food production and related income generation, ensuring global food security, and safeguarding associated supply chains and livelihoods. Steps in this direction have been taken by several research groups across the world. However, the urgency and importance of food security requires a major joint effort transcending existing setups. This should be viewed as an opportunity for European leadership in addressing the global challenges of climate change.

The issue of maintaining food security under climate change is a grand challenge because food, feed, fuel and fibre production are a fundamental resource and leitmotiv of global society ("Nexus problem", Fischler et al. 2015). Research into the impacts of climate change on agriculture and food security requires coordination of approaches, methodologies, and objectives across many disciplines and sectors (climatology, crop and livestock physiology, ecology, geophysics, meteorology, farm and national economics, human nutrition, power production, transportation, sociology), from local to global scales, and involving many types of stakeholder (farmers, industry, politics, consumers). An EU consultation showed a broad consensus on the need for more trans- and interdisciplinary research, given the complexity of the global food system (Fischler et al. 2015). Joined-up approaches must begin with the basis of knowledge – the collection of data. Relevant data for food security and climate change research can be difficult to collect in some cases (farm economics) but also rich and abundant in others (remote-sensing of weather variables, water deficit, and ground cover), creating different sets of challenges spanning technical, logistical and legal considerations.

A co-ordinated approach is needed to meet the challenge of mitigating agricultural emissions within the timeframe necessary to achieve the goals of the Paris agreement. Such an approach will be essential for defining objectives, agreement on coherent mitigation and adaptation scenarios for modelling, advancing methodologies, data provision via monitoring, developing data exchange interfaces, data analyses, uncertainty characterisation, identifying societal priorities in trade-off decisions, and in the dissemination of results.

Advancement in main technologies

This initiative will advance technology across a range of areas and thus address challenges and recommendations posed by Fischler et al. (2015):

- **Development of technologies for data collection** (such as remote sensing, smart patches for livestock, international observation and experimental networks, collation of farm-level economic data) processing (such as improved image analysis, genomic and phenomic approaches) and storage (Big Data) will be essential: 1) to directly improve efficiency, resilience and sustainability in food supply chains (for example through precision farming) and 2) to provide consistently high quality data for models, enabling more complex systems-level analysis to drive deeper change and better forecasting of future scenarios.
- **Development of modelling platforms and components** will facilitate the genesis of 'modular' systems that can be adapted, updated, interchanged and applied flexibly to meet the needs of stakeholders, policy-makers and stakeholders. A key focus will be to develop improved techniques for coupling biophysical and economic models to transform climate change into economic impact more effectively and at relevant spatial and

temporal scales (Ewert et al. 2015). Another will be to incorporate modelling of wider ecosystem service and environmental impact variables (biodiversity impact, carbon sequestration, water use and quality impacts, erosion) into model assessments, to ensure outcomes are viable for society and for future production.

- **Development of applications and user interfaces** will enable decision makers at government level and across supply chains to utilise models to support increased efficiency and sustainability.
- **Educating non-academic audiences in the use of new technologies** will be a priority, within Europe and beyond. Education on climate-smart agricultural technologies and the processing, consumption, and choice of agricultural products is likely to play an important role in achieving food security, ecological sustainability, and mitigation of climate change.

By enabling more holistic and relevant predictions of climate change futures for agriculture and food supply, **this initiative can provide the confidence for greater long term investment in technologies for effective and relevant farming practices and adaptation strategies under future climates.**

Why is it good for Europe?

A flagship on food security under climate change would enable the development of climate-adapted and mitigation-adapted machinery, tools, and practices for agriculture across European regions. This initiative would enable European society to adapt early and in an economically efficient way to changing conditions for food, feed, and fuel production. Food production systems are at the heart of our society; their character, success and sustainability are fundamental shapers of every sphere of our lives, from our values and outlooks to our health and economic well-being. Building a coherent pan-European approach to food security would also harness the benefits of European heterogeneity, which provide an excellent testbed for the use of approaches and technologies across the world. Considerable potential would exist to export solutions and new approaches globally. BRIC countries and Africa have a high potential for adopting climate-smart technologies in agriculture, especially when improvements are delivered through stakeholder-centered innovation processes (e.g. through the Africa-EU Partnership's cooperation on agriculture, food security and safety. Technologies and systems developed to improve the ecological sustainability of food production (safeguarding future production), to provide long term economic sustainability, and to invigorate diverse cultures and communities, would support the achievement of climate change mitigation and social development goals, and **enhance Europe's leading position in agricultural technologies, emphasizing the close relationship between long-term ecological sustainability and future agricultural output.**

The flagship on food security would directly support the recommendations established by the scientific panel of the EU on occasion of EXPO2015 (Fischler 2015):

> *1. Promote systems approaches, via both conducting foresight exercises and in research, to identify the best leverage points where interventions will have the greatest impact. This may be from minimising trade-offs, or identifying synergies. Based on these leverage points, invest in interdisciplinary research to develop integrated solutions.*
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> *2. Synthesise both new, and the body of existing, knowledge and use it better to engage with citizens about the impacts of food choices on nutrition and the environment. This dialogue can empower and underpin necessary societal change.*
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> *3. Stimulate an innovation environment by incentivising a greater degree of co-designed and co-executed work with stakeholder groups with an interest in adopting innovations (where "innovation" is defined broadly to include political, institutional, social and business, to effect positive change via economic growth or reducing economic costs, or cost-neutral changes in social well-being).*
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> *4. Finally, the EU as a global actor should support a new science based global assessment mechanism for global food and nutrition security: an International Panel on Food and Nutrition*

Security (IPFN). This will provide synthesis of scientific knowledge, help to set research agenda on contentious issues, stimulate problem solving new research, and contribute to transparent public discourse on instruments, synergies, trade-offs and risks.

International research initiatives linked to this proposal; positioning of Europe

At European level, FACCE JPI has initiated several projects to tackle climate change impacts on food security. The MACSUR knowledge hub is one of these, and along with AgMIP (acting at the global level) has coordinated the comparison and improvement of agricultural models. Several research or stakeholder focused Global Alliances (on Agricultural Greenhouse Gases, on Climate Smart Agriculture, for the Future of Food) have formed in the past few years to address issues relating to climate change and agriculture. Europe has the potential to develop the tools and provide the resources that enable agriculture to adapt to climate change and to reduce GHG emissions at a global scale. **European industry, by participating in the research, has the chance to develop products that bring a net benefit to their customers under climate change. Their application in case studies will set examples worldwide and provide unique selling positions on the global market.**

What would it take to do it?

Scale of the effort and time required to reach the objectives

In order to realise the full potential of agricultural modelling in relation to climate change and food security we must build capacity in modelling by bringing together modellers across disciplines to focus research efforts, improve model design, increase the relevance of model outputs to real-world problems, spread best practice and create coherent systems linking research to decision makers at all levels. This requires a major new focus on 1) the creation of a cross-disciplinary research network, advancing and learning from previous initiatives, with the resources to build capacity and develop shared tools (information sharing, protocols for model evaluation, synthesis of outcomes for policy and farm level application) and 2) fundamental research (underpinned and focused within a joined-up research community) that will allow significant breakthroughs and lead to practical applications. Specifically, we expect to boost the accuracy and reliability of climate change impact modelling and thus increase the usefulness and applications of models in food production systems. We want to incorporate vital aspects (such as livestock production and ecosystem services) that have so far not been well integrated into climate change impact and adaptation projections at a regional scale. These ambitions require broad multidisciplinary cooperation, well structured and effective administration, and the application of expertise incorporating both quantitative and qualitative research approaches.

It is critical that the full potential of the R&D capability is effectively applied and captured across all stakeholders in the supply chain. The challenges of uptake and adoption by end-users are significant. Overcoming such challenges requires an ongoing, focused exchange of knowledge and expertise between researchers and stakeholders, in order to create economically and ecologically sustainable systems through joint and complementary efforts. The challenge is not only to produce reliable and effective predictive models but also to form a virtuous cycle of sustainable innovation and partnership that recognises the value and interdependence of business, society and environment. Identifying opportunities and translating R&D into on the ground improvements requires a commercial and pragmatic mind-set as well as sound academic expertise and ecological understanding. There will therefore be a strong element of relationship-building between researchers and the variety of stakeholders from government

agencies to farmers and community leaders. The ultimate indicator of success will be clear demonstrations of positive real world impacts arising from modelling advances.

Many modelling tools already exist, but they must be better linked, evaluated and improved. Given appropriate funding significant technological progress can be made within four to six years; this must be underpinned by a similar investment to build shared resources and capacity. Engagement and the building of relationships with stakeholder groups (industry, research, policy-makers, producers, NGOs) requires time, but can be fostered and hastened through well-structured, professionally managed approaches to interaction, from project to strategic levels. **We expect stakeholder interaction to focus and drive technological process over eight to ten years.**

European expertise and capabilities to address the challenge and exploit the results

Research communities working on climate change impact include crop sciences, livestock sciences, climate sciences, ecosystem science, economics, geography, sociology, health and nutrition, geography, geophysics, hydrology and information technology. **The majority of research groups working on climate impact and agricultural modelling are based in Europe.** This is shown by the location of lead researchers in global initiatives. A recent meeting of crop modellers in Berlin organised by MACSUR and AgMIP was estimated to have attracted about 80% of the research groups dealing with climate change and crop modelling. Many fertiliser, machinery, pesticide, etc producing or insurance companies are either European based or have strong European subsidiaries.

National or European research initiatives linked to this proposal; added value

The proponent is one example of a European research initiative, comprising currently 70 institutions in 18 countries. About 50 other collaborative research projects exist or are planned within FACCE JPI. Many nationally funded projects could be mentioned and are listed in the reports on mapping meetings of FACCE. A flagship will achieve greater focus through setting a framework for involvement of producers, research communities, industry and policy. It will further reduce national and European overlap in funding of separate projects in this area while maintaining a variety of approaches in individual fields and regions. The flagship will contribute to implementing the recommendations of the 2015 Lund Declaration on alignment of research in Europe.

References

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