



# The INRA metaprogram

on Adaptation of agriculture  
and forests to climate change

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The second volume of the fifth IPCC (Intergovernmental Panel on Climate Change) report, issued in March 2014, presents a synthesis of the current knowledge on the impacts of climate change, on adaptation issues, and on the vulnerability of various sectors, including food production and food safety. Negative, but also less frequently positive, effects of climate change on crop and terrestrial food production are evident in several regions of the world. Climate change

is partly responsible for yield stagnation of major crops. The overall relationship between weather and yields is often crop and region specific, depending on differences in baseline climate, management and soil, and the duration and timing of crop exposure to various conditions. Projected impacts on mean crop yield are increasingly pessimistic as the end of the 21<sup>st</sup> century is getting closer, with South Asia and southern Africa as the most vulnerable regions. Increased interannual yield



variability is also forecasted. Implementing adaptation strategies may partially balance the negative impacts of climate change but their effectiveness appears to be highly variable according to the crop and region under consideration. It is therefore necessary to mobilize research, innovation and transfer capacity in many areas to improve adaptation strategies.

Considering the research needs prompted not only by climate change but also by other challenges, the French National Institute for Agricultural Research (INRA) has launched since 2010 a series of transdisciplinary research programmes, the metaprogrammes (*see box*). Metaprogrammes have been designed to structure and to coordinate research activities and projects on key challenges. The metaprogramme on Adaptation of Agriculture and Forests to Climate Change (AAFCC) has been launched in 2011. Its first objective is to coordinate, promote and integrate the activities in agricultural research to overcome the scientific and societal barriers that could restrict adaptation. This proactive and pluridisciplinary strategy involves cooperation with French and foreign academic and socioprofessional actors. It should ensure rapid results and progress, for example in multi-criteria assessment of adaptation options. Its second objective is to strengthen the outreach of French agricultural research.

### **Building on a forward-thinking exercise**

While many projects on the impacts of climate change and on the vulnerability of agriculture and ecosystems were already running, INRA has coordinated a forward-thinking exercise, named *Adage*, launched in 2009 by the French National Agency for Research. AAFCC benefited from this dynamic and elaborated its strategy based upon the conclusions of this exercise that identified the

research needs for adapting ecosystems and man-managed production systems to climate change. Among the numerous issues addressed were the adaptation of livestock, the flexibility in cropping or forestry practices for facing climate extremes, or the question of wheat yield stagnation. The metaprogramme is also a way to implement the scientific priorities identified by INRA and its partners of the thematic group "Climate: change, adaptation, mitigation, and impacts" of the national alliance for environment (Allenvi). Favouring the dialogue between disciplines dialogue, AAFCC therefore provides a framework for the various research projects on adaptation of agriculture and forests to climate change.

### **Pluridisciplinarity and integration as keywords**

Discipline-related skills in human and social sciences, agronomy, ecology, genetics, ecophysiology, animal sciences, economy and modelling are mobilised to cover the range of questions raised by adaptation to climate change. The chosen strategy focuses on integrated approaches at the sector or territorial level.

Elaborating and supporting the process of adapting food systems to climate change is a major issue. Due to its multidisciplinary nature, the approach requires promoting interactions between scientists, actors from the development and stakeholders of the concerned sector. Building a common vision of possible futures and key issues for the sector is a vital initial step in the development of prospective scenarios for adaptation. This type of approach is strongly promoted by AAFCC, for example in the case of wine industry: What are the biotechnical leverage actions for maintaining grape production, both in quantity and quality, under future climate? What are the risks and solutions regarding the increase of

climatic hazards? Can winemaking process adapt to face the increase in grape sugar content? Will consumers' tastes and preferences change? How to deal with these changes? Answering to these questions that cascade down from producers to consumers requires the implementation of multicriteria analysis and forward-looking approaches.

Modelling of climate change impacts on agriculture is also a key issue of current research activities. Using a set of different models for estimating the uncertainty around a projection (also known as ensemble modelling) is a common practice in climatology, for example in IPCC work. Its use in agronomy is far more recent. International programmes on crop or grassland modelling such as for example AgMIP (The Agricultural Model Intercomparison and Improvement Project) and MACSUR (Modelling European Agriculture with Climate Change for Food Security) are currently under way. French modellers granted by AAFCC actively contribute to yield modelling for grasslands, maize or wheat. The use of multiple models enhances the reliability of the simulation of the impacts of future climate scenarios. These programmes also support the comparison and improvement of ecophysiological models. They contribute to strengthen the links between modellers at the international level and to initiate new projects. For example, the international community currently debates about the comparative efficiency and robustness of various types of models (semi-empirical, correlative or process-based). Preliminary results suggest that model ranking regarding their performances for yield estimation varies, depending on the use of past and current climate data or data from future climate scenarios

### **Multiple dimensions of work**

Since 2011, AAFCC has supported more than 25 national research

projects and international actions and networks. International actions increase the range of climate conditions and model species under investigation. Research projects address annual and perennial crops, livestock, forests, biodiversity or water and soil resources. AAFCC has also promoted training of young scientists through PhD grants and postdoctoral fellowships.

The issues and general objectives of the programme can globally be ordered according to the increasing response times of the systems, from short- to long-term, and the intensity and 'active' nature of the adaptation: from palliative or support actions, to innovation and technical or collective organisational breakthroughs. Such breakthroughs require strong innovations and a thorough socio-economic assessment.

The actions supported by AAFCC also encompass a gradient that include observation and experiments on agro-systems, ecosystems and socio-systems, and modelling for integrating knowledge and elaborating scenarios for future climate and practices. In addition, support to transfer and analysis of current strategies as well as multi-criteria assessment are implemented to elaborate innovations that should be efficient, economically realistic and socially acceptable.

Several major objectives have been assigned to the metaprogramme:

- assessing and managing the mid-term risks and opportunities, and defining strategies aimed at anticipating and mitigating climate crises;
- planning and developing scenarios (including quantitative estimates of uncertainty) for the regional impacts of climate change on agriculture and managed ecosystems (permanent grasslands, forests);
- understanding and controlling the main effects of climate change on biodiversity and its evolution, as well as the health of ecosystems, agro-systems and livestock;

- genetically improving cultivated, domesticated and livestock species, and strengthening the resilience of the different sectors as well as the crops and production systems;

- developing innovative adaptation technologies compatible with reducing emissions and increasing or maintaining the size of greenhouse gas sinks;

- identifying the costs and benefits of adaptation measures in respect of the various issues at stake (economic performances, biodiversity, water and soil resources, food supply, quality and safety);
- establishing collective organisation systems (governance, insurances, training, innovation, valorisation) that can strengthen the resilience of agriculture and forestry to climate change.

AAFCC-supported projects are a contribution to the implementation of Climate-Smart Agriculture. FAO defined and presented Climate-Smart Agriculture at the Hague Conference on Agriculture, Food Security and Climate Change in 2010. This vision of agriculture is composed of three main pillars: sustainably increasing agricultural productivity and incomes to achieve national targets in term of food security and development; adapting and building resilience of agricultural systems to climate change; reducing greenhouse gases emissions and increasing carbon sinks, where possible.

#### **Governance of AAFCC**

AAFCC governance includes a Steering Committee and an international Scientific Advisory Board. They define the strategic targets for the metaprogramme and they assess its achievements. In addition, a Stakeholders Committee involves end-users, NGOs and decision makers interested by the outcomes of the metaprogramme.

The Steering Committee is a team of researchers and support staff from INRA, chosen for their scientific skills and their knowledge of international tools and challenges. It writes and

manages the call for proposals, it evaluates and selects the international actions, it allocates PhD grants and it identifies the themes for postdoctoral fellows. The committee implements the recommendations of the Scientific Advisory Board and closely interacts with project coordinators. Finally, it provides communication and animation to the community involved in adaptation to climate change through presentations for INRA research divisions and in various events organized for the scientific community, for socio-economic partners and for stakeholders concerned by adaptation of agriculture and forests to climate change.

The Scientific Advisory Board consists in internationally renowned non-INRA scientists. Its purpose is to help in elaborating and actualizing the strategic vision needed for tackling scientific challenges and proposing innovations for adapting agriculture and forests to climate change. Bringing an external view and benefiting from the notoriety of its members, the Scientific Advisory Board evaluates the proposals on the basis of their scientific quality and originality. It also helps the Steering Committee in identifying cutting edge scientific questions.

The Stakeholders Committee has been established to serve as the preferential contact point with the representatives from the different concerned communities (ministry and state agencies, technical institutes, forest managers, representatives from agricultural sectors, competitiveness clusters, NGOs, ...). It gives an advice on the adequacy between on-going activities and needs, and on the impact of metaprogramme activities for stakeholders. It supports the development of AAFCC activities and contributes to their improvement through the co-construction of proposals and priorities for future actions. It also advises on the elaboration and implementation of the strategic agenda of AAFCC, especially from the training and transfer perspectives.

### A key issue: supporting the development of tools for adaptation

Climate change has caused the outbreak of a set of new services, entitled “adaptation services”, for which AAFCC should play a key role. The adaptation services market already represents a business activity with specialized actors (consultants, foundations, insurance companies) and many emerging services, especially regarding scenario making and impact assessment.

AAFCC aims at increasing the range of available services through the proposal of a service portfolio at the national scale with different temporal perspectives according to the considered sectors. This portfolio will rely on tools, maps and graphic illustrations elaborated using an agro-hydro-climatic modelling chain. The implementation strategy consists in elaborating a generic portal enabling public users and scientists to test different adaptation solutions. This portal should provide quantitative estimates of the impacts of climate and practices changes on fluxes and yields. It should also provide indicators useful for the assessment of the efficiency of adaptation measures.

Using a modelling chain, it will be possible to visualize different elements, from climate to water resources, integrating agricultural or forestry activities and the influence of climate, irrigation and aquifer level. Decision making tools will be produced for integrated and shared management of water resources as well as for adaptation of agriculture and forests to climate change, to support adaptive management and strategic adaptation at different scales (territory, watershed, whole metropolitan France).

The modelling chain and the service portfolio should meet the requirements of various stakeholders who are in charge of reasoning, planning and anticipating changes in agricultural

## EIGHT INRA METAPROGRAMMES

- ▶ **AAFCC**: Adaptation of agriculture and forest to climate change (*Coordinator: Thierry Caquet*) [www.accaf.inra.fr/en](http://www.accaf.inra.fr/en)
- ▶ **DIDIT**: Diet impacts and determinants: Interactions and Transitions (*Coordinator: Jean Dallongeville*) [www.didit.inra.fr/en](http://www.didit.inra.fr/en)
- ▶ **EcoServ**: Practices and services of anthropized ecosystems (*Coordinator: Guy Richard*)
- ▶ **GISA**: Integrated management of animal health (*Coordinator: Thierry Pineau*) [www.gisa.inra.fr/en](http://www.gisa.inra.fr/en)
- ▶ **GloFoods**: Study of transitions for global food security (*Coordinator: Alban Thomas*)
- ▶ **MEM**: Meta-omics of microbial ecosystems (*Coordinator: Emmanuelle Maguin*) [www.mem.inra.fr/en](http://www.mem.inra.fr/en)
- ▶ **SelGen**: Genomic selection (*Coordinator: Denis Milan*) [www.selgen.inra.fr/en](http://www.selgen.inra.fr/en)
- ▶ **SMaCH**: Sustainable management of crop health (*Coordinator: Christian Lannou*) [www.smach.inra.fr/en](http://www.smach.inra.fr/en)

### ACCAF KEY FIGURES

- € A budget about **5** million € per year, including operational costs and salaries (2014).
- ⚙️ **25** projects launched, involving **95** units and more than **300** Inra scientists (2014).
- 🌐 **12** Inra scientific divisions involved: Animal Genetics ([www.ga.inra.fr/en](http://www.ga.inra.fr/en)), Animal Physiology and Livestock Systems ([www.phase.inra.fr/en](http://www.phase.inra.fr/en)), Animal Health ([www.sa.inra.fr/en](http://www.sa.inra.fr/en)), Applied Mathematics and Informatics ([www.mia.inra.fr/en](http://www.mia.inra.fr/en)), Environment and Agronomy ([www.ea.inra.fr/en](http://www.ea.inra.fr/en)), Forest, Grassland and Freshwater Ecology ([www.efpa.inra.fr/en](http://www.efpa.inra.fr/en)), Microbiology and the food chain ([www.mica.inra.fr/en](http://www.mica.inra.fr/en)), Plant biology and breeding ([www.bap.inra.fr/en](http://www.bap.inra.fr/en)), Plant Health and the Environment ([www.sp.inra.fr/en](http://www.sp.inra.fr/en)), Science for Action and Development ([www.sad.inra.fr/en](http://www.sad.inra.fr/en)), Science and Process Engineering of Agricultural Products ([www.cepia.inra.fr/en](http://www.cepia.inra.fr/en)), Social Sciences, Agriculture and Food, Rural Development and Environment ([www.sae2.inra.fr/en](http://www.sae2.inra.fr/en))

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practices, in forest composition, productivity, health and management, in soil and water uses, and should therefore choose between different ecosystem services.

### The need for international cooperation

AAFCC is fully in line with the European Joint Programming Initiative on “Agriculture, food security and





Agroforestry, illustrated by this walnut trees-wheat field, is one of the paths for adaptation of agriculture to climate change. It is currently explored worldwide.

Christian Dubraz/MRA

climate change”, initiated by France and the United Kingdom to enhance coordination of national research programmes. In addition to the coordination and rationalization of research efforts between member states, working at the scale of Europe is also relevant for understanding the various phenomena and encompassing a diversity of climatic and soil conditions. Indeed, addressing some processes such as gene fluxes, species migration or pest dispersal requires large-scale studies.

International partnerships also provide interesting support to prediction. For example Mediterranean climate is probably going to expand north and westwards. Studies on this climate may therefore be useful to anticipate the future growing conditions for crops and the adaptation options for some French regions. Partnership reinforcement is also necessary to fully take advantage of the various environmental observatories distributed across Europe and worldwide. AAFCC supports various European-level initiatives through funding of some ERA-NETs. It also supports international (for example cooperative projects with India or south Mediterranean countries) or global (for example ensemble crop modelling) projects. Considering the issues at stake, international cooperation is undoubtedly, along with pluridisciplinary, the most important issue in this domain.

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