FACCE JPI pilot action call for
“The FACCE JPI Knowledge Hub”
on
“A detailed climate change risk assessment for
European
agriculture and food security, in collaboration
with international
projects”

MACSUR2 FULL PROPOSAL
MACSUR - Second Phase
Form A

Submission of the full proposal by the Main Coordinator
on www.submission-faccejpi.com
Deadline: December 03rd, 2014 15:00 CET

For further information, please visit us on the website
http://www.faccejpi.com
or contact the Call Office:
ptj-faccejpi@fz-juelich.de
(+49) 2461 61-2422
A1 - Summary

FACCE MACSUR aggregates research groups specialized on modelling grasslands, livestock, crops, farms, and agricultural trade. Researchers explore jointly how climate change will affect regional farming systems and food production in Europe and what adaptation and mitigation options exist.

In the first phase of FACCE MACSUR (June 2012-May 2015), we put emphasis on activities supporting the networking of scientists across and within the crop, grassland, dairy/livestock, farm, and socio-economic modelling communities. We achieved a greater understanding of the requirements of different existing approaches used in the modelling communities. At Theme level inventories and descriptions of available models served as basis for an agreement on core scenario assumptions for modelling activities across all three Themes in MACSUR, and on the definition of research priorities, e.g. crop rotations, uncertainty, stochastic economic models, grassland quality, representative agricultural pathways, farm-scale GHG emissions. These activities resulted in joint scientific publications, training workshops, and new collaborations within MACSUR and with scientists outside MACSUR.

In the remaining time until May 2015 we will summarise our results for presentations to policymakers and farmers as a base for soliciting further inputs from them. Concrete steps for engagement with stakeholders are planned at European level and in several countries.

In MACSUR2 we intend to build upon the strong links established by networking in MACSUR1 and strive for even greater precision in the scientific work of Theme activities. We will use models, techniques and methodologies already improved during MACSUR1, to carry out a new state-of-the-art Europe-wide climate change risk assessment for farming and food security. The methodology of upscaling of integrated models to European scale builds on the results of MACSUR1. This level of integration is therefore the pinnacle of the work of MACSUR2.

Given the scientific excellence of the Knowledge Hub we will address to a greater extent the interests of policymakers and the agro-food chain, especially farmers. For the implementation of MACSUR2 we will solicit and use input from our dialogue with stakeholders already gained in the 1st phase of MACSUR and continued along with the progress of the 2nd phase of MACSUR.
# A2 - Coordination

## Main Coordinator

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**FACCE JPI Knowledge Hub full proposal – Form A**
**LiveM Coordinator**

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## A3 - List of partners

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A4.1: MACSUR

Period M1-M28

State of the art & Impact on the advancement of the research area until now (describe the state of the art in modelling effects of climate change on agriculture, including the progress made in MACSUR and point out the current main difficulties encountered):

MACSUR represents a large, strong group of highly motivated researchers in the area of crop, livestock, and agricultural economic sciences realizing that understanding the impact of climate change in the area of agriculture and food production requires an analytical tool of integrated models. In MACSUR1 we started to integrate models in these three areas of research at regional level in different regions in Europe. In this first step of integrated assessment of climate change we focused on adaptation of crop and livestock production toward climate change at regional or local level – ideally at the level of agricultural farms. It became obvious that these analyses cannot be achieved by integrating models at global scale with a highly aggregated product and regional representation. Aggregated models especially in the area of economic modelling characterizes the feedback and the repercussions of climate change effects between national, regional and global levels. Assessing the consequences of climate change on food security, however, requires instruments able to cover potential trade-offs between food production, biodiversity and ecosystem services (see e.g. Soussana et al. 2012).

Here, MACSUR aims to develop shared methodologies for using models to assess the impact of climate change on European agriculture for food security with models. As a first step in MACSUR each Theme provided a detailed comparison of the models that are currently available. This work highlighted the strengths and weaknesses of particular models, indicated uncertainty of results and identified the need for further model improvements. This work contributed to a strengthening of the modelling community within each Theme of MACSUR and across different Themes. The outcome of this work is documented in the papers and reports on the three regional Pilot Studies of MACSUR1. One of the aims of MACSUR is to integrate modellers (and not only models!). This work has been carried out in various modelling workshops and training seminars.

As a first summary, one can state that MACSUR is a framework for the collaboration of experts in specialist areas that would not otherwise have achieved the critical mass required for advancement. We have achieved progress in bringing together experts from different disciplines to discuss the improvement of linkages between models, and to understand our requirements for models in other areas which we would like to use to continue and deepen in the next phase of MACSUR2.

Progress in the networking of the research community, including among the three Themes and disciplines & Cooperation with international initiatives (describe why the cooperation within MACSUR and between MACSUR and other initiatives is important for your field of research):

The MACSUR knowledge created a network of research and scientific excellence. The structure of a knowledge hub was new to all participants, although they had been actively involved or coordinated many large-scale international research projects. MACSUR has fostered new
collaborations among partners that have led to new consortia submitting proposals to national, international, EU and global funding schemes. From that point of view our various meetings at consortium and Theme level contributed to create and further develop this network as demonstrated by the publication of many joint papers and of project proposals. Out of MACSUR1 several research projects have been initiated.

The Theme structure of MACSUR provides a low-barriers opportunity for collaboration on defined subjects. Here MACSUR2 will continue to provide this opportunity, but we also would like to create a platform for collaboration on cross-disciplinary topics through joint MACSUR meetings. Here the set of eleven defined cross-cutting activities will become a very important element in MACSUR2 to foster and enhance an integrated assessment of climate change.

Transnational added value of the Knowledge Hub (explain why your work in MACSUR and this international cooperation benefited to all countries involved):

MACSUR involves 18 countries directly, even more through contacts with other projects. For countries with less developed capacity in agricultural modelling MACSUR is an opportunity to pick up on current trends and methodologies, to initiate contacts with established sub-networks and to become involved in cutting-edge project proposals involving MACSUR partners. Overall, collaboration across borders is enhanced and leads to a more complete picture of climate change impacts on agriculture and stakeholders and a European awareness of expected impacts. Internationally, MACSUR has become an access point for collaboration representing "Europe" as opposed to individual countries. This is especially noticeable from the perspective of larger countries like the US, regions like sub-Saharan Africa or international programmes.

Progress made in capacity building (explain how MACSUR improved the capacities of the research in this field in Europe):
Within the 1st phase of MACSUR we had a successful approach to capacity building which aimed in bringing modellers and not (only) models together.
14 supervised theses
7 training workshops: total attendance of almost 140 modellers
6 specialist workshops: total attendance of more than 160 researchers
5 internal workshops: total attendance 81
staff visits: ranging from 1 day to several months, total 248 person-days
Further details about these workshops and courses are described in the annual reports of MACSUR.

Period M28-M36

In addition please describe the main achievements expected until the end of MACSUR (M28-M36):

In the remaining time from October until May 2015 we will summarise our results for presentation to policymakers and farmers as a base for soliciting further input. Concrete steps for engagement with stakeholders are planned at European level and in several countries. Methods for assessing
climate change effects on farm level economics and possible management responses are currently being developed foremost by LiveM and TradeM partners. The implementation of these methods is intended in MACSUR2.

For the remaining time in MACSUR1 our results will be presented at two main events: First, a conference scheduled for April 8-10 at Reading University. This conference aims to develop the future agenda for integrated climate risk assessment in agriculture and food, to reflect on the achievements in MACSUR1 and to plan in detail activities in MACSUR2. Second, a stakeholder congress in Brussels on May 6, 2015. The seminar will presentation our results and enables us to receive inputs and feedback from decision-makers, farmers’ organizations, and other agro-business representatives on our planned activities, especially in the area of cross-cutting activities in MACSUR2. In addition advanced plans will be developed for a joint conference with AgMIP scheduled for February 2016.

A4.2: MACSUR2 (max. 10 pages)

New scientific/technological challenges beyond the first phase & Your concept (identify briefly the main core aspects that should be tackled in the next 2 years by the Knowledge Hub and how MACSUR2 will address them):

The scientific core activity of MACSUR2 continuing from MACSUR1, will be to maintain up-to-date results on climate impacts on agriculture and food security in line with selected core global socio-economic and climate scenarios until 2050. These results will serve as point of reference for additional socioeconomic or climate scenarios, models at sub-national scales, and for the assessment of specific adaptation or mitigation options by groups within MACSUR and also by external groups. Through these activities MACSUR became the first address in terms of integrated assessment of the impact of climate change on agriculture with food security in Europe. We will provide the international research community with tools to explore this information.

A new state-of-the art Europe-wide climate change risk assessment for farming and food security will be prepared based on the upscaling methodologies explored in CropM in MACSUR1 and using stochastic economic modelling approaches that incorporate farm management decisions including livestock and land management. The European assessment will be able to provide projections of general levels of projected crop and livestock production, flows of (EU-)imported and exported agricultural goods, input costs, crop prices, net farm revenues, and the accumulation of net production losses along the food chain under average weather conditions in the 2020s, 2030s and 2050s. This assessment will be area-based (spatially explicit) with coarse resolution (due to modelling restrictions) and broad assumptions on consumer behaviour, farm management, and other boundary conditions. The modelling approach will also address the ‘yield gap’ between actual and potential yields.

The regional case studies are the starting points for addressing region-specific climate and socio-economic impacts, needs and chances for adaptation and mitigation that cannot be addressed at the
European level. The current three regional integrated case studies (in Finland, Austria, and Italy) were selected as centres for testing methodological advancements in modelling aspects of food security with climate change. In MACSUR2, we will make use of the experiences gained in the regional integrated case studies by building up capacity in 10–15 other integrated studies within Europe (likely candidates are in Norway, Poland, UK, France, Spain, Germany, Denmark and Italy) but also outside Europe. The latter will be achieved by initiating a case study in sub-Saharan Africa. The regional case studies are the primary area for interaction with regional and national stakeholders. They will also be a resource for addressing potential shifts in consumer behaviour, obstacles for implementing best or good agricultural practices, and reactions to changes in policies and global economic conditions.

In addition to integrated case studies with a geographic focus we plan to add integrated case studies with a topical focus with contributions from CropM, LiveM and TradeM. These case studies will contribute answering burning questions in the current discussions of options for the mitigation of GHG emissions from agriculture (especially, methane and nitrous oxide) and for adaptation along the food and feed pathways:

1. Assessing the potential of optimising land and animal management (via e.g. fertilisation, feeding systems, feed quality, re-allocation of land use) under climate and socio-economic change.
2. Modelling the impacts of climate change on the quality of grassland/forage crops and the impact of these changes on the efficiency of feed utilisation by livestock and their economic consequences.
3. What difference can be made to GHG emissions from livestock systems through the implementation of mitigation measures versus the effect of changing human diets? Shifting away from livestock products in food diets is not an unrealistic track in post-industrial societies within the next decades. The crucial question is how fast and to what extent diets might change in Europe but also in other countries and regions with fast growing per capita income.

Improvement of networking and cooperation among Themes and disciplines (describe the main aspects that can be improved in terms of cooperation within MACSUR, among the Themes, the disciplines and with other initiatives):

These integrated research activities will require interaction and more intensive exchanges among scientists within and across disciplines. Work on these activities requires intensive exchange among scientists within and across disciplines, e.g. in the stocktaking of implemented methods, to find agreement on common approaches, and to test the validity of assumptions across geographical regions. Many cross-disciplinary interactions are further supported through Hub infrastructure: metadata exploration tools, joint workshops, support for junior researchers for workshop and conference participation, organisation of joint publications for researchers and stakeholders. We will continue from MACSUR1 the interaction with decision makers and agro-food-chain representatives. Investigating the ways in which model projections are utilised (e.g. interpretation of disease risk by policy makers etc.) and further development of farm-level management scenarios based on investigations of the responses of stakeholders to change, are critical elements feeding into geographical and topical integrated studies.

To our current knowledge only eight countries are willing to fund travelling to and participation in MACSUR meetings for the 2nd phase with the consequence of a severely reduced budget for this important activity. Therefore, in order to facilitate networking by physical contacts among MACSUR
members, meetings during the 2nd phase will be organised around four central dates in one place or by co-location with other major conferences.

By streamlining work within Themes and creating cross-cutting tasks and work-packages dealing with areas such as stakeholder involvement, scaling, modelling uncertainty and regional pilot studies, more within-Theme expertise will be shared between Themes, facilitating broad assessments of the state-of-the-art in these areas and collaborative work to fill identified gaps. Pooling resources in this way can create the critical mass of input required to produce policy-relevant outcomes.

**Knowledge Hub structure & Management (describe the overall work plan strategy, governance and management structure and explain the interrelation between WPs, eventually in a graphical way):**

**Lessons learned**
The knowledge hub structure is an innovative concept introduced by FACCE JPI, with MACSUR being the first knowledge hub to use the approach. Therefore, MACSUR had been asked to provide feedback on this instrument. Detailed comments were submitted in September 2013 to WP3 of FACCE JPI and with the mid-term report to FACCE GB, including comments to the appraisal by the SAB, in June 2014 which is summarized here:

**Benefits of a knowledge hub**
The knowledge hub has aggregated a large range of European researchers across the domains of crop modelling, livestock/grassland/farm modelling, and economic modelling that otherwise would not have formed such a consortium. This forum stimulated valuable discussions on the benefits of model improvements and model linkages using coordinated approaches. Results evolving from these discussions at several levels produced a tremendous output of publications, organized meetings, conference contributions, and number of trained people. Interaction with stakeholders was not the main focus of the original call but many discussions with policymakers and farmers occurred at regional and national level and were included in our interpretation of our results. Overall, we achieved a greater understanding of the existing requirements and different approaches in each Theme. The Themes adopted, as far as practical, similar organisational structures, inventories and descriptions of available models, agreed on core scenario assumptions for modelling activities, and research priorities, e.g. crop rotations, uncertainty, supply of feed protein, scaling issues. Members of the FACCE GB and StAB had been invited to comment on specific issues. Integration of WPs within each Theme varied depending on pre-call existence of common approaches within the disciplines. Restricted availability of funding within individual WPs reduced the opportunities for meeting and efficient alignment of research plans. Greater coherence among Themes resulted in joint scientific publications, training workshops, and new collaborations, funded and unfunded, within MACSUR and with scientists outside MACSUR.

Limited resources of course reduced opportunities for participation and active contribution of MACSUR members in MACSUR workshops. A large number of partners actively contributed to the Theme tasks and provided considerable amounts of own funds and resources that enabled the running of the knowledge hub

**Focus and management of a knowledge hub**
The setting-up of a large international Knowledge Hub requires the agreement on goals and methods
and coordination of inputs and outputs among groups, among various disciplines, and among hierarchical levels of the project. It also requires the establishment of modes of communication and data sharing. This preparatory work is typically carried out by the researchers in addition to their normal duties and is therefore spread over many months. In this implementation of a knowledge hub the preparatory work was necessarily part of the planning phase of MACSUR1. The number of tasks, available fresh money, time, and quality of scientific work involve trade-offs in what can be achieved by a knowledge hub. In-kind funding generates additional inflexibility for the contributions to a knowledge hub because the in-kind work is constrained by obligations to third parties. This inflexibility is compounded when it concerns several partners simultaneously.

The management of a knowledge hub with a large contribution of in-kind funding requires that participating members get a clear vision of their benefits they will gain through collaboration. This could be realized through the organization of regular scientific events with a well-defined structure, and the promotion of joint publications and joint research activities. The double nature of the knowledge hub as a network and research project with decentralised funding requires a difficult balance to be achieved between bottom-up driven decisions reached by consensus (as imposed by the structure) and the top-down directions necessary for making external contacts, for administration and, quick progress, and for the co-ordinated research activities. It has implications for reporting and administration of intellectual property rights. These challenges lead to the following conclusions:

(1) A balanced share of in-kind versus fresh funding among partner countries is desirable and conducive for joint efforts.
(2) New research or applying existing methods to new areas and interaction with stakeholders must be funded by fresh money.
(3) Equal eligibility rules for knowledge hub members to travel to meetings and carry out new research reduce the number of constraints that must be considered during project planning.
(4) A clearer scientific focus within the project call indicated by a smaller number of given tasks and a clear prioritisation of goals, would provide the required support to initial project coordination and facilitate the evaluation of a knowledge hub. Priorities must be set either by the funding agency or the project and should be reflected in the evaluation; this should include a clear communication of expectations based on a realistic assessment of what the research structure and associated resources can provide.
(5) MACSUR members must report to national funding agencies, MACSUR/FACCE, and usually to their institution. The time used by each member on reporting could be reduced if the reporting requirements and formats were co-ordinated among countries and if FACCE obtained obtain reports through the involved funding organisations.
(6) Knowledge created by members within MACSUR with „in-kind“ funding from other projects cannot be shared easily with the whole community. Confidential or licensed external data obtained by one MACSUR member (or even the hub) cannot be shared with all MACSUR members without additional negotiations with the data owner. This is because the consortium agreement forbids one member to act on behalf of other members due to concerns of the involved institutes about liability of misappropriated intellectual property.
(7) Projects involving many members need to invest a proportionally greater share of time and personnel to organisation, project management, and internal communication than smaller projects. Within-theme activities were accelerated by dedicated Theme management staff and plans for joint publications. Funding agencies must be aware of the need for the funding of organisational tasks within a knowledge hub.
One of the effects of the dominant top-down thematic organization of MACSUR1 was that cross-cutting activities were harder to achieve. In MACSUR2 we transcended the organisational structure set forth in the original call and introduced dedicated cross-cutting tasks with contributions from different Themes – specifically, in areas such as uncertainty, scaling, scenario development and impact assessment. Furthermore, in reaction to our experiences in MACSUR1, we set up timeslots for joint workshops in order to facilitate face-to-face interactions among groups. In response to reduced direct funding in many countries, other meetings will be organized adjacent to scientific conferences (although this arrangement is more suitable for specialist meetings than cross-cutting topics).

**Structure of MACSUR2**

The basic structure of MACSUR with hub coordination and CropM, LiveM and TradeM Themes, as specified in the original call, will be continued and complemented by emphasized cross-cutting activities (Fig. 1). Contributions to these cross-cutting activities come from each Theme and are coordinated at hub level. The leaders of the cross-cutting activities also serve as contact points for other projects who wish to collaborate on specific areas (Fig. 1).

![Structure of MACSUR2](image)

As specified in the original call and in the Consortium Agreement, the Hub is led by the Project Steering Committee (PSC), consisting of two coordinators of each Theme and two main coordinators. The role of the Theme coordinators was confirmed by the MACSUR membership in September 2014. The main coordinators stand for re-election at a scientific conference in April 2015. The work of the coordinators is supported tremendously by scientific managers.

Experience in MACSUR1 has shown that frequent (about monthly or shorter) virtual meetings of the project steering committee facilitate a coordinated approach to contacts with other programmes, projects, and organisations, dissemination and visibility, stakeholder contact, and networking at conferences. Decisions are usually reached in consensus to ensure endorsement across Themes and support by the overall membership.

Cross-cutting activities in MACSUR2, coordinated at Hub level, will concentrate on issues we
identified in MACSUR1 and would further elaborate in MACSUR2. They focus on tasks requiring a
joint approach across Themes and are supported in the MACSUR membership by sufficient financial
and time resources to carry out various research activities. These comprise scientific activities that
focus on methodological improvements, on regional, and societal and systemic challenges including:
(1) maintenance of results for core climate and socio-economic scenarios that serve as reference for
additional scenarios;
(2) a new state-of-the-art Europe-wide climate change risk assessment for farming and food security
which can address European-scale aspects like yield-gaps, extreme weather events, land allocation and
consumer behaviour;
(3) capacity building through the establishment of additional regional integrated case studies;
(4) addressing management options for mitigation and adaptation at farm level.
For further details of individual cross-cutting activities see the descriptions in WP H1 at the end of
Form A.

Output and products in MACSUR2
Cross-cutting and Theme activities in MACSUR2 expand the work carried out in MACSUR1.
MACSUR2 incorporates the tasks set forth in the FACCE JPI call (FACCE JPI 2011) that was based
on the Scientific Research Agenda (ScRA, FACCE JPI 2010) and addresses goals identified the
Strategic Research Agenda (StRA, FACCE JPI 2012). These can be summarized as capacity building
through interdisciplinary and cross-country learning and international collaboration; dissemination;
scenario development; and advancement of modelling methodologies (Fig. 2).

MACSUR was implemented within core theme 1 of the ScRA (FACCE JPI 2011, p3) with a focus on
scientific networking for improving modelling methodologies (FACCE JPI 2011, p5-6). In October
2012 the MACSUR project steering committee defined the mission of MACSUR, contributing to JPI's
mission (StRA, p9), as
• advancing science on the modeling of agriculture under climate change to improve food security through
  interdisciplinary European collaboration;
• working to the benefit of European policy makers, public institutions, farmers, consumers, and extension services;
• improving and integrating models and tools of crop and livestock production, farms, and national & international agri-
  food markets and demonstrates the integration of these models and tools for selected farming systems and regions;
• identifying the consequences of adaptation and mitigation measures and the availability, affordability and accessibility
to food for people across Europe;
• providing hands-on training to young and experienced researchers in integrative modeling;
• aiming at bolstering European capacity in responding to the challenges of food security and climate change and
  assisting countries outside the EU in their endeavours towards food security in the face of climate change.

Therefore, key outputs of MACSUR1 and MACSUR2 are the establishment of the network, joint
scientific conferences, joint scientific publications - especially statements on state-of-the-art in
modelling—, training courses, workshops, contributions to international research programs, and
maintenance of a website including information for a non-academic audience.

The proposed work reflects input from the MACSUR members and stakeholders obtained through
online-polls and takes into account the heterogeneous levels of direct and in-kind funding of
MACSUR partners. The degree of in-kind funding restricted how far individual contributions of
MACSUR members could be extended from goals of projects funded by other sources and how well
these contributions fit to communal efforts. Since the primary goal of a knowledge hub, as defined in
the call text (FACCE JPI 2011, p3), is to establish a network of researchers, MACSUR is giving
inclusiveness of researchers a higher priority than complementarity of each team's research
contributions.
Fig. 2. Contribution of WPs (coloured boxes) to the outcome of MACSUR (boxes with grey edge) and selected FACCE JPI goals (boxes with red edge). Only selected contributions among WPs are shown to reduce visual clutter. Titles of WPs are listed below.

In MACSUR2 a suitable subset of methodologies and models will be selected and used to assess the impacts of climate change on European agriculture (XC7), addressing goal II of the StRA (FACCE JPI 1012, p15). Since an impact assessment stands at the end of the modelling chain, XC7 will use four climate-socio-economic scenarios (SSP-RCP combinations) to complete the process started in a workshop in June 2013. At the same time, scenarios will be expanded in XC16 for use in a later impact assessment. Similarly, other XC activities and WPs in Themes continue improving methods (e.g. scaling) or expand the look at the ramifications of impacts (e.g. ecosystem services, feed production). The scientific results will be summarized in policy briefs for decision-makers.

Through its large network, MACSUR is addressing the tasks set in the call, thus answering modelling-related research questions in core theme 1 (modelling, benchmarking, policy research perspective) at local, regional, and European scale and cross-cutting issues of the StRA with the ultimate goal of advancing the science of modelling, training integrated modellers, and producing a state of the art impact assessment for Europe. In this way MACSUR is contributing the mission of FACCE JPI, »to achieve, support and promote integration, alignment and joint implementation of national resources under a common research and innovation strategy to address the diverse challenges in agriculture, food security and climate change.«
References
FACCE JPI. 2010. Agriculture, food security and climate change; Joint Programming Initiative (FACCE JPI); Scientific research agenda; Scope, common vision and priority actions. INRA, Paris, France. 18 pp.
FACCE JPI. 2011. FACCE JPI pilot action call for "The FACCE JPI Knowledge Hub" on "A detailed climate change risk assessment for European agriculture and food security, in collaboration with international projects", Forschungszentrum Jülich, Germany; 14 pp. + annexes.
FACCE JPI. 2012. FACCE-JPI Strategic research agenda. INRA, Paris, France. 50 pp.

Overview of work packages

| XC   | Coordination of XC1 'Model comparison & improvement'
| XC2  | Coordination of XC2 'Scaling'
| XC3  | Coordination of XC3 'Uncertainty & risk assessment'
| XC4  | Coordination of XC4 'Capacity building'
| XC6  | Coordination of XC6 'Regional case studies'
| XC7  | Coordination of XC7 'Impact Assessment for Europe'
| XC8  | XC 8 'Variability and extreme events'
| XC9  | Coordination of XC9 'Identifying sustainable opportunities to reduce yield gaps in Europe'
| XC11 | Coordination of XC11 'Feeding livestock: forage production, feed quality, efficiency of feed resource use and animal protein production'
| XC14 | Coordination of XC14 'Impact on ecosystem services and rural development'
| XC15 | Coordination of XC15 'GHG mitigation from agriculture'
| XC16 | Coordination of XC16 'Overall scenario development'
| C    | CropM
| C0   | Coordination
| C1   | Model comparison and improvement
| C2   | Data Management, analysis and presentation
| C3   | Methods of scaling and Model linking
| C4   | Uncertainty and risk analysis
| C5   | Capacity building
| C6   | Cross-cutting issues
| L    | LiveM
| L0   | Coordination
| L1   | Grassland and farm-scale modelling
| L2   | Livestock productivity
| L3   | LiveM-led contributions to XC activities
| T    | TradeM
| T0   | Coordination
| T1   | Model comparison and improvement
| T2   | Scientific advancements supporting integrated assessment approaches
| T3   | Cross cutting in hot-spot areas
| T4   | Capacity building in integrated modelling and policy assessment
**Data Sharing Statement (please include concise plans to facilitate data access and sharing of data and models across the scientific community):**

Data generated within MACSUR can be effectively exchanged via a database hosted by Aarhus University or by personal contacts among MACSUR researchers with rules defined in the MACSUR consortium agreement. Effective sharing of data collected outside MACSUR (mostly needed for calibration, validation, and driving of models) is often restricted by intellectual property rights which cannot be overcome simply within MACSUR because the knowledge hub is not a legal entity and the coordinators have no mandate to enter into legal contracts with third parties. Sharing of data and models in MACSUR2 will be further enhanced by encouraging data owners to publish their data in dedicated data journals (e.g. Open Data Journal for Agricultural Research [ODjAR.org], in collaboration with several other projects) or to deposit models on the AGRIMOD website (http://www.agrimod.org) that is currently under development. Further improvement is expected by national, European, and global initiatives for making data generated with publicly funds more easily available and the digitisation of paper-based data archives.

**Mobility & Capacity building:**

Mobility and Capacity building has several aspects: visits of individual researchers to other institutions and educational forms targeting groups of researchers. To this date five countries are willing to fund additional visits of researchers and five countries are willing to fund additional capacity building within the framework of MACSUR; three countries are willing to fund both.

Modeling and especially integrated modeling plays an important role in understanding climate change impacts within agricultural systems, with a wide range of modeling strategies across a broad spectrum of scientific fields. Many scientists who develop or use these models have only limited formal training in different models and in integrated model assessment work. Therefore limited experience with models from a wider range of fields can be a significant barrier to model integration and cross-Theme working. An important aspect of MACSUR is therefore to provide training and capacity building, both for early career scientists and more established researchers who wish to expand their capacity for integrated research. Post-graduate training courses in various aspects of modeling are therefore important to improve the knowledge of scientists working in this field. Much effort has already been put into development of Theme-specific courses. Training courses, both on-line and in-person, have also been developed at various partner institutions and as part of other projects. MACSUR2 will continue to build the experiences gained by partners so far within the three Themes. Possible options for future training include training for practitioners, e-learning development and use, PhD courses and more. Experience with training development, approaches to training, and training needs may be very different between Themes and the aim of this XC activity is to bring together the range of possibilities and experiences gained for presentation and discussion.

**Potential impact of MACSUR2:**

Cross-cutting activities in MACSUR2, coordinated at Hub level, will concentrate on issues we identified in MACSUR1 and would further elaborate in MACSUR2. These include (1) maintenance of results for core climate and socio-economic scenarios that serve as reference for additional scenarios; (2) a new state-of-the-art Europe-wide climate change risk assessment for farming and food security which can address European-scale aspects like yield-gaps, extreme weather events, land allocation and...
consumer behaviour;
(3) capacity building through the establishment of additional regional integrated case studies;
(4) addressing management options for mitigation and adaptation at farm level.

The modelling results of the cross-cutting activities are geared to inform decision-makers and the agri-food chain about the projected trends in crop and livestock production, and prices resulting from climate change and global population growth, about the implications of farm management practices, and about the feasibility and effectiveness of options for adaptation and mitigation at different spatial and organisational scales.

**A4.3: Beyond 2017**

*Please describe your plans for the continuation of MACSUR after the end of the second phase:*

The foremost goal of MACSUR is to enhance the European capacity for modelling agriculture for food security under climate change. The progress in MACSUR so far indicated that the greatest strength of our Knowledge Hub lies in its networking and setting of agendas for joint research activities across livestock, crop and economic modelling. This is achieved best and initiated through physical meetings and contacts. Therefore, our strategy for future ‘core’ funding will concentrate on securing means for travelling, scientific exchange and organisation of workshops. A visible output of the activity will be the publication of position and state-of-the-art papers and joint organisation of courses for junior scientists. Collaboration with other European and global organisations (e.g. AgMIP, Global Research Alliance on agricultural GHGs) will enhance the visibility of MACSUR and establish point of contacts to experts.

Whether the MACSUR will continue as a Knowledge Hub, as a larger integrated project funded within the current Horizon2020 of the European Commission or as an ERANet is not decided. But first steps for a project within Horizon2020 have already been made. Sources of funding or co-funding will be European programmes with a focus on science (most notably COST, Marie Skłodowska-Curie, ERANets, ESFRI) but also those with a focus on collaboration with practitioners (EIP-Agri Operational Groups) or businesses (ETPs). Basic continued funding, however, will be required for a secretariat for coordination activities like workshop organisation, arrangement of internal and external contacts, external representation and web site maintenance. Examples from other global programmes suggest that this funding may have to come from a single or a group of European countries that are committed to the subject in the long-term.
A5 – Work Packages

<table>
<thead>
<tr>
<th>WP H0</th>
<th>Hub coordination (Lead: Martin Banse)</th>
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<tbody>
<tr>
<td></td>
<td><strong>Start Month: 1</strong></td>
</tr>
<tr>
<td>Partner number</td>
<td>112</td>
</tr>
<tr>
<td>Person-Months</td>
<td>24</td>
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</tbody>
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Aim of the WP (brief description of the objectives and interrelations with other WPs):
This workpackage facilitates a successful co-ordination, implementation and management of the FACCE MACSUR knowledge hub. It will establish an efficient and effective management and co-ordination structure including planning. In order to achieve the successful coordination and management, the following tasks are formulated:

- Provide an infrastructure that will ensure the scientific integration across the three Themes of FACCE MACSUR together with the work in the cross-cutting activities (see WP H1). This work includes the delivery of the achievements according to specified quality and timeframe.
- Assist in the coordination of joint activities with LiveM, CropM and TradeM, as well as with the work packages and tasks located at the main level of FACCE MACSUR
- Facilitate communication across the Themes including the dissemination of results.
- Facilitate and support international collaboration of the Knowledge Hub
- Monitor project progress on a permanent basis

**Task H0.1:** Coordination of Hub activity (Lead: Banse (P112), Tiffin (P154), involved: Ewert (P115), Rötter (P92), Bannink (P173), Brouwer (P192), Scollan (P148), Sinabell (P209)) - Duration (Month 1 – Month 24)

The structure of FACCE MACSUR builds on the organisation of regular joint workshops across all three Themes, with a frequency of approximately every 6 months. Such frequent meetings will strengthen collaboration among the three Themes of the Knowledge Hub. Representatives of each Theme (coordinators and partners responsible to important WPs) will likely be able to attend these meetings. Another advantage of more frequent meetings is the development of existing and new cross-cutting activities across the three knowledge hub Themes. These meeting will serve three goals:
a) Facilitating the dissemination of results and feed-back and discussion of ongoing work;
b) Clarification of organizational issues like dissemination strategies and quality assurance; and
c) Planning of the cross-cutting activities listed in WP H1 below.

The last ‘meeting’ is planned to be a congress. The audience of such a congress is targeted beyond researchers involved in the network.

Work in this task will also provide a check and if necessary update of work plans. The responsibilities of Theme coordinators have been clarified at the start of FACCE MACSUR1, as well as of work package coordinators, coordinators of individual tasks and of the partners. If necessary adjustments will be made in order to achieve the goals of the network. Among the issues that will be continued is the update of our mission statement as well as the continued updating of the MACSUR research strategy. This work includes also the planning and identifying of future areas of research and facilitation of joint activities after the 2nd phase of MACSUR. Exploration of funding structure for MACSUR3 and the notification of funding opportunities for MACSUR members is also part of this.
task. This task also covers work on joint papers on state of the art, gaps, and visions for modelling of agriculture under climate change for food security.

**Task H0.2:** Management of Hub activities (Lead: Köchy (P112), Tiffin (P154), involved: Ewert (P115), Rötter (P92), Bannink (P173), Brouwer (P192), Scollan (P148), Sinabell (P209)) - Duration: Month 1 – Month 24

Among the roles of the knowledge hub management will be to write protocols of the meetings and report the deliverables to all project partners and the FACCE Governing Board providing justification for the expenses of FACCE MACSUR. The current consortium agreement of MACSUR provides a contractual framework guaranteeing that the necessary administrative tasks will be carried out swiftly and effectively. An objective of the main coordinator is to keep the administrative burden of the partners as low as possible without jeopardizing accountability. This management work will also cover the preparation and leading of PSC meetings, the interaction with partners and the interaction with FACCE secretariat, Stakeholder Advisory Board, the Governing Board as well as the Scientific Advisory Board.

Task H0.2 includes a control of workplans for MACSUR2 and the preparation of reports to FACCE, the administration of membership list, e-mail lists, web-site access, and the organisation of central meetings.

**Task H0.3:** Dissemination and visibility - Lead: Köchy (P112), Tiffin (P154), involved: Ewert (P115), Rötter (P92), Bannink (P173), Brouwer (P192), Scollan (P148), Sinabell (P209) - Duration: Month 1 – Month 24

Running and updating of the MACSUR website is an important part of this task. Regular newsletters will also provide detailed information about the outcome and progress of MACSUR. This also includes updating social media and contact to European stakeholders via biannual policy briefs. Opportunities for dissemination and visibility will be based on proposals made by the Theme leaders and available funding. The management of the knowledge hub provides the necessary infrastructure and coordinates these activities. This will also promote networking activities of all partners in the knowledge hub. The organization of special sessions at international congresses is one example of such activities.

A major task in maintaining and increasing the visibility of MACSUR is keeping contact with other projects and programmes. Here close links to AgMIP is one of the most important elements. Joint workshops and conferences together with a close collaboration in various research tasks will deepen our current link with these initiatives.

**Milestones:**
M-H0.1: Outline of the research gap report in collaboration with Theme leaders (M12)
M-H0.2: Regular progress reports (M6, M12, M18, M24)

Regular progress report after each central MACSUR meeting. The progress reports will be included in the newsletters of FACCE-MACSUR and published at the website. While the plan of work will be forward looking, the progress reports will be summarizing the activities.
carried out during the past six months of the Knowledge Hub.
M-H0.3: Upload of workshop presentations given at MACSUR workshops on the MACSUR website (one month after each workshop)

**Deliverables:**

D-H0.1: Research gap mapping (M24)
An important outcome of FACCE MACSUR is a mapping of research gaps which will outline the need for further research in the area of integrated climate change risk assessment for European agriculture and food security. This will integrate the research needs identified in the three Themes of the Knowledge Hub.

D-H0.2: FACCE MACSUR website (continuously)
Continuous update and maintenance of the MACSUR website for internal administration and for the presentation of outputs of all three Themes and for the wider public: This FACCE MACSUR website (www.macsur.eu) will provide the corporate identity of the Knowledge Hub.

D-H0.3: Dissemination of outputs (continuously)
Output and results of FACCE MACSUR will be published on the website if they are not published in scientific journals and related pieces of work will be linked to. Data sets or results of models will be an additional output and these data will be made directly available through the website or indirectly via a link to the website of the partners.

**Risks and contingence:**

Typical risks of project management failure involve unclear and ambiguous responsibilities and roles, lack of coordination between partners and tasks, the missing of deadlines, lower quality of outputs and, in the worst case, the fail of providing the deliverables. These typical risks are already addressed in the description of each Theme. Each Theme itself has a monitoring process in order to minimize these risks. With the established quality checks and control developed under MACSUR1 will try to minimize these risks.

At the main coordination level the main risk involve that the facilitation of partial case studies and the capacity building process starts too late or in the worst case will fail at all. The main coordination of the Knowledge Hub will clarify with the Theme coordinators at the outset of the project roles and responsibilities and make efforts to establish a quality assurance system through frequent progress reports and meetings at the level of Theme coordinators and if necessary with responsible WP leader every 6 months. These frequent meetings provide a framework to swiftly identify deviations from the planned status and to easily respond to deviations.

The experience of the main coordinators and the Theme coordinators in many scientific projects shows that a swift and hassle free project coordination and the provision of valuable public goods (e.g. newsletter, website, information on related project and activities, access to data and models, access to partners) for the partners is the best motivation for them to deliver excellent work. Minimizing the administrative burden of partners combined with clear signals when adjustments are needed in the case of deviations of agreed-upon plans and positive feedbacks in the other case are usually sufficient to motivate partners to give their best. Given that all partners involved in FACCE MACSUR have a high reputation this type of risk seem to be small.
The risk of failing to reach the goals of the FACCE knowledge hub: The project aims – among others - at increasing the scientific and technological excellence, at facilitating the transfer of knowledge, at facilitating data access and data sharing across the scientific community, at enhancing the visibility of European research in the international arena and at supporting policy decision making.

An important safeguard in order to minimize the risk not to reach these objectives is to implement and to continue with a functional project management (see above). The second is to give researchers the freedom to put most efforts into doing what they are best at doing. The team of researchers in FACCE MACSUR has a broad background of experience in modelling, policy advice and interdisciplinary work and all of them have a reputation to be able to transfer knowledge from the field of science to the practical needs of national stakeholders.

The coordination of FACCE MACSUR aims to provide partners the opportunity to learn from others, to report their own findings in a stimulating environment for scientist to collaborate across the three Themes and to learn from each other. For those partners not yet part of the international community of researchers in this field, the FACCE MACSUR will be a hub to become part of it and for those already established the project offers additional resources to strengthen the own role. The management strategy to make this possible is to organize frequent meetings providing opportunities for personal contacts and learning from each other. The aim is to organize the workshops in a way so they are open for other interested researchers to attend in order to maximize network effects. The plan to develop a quality assurance system and to promote the production of scientific journal papers is an effort to reach scientific excellence.
Cross-cutting activities (XC) in MACSUR2 concentrate on issues that in MACSUR1 we identified as requiring a joint approach across Themes and are supported in the MACSUR membership by sufficient financial and time resources to carry out meaningful tasks. These comprise scientific activities that focus on methodological improvements (XC1,3,4), on regions (XC6,7,16), and societal and systemic challenges (XC8,9,11,14,15). [Missing numbers refer to activities that have been relocated to Themes].

<table>
<thead>
<tr>
<th>Cross-cutting activities</th>
<th>Start Month: June 2015 (M1)</th>
<th>End Month: May 2017 (M24)</th>
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<tbody>
<tr>
<td>XC1 Model comparison &amp; improvement</td>
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<td>XC2 Scaling</td>
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<td>XC3 Uncertainty and risk assessment</td>
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<td>XC4 Capacity Building</td>
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<td>XC6 Regional case studies</td>
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<td>XC7 Impact Assessment for Europe</td>
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<td>XC8 Variability and extreme climatic events</td>
<td>149</td>
<td>1</td>
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<tr>
<td>XC9 Identifying sustainable opportunities to reduce yield gaps in Europe</td>
<td>128</td>
<td>2</td>
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<tr>
<td>XC11 Feeding livestock: forage production, feed quality, efficiency of feed resource use and animal protein production</td>
<td>147</td>
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<tr>
<td>XC14 Impact on ecosystem services and rural development</td>
<td>148</td>
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<td>XC15 GHG mitigation from agriculture</td>
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<td>XC16 Overall scenario development</td>
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Results of the cross-cutting activities are geared to inform decision-makers and the agro-foodchain about the projected trends of crop and livestock production, and prices within the constraints of climate change and global population growth, implications of farm management practices, and about the feasibility and effectiveness of options for adaptation and mitigation at different spatial and organisational scales.

These integrated research activities will involve more interactions among scientists across disciplines. Work on these activities requires intensive exchange among scientists within and across disciplines, e.g. stocktaking of implemented methods, agreement on common approaches, and validity of assumptions across geographical regions. Cross-disciplinary interactions are supported through centralised workshops and joint publications. We will continue from MACSUR1 the interaction with decision makers and agro-food-chain representatives foremost by newsletters as suggested by a survey of stakeholder's preferences. Each XC activity has an assigned contact from the Project Steering Committee close integration in hub activities and exchange of information.

Tasks below present each XC activity and its overall goal. Coordinated sub-tasks are led by a member of one of the three Themes (CropM, LiveM, TradeM) where the person-months are also allocated.

Milestones and Deliverables resulting from the coordination of each XC activity are listed at the end of this Work Package.
Task H1.0: Administration of XC activities (Task leader: Köchy (P112)) - Duration: M1 – M24

Providing formal guidance to cross-cutting activities for overall integration.

Task H1-XC1: Coordination of XC1 'Model comparison and improvement' (Task leader: Bellocci (P175), Bindi (P62)) - Duration: M1 – M24

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Triggered by the need to answer new scientific questions, but also by the need to improve the accuracy of simulations, model improvement is expected to continue resulting from emerging new questions, better knowledge of physiological mechanisms, and higher accuracy standards. A scientific knowledge hub is a critical pillar to advance in good modeling practice in relation to model evaluation and improvement, an activity which is frequently neglected in the context of time-limited framework programs. Many of the models used in MACSUR are combining aspects of various disciplines. There is a continuum from models for specific purposes to truly integrated ones. In the first step an overview will be made of integrated models and a method will be developed to classify them. We point out that (1) the evaluation of C-L-T models can be improved through stakeholder follow-up, which is a key for the acceptability of model realizations in practice, (2) model credibility depends not only on the outcomes of well-structured, numerically-based evaluation, but also on less tangible factors that may need to be addressed using complementary deliberative processes, and (3) comprehensive evaluation of simulation models can be achieved by integrating the expectations of stakeholders via a weighting system of preferences and perceptions.

Coordinated sub-tasks:

XC1.1 Survey on model improvement needs (C1.6) (Task leader: Bindi (P62), partners involved: Acutis/Cassardo/Doro/Dono/Cortignani (P62), Biewald (P83), Heckekei/Zimmermann (P115), Slawinski (P139), Kersebaum (P147), Bellocci (P175), Sinabell (P209)) - Duration (M1 – M24)

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In this task partners and stakeholders are asked about their views and priorities with respect to the quality of model outputs and improvement of different models. This task means to increase awareness of model strengths and weaknesses with ground on the modelling exercises performed during the first phase of MACSUR within the three Themes. Taking stakeholders’ perspectives on board in the model improvement will be one way of developing model capabilities with focus on the operational role of models in decision-making and policy implementation. This work will build on the inventories of crop, grassland-livestock and trade models established during the first phase of MACSUR. In a first step, model developers will be asked to identify recent model improvements and the rationale to do so. Once a comparison is established, areas that need to be further improved will be identified. Developing ways to improve existing models and / or designing new ones that are better will be the major work in
this cross-cutting activity. The structure will likely depend either on the scale (global, continental, and local), on the type of model (deterministic, stochastic ...), or on the topic (protein, water demand ...). Attention will be paid to land surface models applied at regional areas in order to improve the knowledge of micrometeorological conditions within the plants and correlate such variables with physiological measurements. This would improve the plant system knowledge and suggest better practices for improving crop productivity. In MACSUR2, we are planning to apply these methods to vineyards (as approached in the first phase of MACSUR). Despite the specific application to vineyards, the methodology adopted could be easy transferred to other systems.

Sub-task milestones and deliverables:
M-XC1.1.1: Progress presentation at MACSUR2 conference (October 2016)
M-XC1.1.2: Science-stakeholders workshop (April 2016)
D-XC1.1.1: Needs of model improvement (June 2016)
D-XC1.1.2: Chapter on the relation between micrometeorological conditions and plant physiology (April 2017)

Sub-task XC1.2 General framework for model evaluation and comparison (L3.1) (Task leader: Bellocchi (P175), partners involved: Acutis/Bindi/Cassardo/Doro (P62), Slawinski (P139), Sandars (P143), Kersebaum (P147), Sinabell (P209)) - Duration (M1 – M24)

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A benefit can be obtained if model evaluation is conceived in a decisional perspective and evaluation techniques are developed at the same pace with which the models themselves are created and improved. Thanks to CropM-LiveM cross-cutting activity on model evaluation, a framework for crop and grassland model evaluation was developed (based on a weighting system of preferences and perceptions, and on lower and upper fuzzy bounds) during the first phase of MACSUR (D-L2.2), which also allows to attach a value to a model in a comparative work. In MACSUR2 we will keep on developing and generalizing a framework for evaluation where we define settings for C-L-T models. The ultimate objective is to improve reliability and robustness of models in order to attain valid results that are useful for decision makers. To develop common judgment criteria over disciplines is an important step. While reviewing the use of metrics for model evaluation, emphasis will be put on the involvement of stakeholders to expand horizons beyond structured, numeric analyses. Two major topics will be discussed: (1) the importance of deliberative processes for model evaluation, and (2) the role computer-aided techniques may play to integrate deliberative processes into the evaluation of C-L-T models. We utilize the most important metrics and weighting factors to evaluate models with respect to the needs identified in task XC1.1. Hence a more explicit link will be established between model evaluation, model development and model-based decision-making. In this task we focus on the plausibility of evaluation settings for operational purposes and good modelling practice.

Sub-task milestones and deliverables:
M-XC1.2: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC1.2.1: Review of metrics for model evaluation (June 2016)
D-XC1.2.2: Common protocol for model evaluation (April 2017)
Sub-task XC 1.3 Establishing links to other research activities in the field of model comparison and improvement (C1.7) (Task leader: Haas (P101), partners involved: Semenov (P25), Bindi/Cassardo (P62), Bojar/Knopik/Żarski (P100), Slawinski (P139), Kersebaum (P147), Bellocchi/Jayet/Perez-Barahona (P175), Lazar (P191), Helming (P192)) - Duration (M1 – M24)

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This task will be developed in close connection with XC Uncertainty, task 3.2, to establish links to other research activities and consortia on the field of model comparison and improvement. Potential consortia to establish links are AgMIP Uncertainty (http://www.agmip.org/uncertainty) and crop pilots, GRA Uncertainty (http://www.globalresearchalliance.org) and other national, EU and global projects on the field of model comparison and improvement. As well as XC3.2, the task aims to establish links to other projects and researchers, to communicate recent results, to share methods, to establish and foster cooperation between MACSUR partners and other researchers and to communicate opportunities for future research calls to involve MACSUR2 partners. The task aims as well to report MACSUR findings to other consortia.

Sub-task milestones and deliverables:
M-XC1.3: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC1.3: Links established with other consortia (June 2016)

Task H1.XC2: Coordination of XC2 'Scaling' (Task leaders: Ewert/Hoffmann (P115)) - Duration: M1 – M24

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This activity will provide an inventory of scaling methods of models used in the different Themes. For this purpose, crop, farm and economic models used in MACSUR and beyond will be screened for data types and data scales. The flexibility, rules and restrictions when dealing with data at different scales will be reported along with the applicability and actual use of scaling methods. In order to establish a basis for the comparison of scaling methods across varying model types, suitable common parameters of model-scaling method combinations will be identified. These are intended to serve as indicators for characterizing the model and data scale set-up. In addition, possible metrics for evaluating scaling methods across model types will be screened and rated qualitatively based on simulation experiments and literature.

Coordinated sub-task:
Sub-Task XC2.1: Inventory of scaling methods across crop, farm and economic models (C3.6) (Task leaders: Ewert/Hoffmann (P115), partners involved: Roberts/Eory/Stott (P47), Minet/François (P51), Rolinski (P83), Tao/Rötter (P92), Kiese/Haas/Arneth (P101), Dechow/Grosz (P112), Sandars (P143), Kersebaum/Nendel (P147), Saetnan (P148),
Scaling methods for different model types across all MACSUR Themes will be studied for common characteristics. The range of application (scale) and flexibility, rules and restrictions with varying data types will be reported based on findings from the literature. An inventory of scaling methods for model in different as typically used in the three Themes and possible metrics for evaluation will be reported.

Sub-task milestones and deliverables:
M-XC2.1: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC2.1: Review of scaling methods (April 2017)

Task H1.XC3: Coordination of XC3 'Uncertainty and risk assessment' (Task leader: Haas (P101)) - Duration (M1 – M24)

Future food security will be challenged by the likely increase in demand, changes in consumption patterns and the effects of climate change. Framing food availability requires adequate agricultural production planning. Decision-making can benefit from improved understanding of the uncertainties involved. The aim of the study is to identify and quantify the sources of this uncertainty and explore their interactions and influence on precision and accuracy of agricultural estimates, with emphasis on modeling of food and fodder. International model inter-comparison projects (as AgMIP or MACSUR) may represent an ideal framework to conduct a deeper analysis of this issue. Ignorance about future crop varieties and phenological development features are a significant source of uncertainty in the future agricultural socio-economic context for adaptation to climate change (and a significant aspect for the design of the Representative Agricultural Pathways).

Models may estimate the risks that farmers and consumers face in an increasingly uncertain and variable climate. Farmers will face yield and price risk, while consumers face only the price risk. On the other hand, farmers have generally larger volumes exposed to price risk, while the price risk can be life-threatening for low-income consumers. For farmers the low yields are to some extent correlated with compensating high prices.

Coordinated sub-tasks:

Sub-task XC3.1 Overview on studies and research activities relevant to uncertainty assessments and quantification (C4.7) (Task leaders: Haas (P101), Trnka (P17), involved partners: Severini/Dono/Cortignani (P62), Porter (P71), Rötter/Palosuo (P92), Arneth (P101),
Höglind (P128), Wallach (P175))

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All partners will collect information of all studies and research activities relevant for assessing and quantifying uncertainty in crop, feed and livestock production across CropM, LiveM and TradeM. This review will condense the results of related studies in arable and grassland systems for crop and feed production as well as in livestock production at farm level. The review will also include socio economic studies to represent the knowledge base of MACSUR. Based on the result of the review specific uncertainty assessment and quantification methodologies applicable on European agricultural systems will be analysed, validated and shared across all MACSUR members.

The cross cutting communication of results on uncertainty studies will lead to an exchange of methods and methodologies among MACSUR partners. This will be conducted in close relation to all MACSUR summer schools.

**Sub-task milestones and deliverables:**
M-XC3.1.1: Document summarizing all uncertainty related activities in MACSUR. To be communicated with the MACSUR Newsletter at least bi-yearly (June 2016, May 2017)
M-XC3.1.2: Workshop on the review of studies and research activities relevant for uncertainty assessment and quantification in crop, feed and livestock production in MACSUR (May 2016)
M-XC3.1.3: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC3.1.4: Summary document on uncertainty and risk in MACSUR (Oct 2016)
D-XC3.1: Review paper and/or special issue on studies and research activities relevant for uncertainty assessment and quantification in crop, feed and livestock production in MACSUR (January 2017)

**XC3.2. Establishing links to other research activities in the field of uncertainty assessment and quantification** (C4.8) (Task leader: Haas (P101), Partners involved: Severini/Quaranta (P62), Rötter (P92), Bojar (P100), Arneth (P101), Hoveid (P128), Wallach (P175)) - Duration (M1 – M24)

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We will establish links to other research activities and consortia on the field of uncertainty assessment and quantification. Potential consortia to establish links are AgMIP Uncertainty ([http://www.agmip.org/uncertainty/](http://www.agmip.org/uncertainty/)), GRA Uncertainty ([www.globalresearchalliance.org](http://www.globalresearchalliance.org)) and other projects from national to global dealing with uncertainty assessment and quantification related to climate change impact and adaptation. Examples of relevant national level projects include, e.g. Academy of Finland projects PLUMES and NORFASYS ([http://www.mtt.fi/modags/modags_PilotStudies.html](http://www.mtt.fi/modags/modags_PilotStudies.html)). AgMIP has performed some studies according to various models, RAPs and SSPs and the task aims to give MACSUR partners up to
date summaries and reviews. We will also consider stochastic modeling from finance and macroeconomics which might have been transferred to applications in agriculture. The task aims to establish links to other projects and researchers, to communicate recent results, to share methods, to establish and foster cooperation between MACSUR partners and other researchers and to communicate opportunities for future research calls to involve MACSUR2 partners. The task aims as well to report MACSUR findings to other consortia.

**Sub-task milestones and deliverables:**

M-XC3.2: Bi-yearly communicating external activities and research findings within MACSUR2 (June 2016, May 2017).

D-XC3.2: Documents summarizing all uncertainty related activities of interest to MACSUR to be communicated at the MACSUR Scientific Conference (2016) and with the MACSUR Newsletter (bi-yearly (June 2016, May 2017)).

**Task H1.XC4: Coordination of XC4 'Capacity building'** (Task leader: Eli Saetnan (P148)) - Duration (M1 – M24)

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Modelling has become a widespread tool for understanding complex dynamic systems. In particular, modelling plays an important role in understanding climate change impacts within agricultural systems, with a wide range of modelling strategies across a broad spectrum of scientific fields. Many scientists who develop or use these models have only limited formal training in model development. Any experience with models from a wider range of fields is even more limited, which can be a significant barrier to model integration and cross-Theme working. An important aspect of MACSUR is therefore to provide training and capacity building, both for early career scientists and more established researchers who wish to expand their capacity for integrated research. Post-graduate training courses in various aspects of modelling are therefore important to improve the capacity of scientists working in this field. Much effort has already been put into development of Theme-specific courses. Training courses, both on-line and in-person, have also been developed at various partner institutions and as part of other projects. MACSUR2 will continue to build the experiences gained by partners so far within the three Themes. Possible options for future training include training for practitioners, e-learning development and use, PhD courses and more. Experience with training development, approaches to training, and training needs may be very different between Themes and the aim of this XC activity is to bring together the range of possibilities and experiences gained for presentation and discussion.

**Coordinated sub-tasks:**

**Sub-task XC4.1: Development of integrated training strategy** (L3.2) (Task leader: Saetnan (P147), involved: members of CropM, LiveM, TradeM)

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Developing new training courses requires a clear strategy, and considerable time and resources. It is therefore important to clarify which training resources are currently available, provide appropriate signposting for relevant training, and identify gaps in training needs. Possible options for future training include training for practitioners, e-learning development and use, PhD courses and more. Training courses can range widely in the intended audience (from novice to advanced, developer to user), focus (general to specific), and format (in person or online). For MACSUR to function as an effective knowledge hub, it is important to consider not only Theme specific needs, but also the needs of the wider community in order to develop an effective training strategy.

Sub-task milestones and deliverables:
M-XC4.1: Workshop at Reading hub conference (Apr 2015) The session will bring together interested partners to decide the focus, extent and structure of the MACSUR phase 2 training strategy, building on work developed within the knowledge hub in phase 1, the review paper on communicating modelling (Kipling & Ozkan – in preparation), identified gaps in training, and the interests and capacity of partners.

D-XC4.1.1: Report describing the MACSUR phase 2 training strategy, including a timeline for and the focus and extent of training resources, and a plan for attracting funding for continuation of training structures beyond 2017 (July 2015)

D-XC4.1.2: An on-line signposting resource assembled and made available for scientist and students working in the field of agricultural modelling (November 2015)

Sub-task XC4.2: Development of a multidisciplinary e-learning course aimed at MSc and PhD students (C5.2) (Task leader: Porter (P71), partners involved: Bindi/Dono/Cortignani (P62), Saetnan (P148), Wallach (P175), van Ittersum (P195), Manschadi/Schmid (P208)) - Duration (M1 – M24)

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Online training courses provide an effective way to raise awareness of agricultural modelling, allowing participants from across Europe and beyond to engage with course content and increase their understanding of the techniques and value of modelling as a tool for informing decisions at both farm and policy levels. Within MACSUR, the development of an online training resource would enable a rich variety of training materials to be brought together from partners in different Themes and different countries. The course will be based around IPCC AR5 themes, to give it a relevant focus for a wide audience. Such a multidisciplinary course could be expected to attract as many as 70 students per year based on current numbers and experience (please see www.climate-change.dk). The timetable for this would be 12 months for implementation of the course for MACSUR2, with the course running once per year (15 ECTS) during the MACSUR2 project thereafter.
**Sub-task milestones and deliverables:**
M-XC4.2: Outline of course reported (January 2016)
D-XC4.2: Online training for agricultural professionals active (extent and detail of the resource to be determined in D-C5.1) (May 2016)

**Subtask XC4.3: Course on agricultural production and environmental modeling (T4.1)**
(Task leader: Schmid (P208), partners involved: Dono/Cortignani (P62)) - Duration (Month 01 – Month 24)

The objectives of the course are (i) to learn how to use GAMS (General Algebraic Modeling Systems) in building and solving programming models, (ii) to learn good model building in GAMS, (iii) to build and apply programming models, and (iv) to interpret, synthesize, and report model results. Students will be able to build and analyse farm, regional, and partial equilibrium programming models and to integrate risk in farm level analyses and trade in regional analyses. Strategies to integrate environmental indicators and to link different types of models (e.g. biophysical models and economic models) will be demonstrated in the context of land use model analyses. Selected scenarios developed in WP T1 will be discussed during the course and working on them give the students the opportunity to get involved in an international project. The focus group of the course will be students but will be open for partners of the Knowledge Hub to attend.

**Sub-task milestones and deliverables:**
M-XC4.3.1: Training course on policy impact assessment announced (M4)
M-XC4.3.2: Training courses on policy impact assessment finalised (M20)
M-XC4.3.3: Participants receive ECTS points for their attainments (M22)
D-XC4.3.1: Curriculum and announcement for course on policy impact assessment (M02)
D-XC4.3.2: Report on achievements of modelling course (M24)

**Subtask XC4.4: Co-operation in capacity building activities with international partners (T4.2)**
(Task leader: Schmid (P208))
The objective of this task is to establish links to international partners (e.g. AgMIP) working in related fields and to seek for co-operation in capacity building activities. One element of such a co-operation could be to hosting courses for international partners, a second element could be to making arrangements that researchers among the partners of the MACSUR network are invited to get involved in such activities. The final attainment in this task is beyond the control of TradeM because it also depends on the willingness of international partners to get involved in such an activity.

**Sub-task milestones and deliverables:**
M-XC4.4.1: International modelling course is announced (M6)
M-XC4.4.2: International workshop takes place (M18)
D-XC4.4.1: Curriculum and announcement for international modelling workshop (M2).
D-XC4.4.2: Report on achievements of modelling course (M 24)
Case studies at a small regional scale are well suited for integration of crop production, livestock production and farm models, interaction with stakeholders and consideration of environmental conditions. The complexity explored at the case studies level will enable us to deconstruct the climate change-related-issues grounded in a wide range of EU biophysical and socio-economic contexts, which is the basis for a European wide picture that complements the Impact Assessment for Europe (XC7) from a regional perspective. The different approaches that have been used for conducting integrated assessments from a Crop, Live and Trade perspectives at the regional case study scale, will allow us to explore the implications for developing effective adaptive responses in different contexts. Such assessment will be enhanced in some cases by the integration of scientific and lay knowledge leading to contextualized scenario analyses in which model outputs can provide conducive mediating objects between researchers, stakeholders and policy makers. The integrated analyses will be summarized according to a comparative SWOT framework (strengths and weaknesses, opportunities, threats) with respect to their suitability for assessing CC impacts on agriculture for food security (including e.g.: model integration, participation of decision makers and decision takers, scenario development, scaling potential, uncertainty reflection, and tool development). The comparison will allow researchers and policy makers to learn and reflect on the development of effective adaptive responses to CC impacts on agriculture and food security.

Coordinated sub-tasks:

Sub-task XC6.1. Integrated assessment modelling at the regional case study scale (T3.1)  
(Temporary task leader: Mittenzwei (P128), Roggero (P62), involved persons: Acutis/Bindi/Cassardo/Dono/Cortignani/Doro/Lacetera/Pasqui/Ponti/Quaranta/Toderi/Ventrella (P62), Dalgaard (P189), Höglind/Özkan/Mittenzwei (P128), Holman/Sandars (P143), Sieber/Zander (P147), Lazar (191), Sinabell (P209)) - Duration (M1 – M24)

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The task is intended to answer to the following questions: (i) what kind of impacts in terms of farming performances can we expect from climate change on the agricultural systems in different European contexts? (ii) what kind of adaptive responses can be envisaged to mitigate the impacts or to identify win-win pathways for agriculture in different environmental and socio-economic contexts in EU? (iii) How is it possible to combine crop +live + trade models in developing an integrated assessment at field to district scale of the impact of changing climate conditions?
in relevant EU farming systems?

The hypothesis underlying this task is that the available data at each MACSUR regional case study is sufficient for the calibration and validation of Crop and/or Live and or Trade models able to assess the impact of climate change on crops and/or livestock and grasslands and consequently on trade systems. Ideally, datasets should be designed according to a preliminary consultation of stakeholders to identify relevant indicators/variables about CC impacts of farming systems. The regional case studies are intended to provide a contextualized assessment of the CC impact to address adaptive responses at different levels (farm to district). The modelling will integrate the downscaled climatic scenarios with crop or livestock and grassland models and the Crop/Livestock model outputs will be input for economic assessments. Various models and approaches will be used in the different case studies, depending on specific tools and input datasets available. The case studies will provide a unique opportunity for engaging an interdisciplinary assessment of the many uncertainties associated with integrated modelling. This activity will be closely correlated with those Theme activities on models development in the three MACSUR Themes.

Sub-task milestones and deliverables:

M-XC6.1.1: Workshop to design the minimum datasets required for a case study to be eligible, including climatic datasets and to make an inventory of the models and methods of integrated assessment used for each case study (October 2015) [This milestone is intended to take into account of the chosen scale for each case study (farm-type, district or region)]

M-XC6.1.2: Exchange (via shared platform) of outcomes on preliminary assessment of CC impacts on crops and/or livestock/grasslands (April 2016)

M-XC6.1.3: Exchange (via shared platform and skype conferences) of outcomes about the preliminary assessments of CC impacts at farm/district scale using trade models (October 2016)

M-XC6.1.4: Final workshop on the results of the Integrated assessment by combining biophysical and economic models (October 2016)

D-XC6.1.1: List of case studies, archives of datasets for model calibration, models and integrated assessment procedures for each case study (December 2015)

D-XC6.1.2: Report on preliminary assessment of CC on relevant crops/live/grasslands

D-XC6.1.3: Report on preliminary assessment of CC at case study (i.e. food chain, farm type or district scales) (December 2016)

D-XC6.1.4: Paper(s) on case study assessments (June 2017)

Sub-task XC6.2. Comparison of case studies including development of criteria of comparison (L3.3) (Task leader: Dalgaard (P189), partners involved: Lorite/Ruiz-Ramos/Gabaldón (P24), Roggero/Dono/Ventrella/Viagi (P62), Rusu (P85), Lehtonen (P92), Bojar/Knopik/Żarski (P100), Kozyra (P125), Mittenzwei (P128), Sławiński (P139), Zander (P147), Hoffmann (P154), Schönhart (P208)) - Duration (M1 – M24)
The task is intended to answer the following question: what are the commonalities and divergences among the different impacts of CC in agricultural systems under different EU contexts? The comparative analysis is designed to compare the same agro-food sector under different climatic, agricultural and socio-economic context but also to assess the expectations of the impacts of CC in different EU regions and districts. The comparative analysis will evidence the vulnerability of the relevant agricultural districts in the EU in relation to the specific expectations on local climatic scenarios and the structure of the agro-food sectors in the different EU regions. The comparative analysis will provide a detailed and contextualized picture of issues and options for adaptive responses. A synthetic comparison may be designed through a multiperspective SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis deriving from integrated modelling assessments (i.e. XC6.1) and scenario analyses developed through a sound design of stakeholder engagement strategies (developed in MACSUR 1). The hypothesis underlying this task is that the options for the development of site-specific adaptive responses will emerge from an integrated assessment by combining scientific and lay knowledge. However, the comparative analyses will also serve as a learning space to understand the demand of scientific knowledge and innovation in the governance of the CC adaptation strategy.

Sub-task milestones and deliverables:

M-XC6.2.1: Workshop to design a common framework for the comparative analysis
M-XC6.2.2: Exchange (via shared platform) of the outcomes of the comparative analyses based on integrated modelling assessments
M-XC6.2.3: Exchange (via shared platform) of the outcomes of the SWOT analyses of each case study
D-XC6.2.1: Report on shared framework for comparative analysis of case studies (December 2015)
D-XC6.2.2: Report on preliminary outcomes of the comparative analyses based on IAM (December 2016)
D-XC6.2.3: Report on comparative SWOT analysis (February 2017)
D-XC6.2.4: Paper(s) on case study comparative analysis at regional or pan European scales (June 2017)

Sub-task XC6.3 Synopsis of case studies from a European perspective and comparison with results by XC7 (C6.1) (Task leader: Roggero (P62), partners involved: Lorite/Gabaldón/Ruiz-Ramos (P24), Dono/Lacetera/Ventrella (P62), Lehtonen (P92), Höglind/Mittenzwei (P128), Sławiński (P139), Zander (P147), Schönhart (P208))
This task is designed to summarize the outcomes obtained from XC6 in a way that can be used to engage institutional stakeholders in identifying gaps and pathways to address effective adaptive responses to CC challenges in agriculture throughout the EU. The hypothesis is that by providing a wide range of detailed contextualized quantitative analyses of the impact of CC on farming systems, we will address the most relevant constraints and gaps in knowledge to develop adaptive responses to CC for food security in the EU. This approach is not designed to achieve a pan-EU analysis at broad scale (e.g. broad scale maps of CC impacts): instead, the detailed contextualized analysis of contextualized situations will provide a unique opportunity to identify communalities and divergences in addressing CC issues in different climatic and socio-economic situations. The synopsis is expected during the last 6 months of the MACSUR-2 activities, after the quantitative assessments have been obtained and at least a first iteration of combining modelling with stakeholders engagement.

Sub-task milestones and deliverables:

M-XC6.3.1: Exchange (via shared platform) of a preliminary synopsis containing main issues addressed by XC6 in the different case studies (December 2016)

M-XC6.3.2: Final workshop (June 2017)
D-XC6.3.1: Preliminary report on synopsis of case studies from a European perspective (December 2016)
D-XC6.3.2: Final report and manuscript on synopsis about lessons learned from the XC6.3 task (June 2017)

Task H1.XC7: Impact assessment for Europe (Task leaders: Zimmermann/Heckelei/Ewert (P115), Rolinski (P83)) - Duration (M1 – M24)

A new state-of-the-art Europe-wide climate change risk assessment for farming and food security will be prepared based on the upscaling methodologies explored in MACSUR1 and using economic modelling approaches that incorporate farm management decisions including livestock and land management. The assessment will provide general levels of projected crop and livestock production, flows of (EU-) imported and exported agricultural goods, producer and consumer prices, net farm revenues for the climate in the 2020s, 2030s and 2050s, as well as environmental indicators such as GHG emissions and nutrient surpluses. This level of assessment will also be a reference for describing sore spots in the various scenarios (e.g. concurrent crop failures in major crop producing countries) for food security that are poorly covered by current modelling activities and would require attention in funding agendas. Furthermore, the European assessment will summarize the different strands of cross-cutting activities and allows stakeholders in regions outside the case studies to form an opinion about future climate impacts.

Coordinated sub-tasks:
Sub-task XC7.1=XC16.3 Common baselines for integrated EU-wide impact assessment
(T3.2) (Task leader: Zimmermann/Heckelei (P115), partners involved: Havlík (P251)) - Duration (M1 – M24)

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This task is exactly the same as proposed in XC16-Scenario development. For completeness and consistency it is repeated here. Consistent with AgMIP, SSP2 was introduced as baseline scenario in MACSUR1. In close cooperation with the global land use model GLOBIOM, the economic agricultural sector model CAPRI generated producer and consumer prices, agricultural production and yields for the years 2010, 2030 and 2050 based on the SSP2 baseline at regional level for the EU. The results were provided as input for the three regional pilot studies. For MACSUR2, the coordinated GLOBIOM-CAPRI baseline will be updated considering recent policy developments, data, and methodological advancements. Results will be made available for all regional pilot studies in MACSUR2 and serve as reference run for the EU-wide impact assessment.

Sub-task milestones and deliverables:
M-XC7.1.1 = M-XC16.3.1: Delivery of data to regional pilot studies (June 2016)
M-XC7.1.2 = M-XC16.3.2: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC7.1.1 = D-XC16.3.1: Result tables (June 2016)
D-XC7.1.2 = D-XC16.3.2: Chapter on the baseline in the joint publication ‘Comprehensive assessment of climate change impacts on European agriculture’ (April 2017)

Sub-task XC7.2 Providing ensembles of EU-wide/global consistent sets of crop yield changes (C6.2) (Task leader: Ewert (P115), partners involved: Semenov (P25), François (P51), Ponti/Doro (P62), Müller (P83), Rötter (P92), Haas (P101), van Ittersum (P195)) - Duration (M1 – M24)

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Within this task, crop modellers will cooperate to develop ensembles of EU-wide/global datasets on crop yields simulated by crop growth models for the RCP and SSP scenarios defined in XC16. These ensembles will systemically cover differences in crop modelling, e.g. with regard to limiting factors, reflected adaptation measures, w/wo CO₂ fertilization, w/wo heat stress. A common protocol will be developed to feed these ensembles into the CAPRI model which will use them in further simulations and provide key result variables (harmonized with task XC7.1), such as crop shares, animal herds, production, demand, trade and prices. The combination of the crop modelling ensembles and matching CAPRI results are then input into a meta-analysis to assess impacts of crop model characteristics/assumptions on the key variables. The task is closely related to the XC activities scaling and uncertainty (XC2 and XC3).

Sub-task milestones and deliverables:
M-XC7.2: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC7.2.1: Deliver ensembles of EU-wide/global consistent sets of crop yield changes in common protocol format to XC7.4 (June 2016)

D-XC7.2.2: Chapter on the involved models and modelling results in the joint publication ‘comprehensive assessment of climate change impacts on European agriculture’ (April 2017)

Sub-task XC7.3. Providing ensembles of EU-wide/global consistent sets of grassland yield changes (L3.4) (Task leader: Rolinski (P83), partners involved: François (P51), Haas (P101), Bellocchi (P175)) - Duration (M1 – M24)

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Within this task, livestock modellers will cooperate to develop ensembles of EU-wide/global datasets on grassland yields simulated by livestock models for the RCP and SSP scenarios defined in XC16. These ensembles will systematically cover differences in grassland modelling, e.g. with regard to livestock densities. A common protocol will be developed to feed these ensembles into CAPRI which will use them in further simulations and provide key result variables (harmonized with task XC7.1), such as crop shares, animal herds, production, demand, trade and prices. The combination of the livestock modelling ensembles and matching CAPRI results are then input into a meta-analysis to assess impacts of grassland model characteristics/assumptions on the key variables.

Sub-task milestones and deliverables:
M-XC7.3: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC7.3.1: Deliver ensembles of EU-wide/global consistent set(s) of grassland yield changes in common protocol format to XC7.4 (June 2016)
D-XC7.3.2: Chapter on the involved models and modelling results in the joint publication ‘comprehensive assessment of climate change impacts on European agriculture’ (April 2017)

Sub-task XC7.4. Integrated EU-wide impact assessment of ensemble runs (T3.2) (Task leader: Zimmermann/Britz (P115), partners involved: François (P51), Rolinski (P83), Ewert (P115), Mittenzwei (P128), Holman (P143), Helming (P192)) - Duration (M1 – M24)

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Within this task, the actual integrated EU-wide impact assessment will take place. As described above, the ensemble runs of crop and livestock models will feed into CAPRI which will simulate these ensembles and provide key result variables (harmonized with task XC7.1), such as crop shares, animal herds, production, demand, trade and prices. In addition, an update and improvement regarding indicators describing food security will be undertaken. The combination of the crop and grassland modelling ensembles and matching CAPRI results are then input into a meta-analysis to assess impacts of crop/grassland model characteristics/assumptions on the key variables. The task is closely related to the XC activities scenario development, scaling,
uncertainty, and animal feed (XC16, XC2, XC3, XC11). The ensemble runs provide also
important input for the regional case studies in XC6, which can chose the best fitting ensemble
runs as input for their analysis, e.g. to drive national/regional economic models with price
changes.

Sub-task milestones and deliverables:
M-XC7.4.1: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC7.4.2: Protocol for data exchange with XC7.2 and XC7.3 (Dec 2015)
M-XC7.4.3: Integrated ensemble runs (Aug 2016)
M-XC7.4.4: Meta-analysis of integrated ensemble runs (Dec 2016)
D-XC7.4.1: Protocol for data exchange with XC7.2 and XC7.3 (Dec 2015)
D-XC7.4.2: Chapter on the integrated analysis in the joint publication (April 2017)

Sub-task XC7.5. Deepening of the EU-wide analysis with regional/national crop, livestock
and economic models (cross-checking results with XC7.4) (T3.2) (Task leader: Lehtonen
(P92), partners involved: Ruiz Ramos (P24), François (P51), Dono/Cortignani (P62), Rötter
(P92), Mittenzwei (P128), Holman (P143), Reidsma/van Ittersum (P195), Tiffin (P154), Havlík
(P251)) - Duration (M1 – M24)

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This task summarizes the results from smaller-scale (national, regional, local) integrated models
from XC6, to be compared with the results of the EU-wide analysis in XC7.4. In XC6 selected
region and country specific crop level adaptation options (e.g. crop yield and nutrient use of
new cultivars, split fertilization) will be implemented and evaluated based on the interaction
between crop, livestock and economic modellers. Results from multiple crop, livestock and
farm system models will be compared and used as inputs in regional, national and global
agricultural economic models. This will be done for different scenarios, including different
EU/global price levels and most relevant policy incentives and restrictions specified in RAP-
scenarios developed in XC6 and XC16. In the end, regional case studies participating in task
XC7.5 will validate their results using the outcomes of the EU-wide impact assessments.
Results on the regional crop, farm and sector level adaptations, focusing on the multi-scale
propagation of the impacts under different SSP and RAP scenarios, will be reported and
summarized. Additionally, the EU-wide impact assessment will be framed and validated by
outcomes of related projects at global and European level (e.g. from GLOBIOM and the
IMPRESSIONS project). The work is linked to and utilised in national level climate change
impact assessments on-going in some EU member states (such as the UK).

Sub-task milestones and deliverables:
M-XC7.5: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC7.5.1: Main conclusions from the regional case studies for the European level impact
analysis (Feb 2017)
D-XC7.5.2: Chapter on regional validation in the joint publication “Comprehensive assessment
of climate change impacts on European agriculture” (April 2017)
Sub-task XC7.6. Methodology and analysis of impacts that cannot be modelled (T3.2)
Task now partially covered by XC1.14 due to German budget considerations

Task H1-XC8: Understanding the Impacts of Extreme Events (Task leader: Tiffin (P154), partners involved: Ruiz-Ramos/Mínguez/Lorite/Gabaldon (P24), Rötter (P92), Lotze-Campen (P83), Gutierrez/Dono (P62), Hoveid (P128), Olesen (P189), Bojar/Knopik/Zarski (P100), Kersebaum/Nendel (P147)) - Duration (M1 – M24)

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There is little effort directed at modelling the impacts of extreme weather events on the agrifood system. This may in part be because the interactions between climate extremes and the agrifood system are complex and understanding the significance of short term weather variability for society as a whole is still limited. The impacts will depend on (i) the effects of climate variability and extremes on primary production, be that crop or livestock, and (ii) on the way human actors and the food system respond by adapting to current and future climate risks. The food system has a degree of resilience: it is able to recover and deliver the demands of society within a reasonable period of time. The capacity for such adjustment is at present poorly understood however.

The impact of a loss in productivity on prices requires both crop, livestock and economic modelling. The impact on international trade requires information from climate modelling to understand patterns of possible spatial correlations in weather events and their severity.

The focus of this workpackage is therefore on building capacity and understanding of approaches to conducting impact assessments for extreme events. The goal will be to develop a number of meaningful scenarios which can illustrate the way in which the food system will respond to an event. This will help to inform where modelling is needed to improve our understanding. It will link to and draw on the modelling in activity C1.2 Implementation of extreme events in crop models (Task leader: Trnka (P17)).

Task milestones and deliverables:
M-XC8: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC8: Publication draft, titled "Synopsis of modeled climate change effects at regional level across Europe, 2050." (April 2017)

Task H1.XC9: Coordination of XC9 'Identifying sustainable opportunities to close yield gaps in Europe' (Task leaders: van Ittersum/Schils (P195), Zimmermann/Heckelei (P115)) - Duration (M1 – M24)

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The increasing demand for food requires a sustainable intensification of crop production in low-yielding areas. Actions to improve crop production in these regions call for accurate spatially explicit identification of yield gaps (YGs). The Global Yield Gap Atlas (GYGA) proposes a
consistent bottom-up approach to estimate YGs. The first objective of this work package is that by the end of 2015, all major cereal growing regions will be covered, together with local partners. The quantification of YGs can be considered a first step towards decreasing or even closing the YG. The second objective focuses on identification of the underlying factors that contribute to the YGs. The challenge of this XC activity is to identify the relevant drivers within a larger set of biophysical and socio-economic factors. Following the identification of the relevant drivers, the next step towards a sustainable YG reduction requires an assessment of how measures to decrease the YG can be implemented with minimal negative trade-offs for farm income and environment, and in an optimal synergy with climate adaptation measures.

Our work is organised in a matrix, combining three tasks and four geographic regions (Mediterranean, Eastern Europe, Nordics, Western Europe). Tasks 1 and 2 reflect the different steps from identifying to explaining YGs. Task 3, depending on additional funding (currently not there), involves regional cases for sustainable reduction of YGs.

Coordinated sub-tasks:

**Sub-task XC9.1 Quantifying yield gaps** (C6.3) (Task leaders: Van Ittersum/ Schils (P195), Mediterranean: Marrou (P175), East: Kozyra (P125), Nordic: Rötter (P92), West: Schils (P195), partners involved: Minguez-Tudela (P24), Doro (P62), Heckelei (P115), Höglind (P128), Kersebaum/Nendel (P147), Bradley (P154), Eckersten (P163), van Middelkoop (P173), Lazar (P191)) - Duration (M1 – M24)

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European coverage of all major cereal growing regions will be covered along the lines set out in the GYGA-protocol, together with local partners. The analysis can be extended with alternative modeling approaches and scales (eg. farm scale), as well as other crops, including grasslands to establish a link with livestock.

**Sub-task milestones and deliverables:**

M-XC9.1: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC9.1.1: Publication draft, titled "Yield gaps of cereals in Europe, using a stratified sampling approach " (April 2017)
D-XC9.1.3: Workshop to explore the state-of-the-art in quantifying yield gaps in grassland (Oct 2016) organisation by P128 and P173

**Sub-task XC9.2 Explaining yield gaps** (T2.4) (Task leader: Zimmermann (P115), Mediterranean: Marrou (P175), East: Kozyra (125), Nordic: Rötter (P92), West: Schils (P195), partners involved: Garrido (P24), Lehtonen (P92), Heckelei (P115), Nendel (P147), Olesen (P189), van Ittersum (P195)) - Duration (M1 – M24)

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Multi-factorial assessment of underlying drivers for yield gaps, covering the major cereal growing regions in Europe. Yield gaps will be taken from the GYGA atlas and other available sources, while quantitative information on underlying factors will be extracted from existing biophysical and socioeconomic databases with sufficient spatial resolution. In analogy with the GYGA bottom-up approach, we will build on local expertise as well.

**Sub-task milestones and deliverables:**
M-XC9.2: Progress presentation at MACSUR2 conference (Oct 2016) :
D-XC9.2.1: Publication draft, titled "Underlying drivers for yield gaps of cereals in Europe" (April 2017)
D-XC9.2.2: Online maps of cereal production, yield gaps and underlying drivers are presented in the Wageningen UR (+ partners) Benchmarking Atlas (April 2017)

**Sub-task XC9.3 Sustainable options to reduce yield gaps (depending on availability of additional financial sources)** (T2.4) (Task leader: Lehtonen (P92), partners involved: Kozyra (P125), Bradley (154), Marrou (P175)) - Duration (M1 – M24)

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Development of 3-4 regional cases in which we describe scenarios towards a sustainable yield gap reduction. Regions will be selected with relative high yield gaps. The analysis builds upon the outcome of tasks 1 and 2, leading to a set of proposed measures. Relevant stakeholders will be invited to present their views and optimise the proposed measures. Special attention will be given to assessing the environmental effects (e.g. GHG emissions, soil NP-surpluses, nitrate leaching) and climate adaptation potential of measures to decrease yield gaps. We will use integrated models that are able to simulate the relevant bio-physical and financial processes in the soil-crop-farm domains.

- One example is the dynamic model of farm management and crop rotation already implemented at 2 farm types with different socio-economic attributes in North Savo regional case study in Finland. In the model the yield (gap) is largely endogenised. The realized and future yield development can be simulated under different climate and global scenarios (link to XC16 Overall scenario development).
- For the Mediterranean region, Tuscany (IT) and Plateau de Valensole (FR) may be available as case study region.
- The “UK Yield Enhancement Network” will be used as a case study region in the West.

**Sub-task milestones and deliverables:**
M-XC9.3.1: First results from integrated models, for evaluation for the project team (May 2016).
M-XC9.3.2: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC9.3.1: Publication draft, titled "Sustainable options to decrease yield gaps of cereals in
Europe" (April 2017)
D-XC9.3.2: Storylines of cases are presented in the Wageningen UR (+ partners) Benchmarking Atlas, together with the related maps (April 2017)
D-XC9.3.3: Report on the integrated model based analysis on the implications and sustainability of the decreased yield gaps on selected case study cases (April 2017)

**Task H1.XC10:** XC10 'Contributions of new technologies to adaptation and mitigation'  
*Activity realized in TradeM T3.3*
Task H1.XC11: Coordination of XC11 'The animal feed story (feed quality, feed utilisation and protein availability)' (Task leader: Amon (P147), Bannink (P173)) - Duration (M1 – M24)

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Improving the quality and use efficiency of animal feed, is essential to achieve economic and environmental sustainability in livestock production, while meeting increasing demand for meat and dairy products from a fixed amount of land, without compromising the functioning of essential ecosystem services. The provision of economically and environmentally sustainable protein feeds is a particular research priority within the animal feed story. Concentrate feeds represent a major cost for farmers, and the need for protein is often met by imported soy. This has led to concern about the economic sustainability of reliance on a single crop, as well as the environmental externalities associated with its production and import.

MACSUR2 examines the multi-disciplinary challenge of developing sustainable high quality feed sources for the EU livestock production sector. Modelling the effects of climate change on grass and crop quality, including assessments of home-grown protein feed crops, will be an important aspect of this activity. Farm-scale modelling can explore the economic and environmental costs of changes in feed quality as well as the use of alternative protein sources. At the regional scale, economic modellers can analyse the consequences of changes in feed quality, and of growing import-dependency for protein crops. Activities on this topic will complement and support thematic activities, such as the proposed LiveM tasks on modelling herbage quality and farm-scale adaptation to climate change.

Coordinated sub-tasks:
**Sub-task XC11.1: Overview on studies and research activities relevant for the animal feed story and development of region specific livestock diets** (L3.5) (Task leader: Bannink (P173), partners involved: Amon (P147), Marley (P148)) - Duration (M1 – M24)

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In task XC11.1, MACSUR partners collect information on feed quality and high quality feed sources for livestock in core European regions. Dairy cow diets vary in inclusion of roughage and milk yields that can be achieved. Data and research activities on feed utilisation and on alternative feeds and/or home grown protein sources will be reviewed and connected with recent model developments.

The review will include recent activities such as e.g. the FP7 funded projects SOLID and Legumefutures. Projections of associated costs for roughage and animal breeding are taken into account to provide information for region based assessments (such as XC7). Further it will be considered how yield and yield improvements alter land or nutrient requirements in order to generate data on resource use efficiencies and potential emissions which allow integration in agro-economic model assessments (XC16).
Based on the result of the review, region specific livestock diets in main European regions including contrasting levels of protein and roughage and novel protein sources will be suggested. Those diets will undergo an economic and LCA assessment. Task 1 will receive input from L1.1. “Modelling grassland vulnerability to climate change”, L1.2 “modelling grassland quality under climate change”, L2.4 “modelling the impacts of changes in grassland on livestock productivity”. While past and some on-going work is doing similar work on current climate conditions, MACSUR2 will evaluate especially the role of climate change, as well as the global change (e.g. XC16 “Overall scenario development”).

***Sub-task milestones and deliverables:***

M-XC11.1: Workshop on the review of novel developments in livestock diets including alternative protein sources (May 2016)

D-XC11.1: Review paper and/or special issue on of novel developments in livestock diets including alternative protein sources (November 2016)

Sub-task XC11.2: Suggestion of future livestock diets under conditions of climate change and reduction of protein imports (L3.6) (Task leader: Bannink (P173), partners involved: Amon (P147), Rolinski (P83), Lehtonen (P92), Dono/Cortignani (P62)) - Duration (M1 – M24)

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Task XC11.2 goes one step beyond task XC11.1 by suggesting livestock diets considering future climate change scenarios and taking into account the effects on local farming conditions. The various region specific diets and alternative protein sources will be ranked and most promising diets be selected. Open questions and further research needs will be identified to meet challenges of sustainable livestock diets under conditions of climate change.

Task XC11.2 will receive input from XC2.1. “scaling up”, and L2.3 “modelling adaptation to climate change”. It also considers cost effects and evaluates resource use efficiencies and emission potentials of roughage and livestock breeds. Task XC11.2 will use various farm level models.

As an illustrative case, a sector level economic analysis of the competitiveness of increased clover grass forage production in Northern Europe is reported. Clover grasses may benefit more from the longer growing period and higher temperature sum than pure grasses cultivated intensively for grass silage. The competitiveness of the clover grass, providing higher protein content in the feed, is evaluated under different scenarios developed in XC16 “Overall scenario development”. Economic analysis is also linked to XC7 European wide assessment (esp. task XC7.5 “Deepening the EU wide analysis”). A regional or national economic sector level model is utilised. The model accounts for competition for land.

***Sub-task milestones and deliverables:***

M-XC11.2.1: Workshop on future livestock diets under conditions of climate change (November 2016)

M-XC11.2.2: First results on the integrated analysis on the competitiveness of feed protein production in regional level, to be cross-checked by the partners (September 2016)

D-XC11.2.1: Paper on future livestock diets for main European regions under conditions of...
FACCE JPI Knowledge Hub full proposal – Form A

climate change and reduction of protein imports including aspects of on competitiveness and land use implications of protein feed production (May 2017)

Task H1.XC12: XC12 'Farm-scale risk assessment'
Activity now covered in WPs C3, L1, T2

Task H1.XC13: XC13 'Impact of consumer behaviour'
Activity realized in TradeM T3.6

Task H1.XC14: Coordination of XC14 'Impacts on ecosystem services and rural development' (Task leader: Helming (P147)) - Duration (M1 – M24)

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MACSUR utilizes modelling approaches to to develop scenarios of agricultural adaption to increase production services (e.g. food, fiber, fuels). However, agricultural systems are also expected to provide other ecosystem services and contribute to rural development. We will address the impacts of agricultural management scenarios on ecosystem services and rural development.

We will start with the development of an analytical framework for the ex-ante assessment of ecosystem services and rural development from agricultural land use. Then, we will map output indicators of existing MACSUR models. For example, some models have nitrogen surplus or GHG emissions or erosion vulnerability as an outcome besides the yield simulations. This way we generate an understanding in how far the analytical framework can be covered with existing models. Likewise, we identify analytical gaps to be closed in future model developments or by expert-based evaluation systems. It will be facilitated by collaboration with other researchers e.g. from the Ecosystem Service Partnership (ESP). While the analytical framework will be developed at hub level, mapping of activities will be carried out in the regional case studies. Close cooperation will be set up with C1.1 "Model response to variable site conditions on crop production and ecosystem services" and C1.3 "Long term effects of management and cropping systems on crop production and ecosystem services".

Coordinated sub-tasks:

Sub-task XC14.1. Analytical framework and indicators for ecosystem service assessment (T2.6) (Task leader: Helming (P147), partners involved: Whitmore (P65), Schönhart (P208), Roggero/Seddauiu (P62)) - Duration (M1 – M24)

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Since the Millenium Assessment, ecosystem services is a prominent concept to assess the value
of ecosystems for human well-being. Recent examples have shown the potential of the concept for the assessment of agricultural management. For this purpose, it can be integrated into the procedural steps of impact assessment, such as employed at the European Commission. We will do this and develop an analytical framework for identifying key issues of agricultural management, how they affect certain ecosystem services at what spatio-temporal scales. Indicators are an important element of the framework and they have to serve both the European Impact Assessment (XC7) and the regional case studies (XC6). Indicators need to be sensitive to parameters of agricultural management simulated in MACSUR. The outcome will be a consistent indicator framework linking output of MACSUR modelling activities to ecosystem services and rural development at European and regional case study level. It helps to present a first overview on trade-offs and synergies between agricultural management, ecosystem services and rural development. We attempt to make the framework compatible with existing assessment initiatives at European (MAES, TEEB) and national levels (NEA-DE).

Sub-task milestones and deliverables:

M-XC14.1: Indicator framework for ecosystem service assessment of MACSUR scenarios (February 2016)

D-XC14.1: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on analytical framework (January 2017)

Sub-task XC14.2. Mapping of model outputs from the European Assessment and from the regional case studies (T2.6) (Task leader: Schönhart (P208), partners involved: Bannink (P173), Dono/Cortignani/Roggero (P62)) - Duration (M1 – M24)

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From the models used in all Themes we will map those output variables that come along with the key model outputs (yield) and that can be used to determine ecosystem service and rural development indicators identified in XC14.1. In the best case, those model outputs can directly be used for the assessment of specific ecosystem services. In other cases some further processing of model outcomes might be necessary. This task will identify the steps necessary to do so. The ambition is to identify most suitable ways for the transformation of model outputs towards a coherent indicator framework across all regional case studies and the European-level assessment. This way we will generate an understanding of how far the analytical framework can be covered with existing models. Likewise, we will identify analytical gaps to be closed in future model developments or by expert-based evaluation systems. To show a possible application and advantage of such mapping, one outcome of this task will be a list of typical synergies and trade-offs among ecosystem services linked to agricultural land use based on regional case study results. Another outcome is further developed in task XC14.3.

Sub-task milestones and deliverables:

M-XC14.2: Overview of the potential of existing MACSUR modelling for ecosystem service
assessments (February 2016)

D-XC14.2: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on model competences (January 2017)

Sub-task XC14.3. Definition of gaps in ecosystem service assessment (T2.6) (Task leader: Whitmore (P65), partners involved: Helming (P147), Schönhart (P208), Seddaiu (P62)) - Duration (M1 – M24)

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By matching the results of the model mapping of XC14.2 with the indicator framework of XC14.1 we will distill the reciprocal, which are ecosystem service and rural development topics that are not addressed with the models in MACSUR. This gap analysis is the starting point for a strategic search for possible partners and other research communities (ESP, IPBES) to seek collaboration in the ecosystem service assessment.

Sub-task milestones and deliverables:

M-XC14.3: Progress presentation at MACSUR2 conference (Oct 2016)

D-XC14.3: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on gap analysis in assessment methods (May 2017)

Sub-task XC14.4. Development of options to improve ecosystem service assessments in MACSUR scenario assessments (L3.7) (Task leader: Whitmore (P65), partners involved: Helming (P147), Seddaiu (P62)) - Duration (M1 – M24)

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For this task we can follow two strategies. First, modellers will check options of extending/improving their models to cover indicators of the analytical framework. This can be done for each model individually but following a common protocol. Consequently, we will reveal the opportunities and challenges of modelers to cover particular ecosystem services. Second, we interact with ongoing research activities on ecosystem service assessments and seek for collaboration. This will improve our understanding on the benefits and challenges of combing quantitative integrated model outputs and other, eventually more qualitative, assessment methods.
Since 1970 total global agricultural production has more than doubled and is now responsible for c. 30% of global human greenhouse gas (GHG) emissions. A growing global population requires food production to increase but emissions to be reduced. Agricultural GHG emissions have and are being decoupled from production, and the GHG footprint of agricultural products is 35% lower than 40 years ago. Emission intensity from land-use change, livestock and fodder production have almost halved; only energy-based emissions have increased per unit of food produced. We can try and show how managing the needed future agricultural intensification can be made sustainable, through a deconstructed analysis of the components of GHG emissions in farming. We may conclude that emissions need not increase, even given an increase in future food production.

Coordinated sub-tasks:
Sub-task XC15.1. Overview on studies and research activities relevant for GHG mitigation in crop, feed and livestock production (C6.4) (Task leader: Haas (P101), partners involved: Vallejo/Sanz /del Prado/Pardo/Rivera (P24), Philippides (P36), Seddaia/Lacetera (P62), Misselbrook (P65), Porter (P71), Rusu (P85), Arneth (P101), Grosz/Osterburg (P112) , Borzęcka-Walker (P125), Amon/Zander (P147), Matthews/Yeluripathi (P150), Bannink (P173), Klumpp (P175), Olesen (P189), Lazar (P191), Schönhart (P208)) - Duration (M1 – M24)

In task 1 of the XC activity mitigation all partners will collect information of all studies and research activities relevant for GHG mitigation in crop, feed and livestock production across CropM, LiveM and TradeM. This review will condense the results of related studies in arable and grassland systems for crop and feed production as well as in livestock production on farm level. The review will also include socio economic studies to widen the knowledge. Based on the result of the review specific mitigation options applicable on European agricultural systems will be validated and shared across all MACSUR members. Task members have distinct knowledge and skills on GHG mitigation from Mediterranean, central and northern European agro-ecosystems.

Sub-task milestones and deliverables:
M-XC15.1.1: Document summarizing all mitigation related activities in MACSUR. To be communicated with the MACSUR Newsletter at least bi-yearly.
M-XC15.1.2: Workshop on the review of studies and research activities relevant for GHG mitigation in crop, feed and livestock production in MACSUR (May 2016)
M-XC15.1.3: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC15.1.4: Summary document on GHG mitigation in MACSUR (Oct 2016)
D-XC15.1.1: Review paper and/or special issue on studies and research activities relevant for GHG mitigation in crop, feed and livestock production in MACSUR (January 2017)

Sub-task XC15.2. Evaluation of mitigation vs. adaptation strategies (L3.8) (Task leader: Gengler (P51), partners involved: del Prado (P24), Orlandini (P25), Phillippides (P36), Topp (P47), Lacetera/ Dono/ Cortignani (P62), Haas (P101), Kozyra (P125), Matthews/Cammarano (P150), Bannink (P173), Olesen (P189), Schönhart (P208)) - Duration (M1 – M24)

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Task XC15.2 aims to link MACSUR2 to studies and research activities relating and comparing mitigation of climate change via GHG sources and sinks vs. planned adaptation to the impacts and vulnerabilities due to climate change strategies and considering them in appropriate manner in policy responses. Consequently, we will also focus on the synergies and trade-offs among mitigation and adaptation strategies. Task XC15.2 will focus on LiveM but will be open to contributions from CropM and TradeM. Based on the result of the review, a document evaluating mitigation vs. adaptation strategies will be written and shared across all MACSUR2 members.

Sub-task milestones and deliverables:
M-XC15.2: Draft of document about “Evaluation of mitigation vs. adaptation strategies” to be shared among MACSUR2 (Jan 2016)
D-XC15.2: Document about “Evaluation of mitigation vs. adaptation strategies” to be shared among MACSUR2 (Sept. 2016)

Sub-task XC15.3. Establishing links to other GHG mitigation activities (C6.5) (Task leader: Haas (P101), partners involved: Vallejo/Sanz/del Prado/Pardo (P24), Phillippides (P36), Seddaiu/Lacetera (P62), Kozyra (P125), Bannink (P173), Klumpp (P175)) - Duration (M1 – M24)

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Task XC15.3 aims to link MACSUR2 to other research activities in this field. Some potential activities to link up are the COST action FA1302 Methagene (Large-scale methane measurements on individual ruminants for genetic evaluations) or ASGGN (GRA Animal Selection, Genetics and Genomics Network), the CN-MIP project (C and N Models Intercomparison and Improvement to assess management options for GHG mitigation in agrosystems worldwide), the MGGNET project („Quantifying Greenhouse Gas Mitigation
Effectiveness through the GRA Croplands Greenhouse Gas Network, Global Research Alliance on Agricultural Greenhouse Gases (http://www.globalresearchalliance.org/) and all AgMIP activities. (CN-MIP and MAGGNET are funded by FACCE JPI). The task also aims to connect to previous and on-going national, EU and global projects focusing on GHG mitigation in agriculture relevant for MACSUR.

Sub-task milestones and deliverables:
M-XC15.3: Summary synthesis of activities on the field of GHG mitigation performed by other consortia/projects to be reported to MACSUR partners via the MACSUR Newsletter (bi-yearly) (June 2016, May 2017).
D-XC15.3: Summary synthesis of activities on the field of GHG mitigation performed by other consortia/projects to be reported to MACSUR partners via the MACSUR Newsletter (bi-yearly) (June 2016, May 2017).
Task H1.XC16: Overall scenario development (Task leader: Biewald/Lotze-Campen (P83), Ewert (P115)) - Duration (M1 – M24)

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Agricultural aspects have been covered in the scenario process on shared socio-economic pathways (SSPs), but only to a limited extent. In order to analyze the future dynamics of agricultural development they need to be complemented and specified by Representative Agricultural Pathways (RAPs), which cover different aspects of agricultural development as for example EU policy, different livestock management systems, cropping systems or irrigation efficiencies. The RAPs can only to a certain degree be developed as global guidelines which are nationally implemented. Since agricultural aspects are extremely region dependent it is important to translate the overall storylines from SSPs into a specific scenario parameterization at national and regional levels.

In this activity we will develop a general framework for RAPs where we define for each SSP the development of EU-policies and their corresponding suitable RCPs. Based on that we outline the crop management systems (e.g. fertilizer or irrigation efficiency) compatible to certain RCPs, and the intensity and efficiency of livestock systems. This will also serve as input to AgMIP. On this basis we will deliver detailed region-specific RAPs, serving our work in the regional case studies.

In MACSUR 1 a baseline has been introduced for SSP2. CAPRI generated producer and consumer prices, agricultural production and yields for the years 2010, 2030 and 2050 were provided for the three regional pilot studies. In this XC activity CAPRI input for the regional case studies will be extended to the other SSPs.

Coordinated sub-tasks:
Sub-task XC16.1: Stakeholder centered expectations (T1.2) (Task leader: Brouwer (P192); involved partners Carter (P92) Duration: M1 – M6

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Stakeholder interaction is essential in order to achieve credibility of any scenarios. In this task stakeholders from the case study regions are therefore interviewed about their views and priorities with respect to adaptation challenges in different RAPs. We envisage to interview representatives from Commission Services (e.g. DG CLIMA, DG AGRI; JRC) and some national and regional authorities from 2 EU member states (i.e. Finland and the Netherlands). One open regional workshop will be held collecting the views on the specific regional needs for adaptation. The collected views on the regional level needs and expressed European and national priorities are already interesting as such but primarily they are utilized in developing the general framework (task XC16.2) and more specific scenarios for the pilot studies (task XC16.4). This task will also increase awareness of the regional stakeholders on the role of global change developments and policy systems on the agricultural development in regional
Taking regional stakeholders onboard in the scenario development is one way of identifying the weak points in regional adaptation capacity that require attention.

**Sub-task milestones and deliverables:**
M-XC16.1: Presentation of progress at MACSUR conference (October 2015)
Interim findings of the interviews are presented to reflect the European and national dimensions of food security and climate change in the context of agriculture.
D-XC16.1: Paper on challenges to European farmers to address global food security (January 2016)

**Sub-task XC16.2: Developing a general framework for RAPs (T1.2)**
(Task leaders: Biewald (P83), involved partners: Müller/Lotze-Campen (P83), Lehtonen (P92), Zimmermann/Ewert (P115), Dalgaard (P189), Holman (P143))
Duration (M1 – M8)

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Based on AgMIP activities we will develop a framework where we define the RAPs based on different SSPs. We will determine a climate path representing a certain development of yield and water availability for each SSP-RCP. The RAPs will include aspects of EU-policies, including trade, agricultural and environmental policies, including the available funding in each area of CAP (pillars 1 and 2). The regional level issues are largely connected to pillar 2, especially agri-environmental schemes that are implemented in detail at the national and regional level, though the principles of the schemes are specified at the EU level. Since the agri-environmental issues are already identified as important for adaptation and mitigation they need some emphasis. In the general framework to be developed we specify logical rules and consistency checks on the feasibility and priority of different policy instruments in each RAP, to be specified in more detail for the case study regions in task 16.4. However, already here one may already specify feasible livestock efficiencies, extensive and intensive farm management as well as crop management consistent to the different RAPs.

Besides interest in regional agricultural productivity, RAPs have to be clear about the development of land resources (e.g. land use change from and to agriculture). Some selected regional pilot studies, for which RAPs are already exist for 1 or more SSP scenarios, are used as examples for the general framework design.

**Sub-task milestones and deliverables:**
M-XC16.2: Presentation of progress at MACSUR conference (Oct 2015)

**Sub-task XC16.3 = XC7.1: Common baselines for integrated EU-wide impact assessment**
(T3.2) (Task leader: Zimmermann/Heckelei (P115), partners involved: Havlík (P251))
Duration (M1 – M24)
This task is exactly the same as proposed in XC16–Scenario development. For completeness and consistency it is repeated here.

Consistent with AgMIP, SSP2 was introduced as baseline scenario in MACSUR1. In close cooperation with the global land use model GLOBIOM, the economic agricultural sector model CAPRI generated producer and consumer prices, agricultural production and yields for the years 2010, 2030 and 2050 based on the SSP2 baseline at regional level for the EU. The results were provided as input for the three regional pilot studies. For MACSUR2, the coordinated GLOBIOM-CAPRI baseline will be updated considering recent policy developments, data, and methodological advancements. Results will be made available for all regional pilot studies in MACSUR2 and serve as reference run for the EU-wide impact assessment.

Sub-task milestones and deliverables:
M-XC7.1.1 = M-XC16.3.1: Delivery of data to regional pilot studies (June 2016)
M-XC7.1.2 = M-XC16.3.2: Progress presentation at MACSUR2 conference (Oct 2016)
D-XC7.1.1 = D-XC16.3.1: Result tables (June 2016)
D-XC7.1.2 = D-XC16.3.2: Chapter on the baseline in the joint publication ‘Comprehensive assessment of climate change impacts on European agriculture’ (April 2017)

Sub-task XC16.4: Specifying the scenarios for the case studies (T1.2) (Task leaders: Schönhart (P208), partners involved: Lehtonen (P92), Roggero/Dono/Cortignani (P62), Belloccchi (P175)) - Duration: M6 – M18

The RAPs developed in the general framework will be specified in more detail for the purposes of the regional case studies. This is achieved by the individual research teams in each case study. They utilize the most important needs and priorities expressed by the regional stakeholders (task XC16.1) and proceed along the general framework (task 16.2). Hence more explicit policy alternatives are to be developed in the case of each SSP-RCP combination for the case study regions. This is in close cooperation to XC activity “Regional pilot studies”. In XC16.4, we focus on the plausibility check of the regional scenarios utilizing the general framework (task XC16.2) and outcomes of task XC16.3 (price and yield developments). This includes e.g. analysis of pillar 2 measures and their re-formulations in different SSPs. Existing pillar 2 measures are rather detailed and region and case specific. The achievements and challenges of this process at the level of each regional case study will be documented in D-XC16.4 to guide future RAPs comparisons.

Sub-task milestones and deliverables:
M-XC16.4: Regionalized RAPs available (September 2016)
The milestone of this task is a documented set of regionalized RAPs to each SSP. It is available for each regional case study that participates in XC16.
D-XC16.4: RAPs documentation (November 2016)
We provide a joint working paper on the general framework (task XC16.2) on RAPs and its application to the regional case studies (results, challenges and achievements).

Milestones:
M-XC1: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC2: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC3: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC4: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC6: Presentation of approach at a MACSUR2 workshop (April 2016)
M-XC7: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC8: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC9: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC11: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC14: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC15: Progress presentation at MACSUR2 conference (Oct 2016)
M-XC16: Progress presentation at MACSUR2 conference (Oct 2016)

Deliverables:
D-XC1: Output from the individual tasks
D-XC2: Output from the individual tasks
D-XC3: Publication draft (April 2017)
D-XC4: Output from the individual tasks
D-XC7: Publication draft, titled "Comprehensive assessment of climate change impacts on European agriculture" (April 2017)
D-XC8: Publication draft, titled "Synopsis of modeled climate change effects at regional level across Europe, 2050." (April 2017)
D-XC9: Output from the individual tasks
D-XC11: Output from the individual tasks
D-XC14: Publication draft, titled “Impacts of agricultural adaptation scenarios on ecosystem services and rural development” (May 2017)
D-XC15: Output from the individual tasks
D-XC16: Report, titled “RAPs at the small and at the large: how representative agricultural pathways can be implemented a global as well a local level” (May 2017)

Risks and contingency
This work package relies on the interaction of many people. A lack of communication about intermediate results and plans could lead to duplication of work or loose ends that may cause disappointment of the scientists. Therefore, structured communication is pivotal. We will encourage the leader(s) of each XC activity to regularly contribute to internal newsletters and present their progress at the central meetings. In addition, XC leaders will discuss the progress of XC work at Project Steering Committee meetings and each XC activity is in charge of one member of the Project Steering Committee.
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**MACSUR2**

**Hub**

- Hub coordination

**XC Activities**

- XC Activity management

- Coordination of XC1 'Model comparison & improvement'
- Coordination of XC2 'Scaling'
- Coordination of XC3 'Uncertainty & risk assessment'
- Coordination of XC4 'Capacity building'
- Coordination of XC6 'Regional case studies'
- Coordination of XC7 'Impact Assessment for Europe'
- XC 8 'Variability and extreme events'
- Coordination of XC9 'Identifying sustainable opportunities to…'
- Coordination of XC11 'Feeding livestock: forage production, f…'
- Coordination of XC14 'Impact on ecosystem services and rural…'
- Coordination of XC15 'GHG mitigation from agriculture'
- Coordination of XC16 'Overall scenario development'

**CropM**

**LiveM**

**TradeM**
| Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
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| MACSUR2 | H | Hub | Coordination | CropM |
| C0 | C1 | C1.1 | Model response to variable site conditions on crop productivity | C1.2 | Implementation of extreme events in crop models | C1.3 | Long term effects of management and cropping systems on crop... | C1.4 | Extend crop model assessment to more cropping systems | C1.5 | Incorporation of diseases and pests in crop models |
| C1.6/XC1.1 | XC1.1 | Survey on model improvement needs (C) | C1.7/XC1.3 | XC1.3 | Establishing links to other research activities in the... |
| C2 | Climate Change Scenarios | Quantify gaps for crop modelling | Observed adaptation options and their efficacy | C2.1 | C2.2 | C2.3 | C2.4 | C2.5 | Empirical analyses of crop responses to climatic variation |
| C3 | Methods of scaling and Model linking | Review progress in scaling methods and supervision of activities | C3.1 | Development of a joint data sharing mechanism for scaling eco... | C3.2 | Comparison of scaling methods | C3.3 | Evaluation of scaling methods for other crops and regions |
| C3.4 | C3.5 | Application of scaling crop models for integrated assessment... | C3.6/XC2.1 | XC2.1 | Inventory of scaling methods across crop, farm and eco... |
| C4 | Uncertainty and risk analysis | Comprehensive framework for assessment of error and uncertainty... | C4.1 | Best practices for building and analyzing the results of multiple... | C4.2 | Analysing model sensitivity to perturbations in climate variation |
| C4.3 | C4.4 | Probabilistic ensemble-based assessment of region specific analys... | C4.5 | Designing future crop ideotypes using multiple crop models |
| C4.6 | C4.7/XC3.1 | Model uncertainty quantification | XC3.1 | Overview on studies and research activities relevant to crop... |
| C4.8/XC3.2 | XC3.2 | Establishing links to other research activities in the... |
| C5 | C6 | Capacity building | Cross cutting issues |
| L | TradeM | LiveM |
### Grassland and farm-scale modelling

- Modelling grassland vulnerability to climate change
- Modelling grassland quality under climate change
- Bringing together grassland and farm-scale modelling
- Reusing and linking models in livestock farming

### Livestock productivity

- Impacts of climate change on animal health, disease and productivity change
- Modelling adaptation to climate change
- Modelling the impact of climate change on livestock productivity

### LiveM-led contributions to XC activities

- XC1.2 General framework for model evaluation and comparison
- XC4.1 Development of integrated training strategy (L)
- XC6.2 Comparison of case studies including development of crop models
- XC7.3 Providing ensembles of EU-wide/global consistent sets
- XC11.1 Overview on studies and research activities relevant to livestock
- XC11.2 Suggestion of future livestock diets under different conditions
- XC14.4 Development of options to improve ecosystem service assessment
- XC15.2 Evaluation of mitigation vs. Adaptation strategies (Livestock)
### MACSUR2

**Hub**
- CropM
- LiveM

**TradeM**
- Coordination
  - Implementation and facilitation
  - Administrative tasks and reports

**TradeM Workshops**

### Model comparison and improvement

**Model comparison and improvement**

**T0**
- Coordination
  - Implementation and facilitation
  - Administrative tasks and reports

**T1**
- Model comparison and improvement
  - Interaction with international networks
  - Dissemination activities

**T1.2/XC16.1**
- XC16.1 Stakeholder centered expectations (T)

**T1.2/XC16.2**
- XC16.2 Developing a general framework for RAPs (T)

**T1.2/XC16.4**
- XC16.4 Specifying scenarios for the regional case studies (T)

**T1.3**
- Interaction with international networks

**T1.4**
- Dissemination activities

**T2**
- Scientific advancements supporting integrated assessment app...

**T2.4/XC9.2**
- XC9.2 Explaining yield gaps (T)

**T2.4/XC9.3**
- XC9.3 Sustainbale options to reduce yield gaps (depending on...

**T2.5**
- Farm-scale risk assessment

**T2.6/XC14.1**
- XC14.1 Analytical framework and indicators for ecosystem ser...

**T2.6/XC14.2**
- XC14.2 Mapping of model outputs from the European Assessment...

**T2.6/XC14.3**
- XC14.3 Definition of gaps in ecosystem service assessment (T...)

**T3**
- Cross cutting in hot-spot areas

**T3.2/XC6.1**
- XC6.1 Integrated assessment modelling at the regional case ...

**T3.2/XC7.1/XC16.3**
- XC7.1 Common baselines for integrated EU–wide impact assessm...

**T3.2/XC7.4**
- XC7.4 Integrated EU–wide impact assessment of ensemble runs ...

**T3.2/XC7.5**
- XC7.5 Deepening of the EU–wide analysis with regional/nation...

**T3.3**
- Contributions of new technologies

**T3.6**
- Impact of consumer behaviour

**T4**
- Capacity building in integrated modelling and policy assessm...

**T4.1/XC4.3**
- XC4.3 Course on agricultural production and environmental mo...

**T4.2/XC4.4**
- XC4.4 Co–operation in capacity building activities with inte...
FACCE JPI pilot action call for “The FACCE JPI Knowledge Hub” on “A detailed climate change risk assessment for European agriculture and food security, in collaboration with international projects”

MACSUR2 FULL PROPOSAL
MACSUR - Second Phase
FORM B CropM

Submission of the full proposal by the Main Coordinator on www.submission-faccejpi.com
Deadline: December 03rd, 2014 15:00 CET

For further information, please visit us on the website http://www.faccejpi.com or contact the Call Office: ptj-faccejpi@fz-juelich.de (+49) 2461 61-2422
## B1 – Coordination

### CropM Coordinator

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</tr>
<tr>
<td>Country:</td>
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<tr>
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<tr>
<td>Street name, number:</td>
<td>Katzenburgweg 5</td>
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<tr>
<td>Additional (e.g. department, building…):</td>
<td>Institute of Crop Science and Resource Conservation (INRES)</td>
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<tr>
<td>Website:</td>
<td><a href="http://www.lap.uni-bonn.de">http://www.lap.uni-bonn.de</a></td>
</tr>
<tr>
<td>Title:</td>
<td>Mr</td>
</tr>
<tr>
<td>First name:</td>
<td>Frank</td>
</tr>
<tr>
<td>Last name:</td>
<td>Ewert</td>
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<td>Function:</td>
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</tr>
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<td>E-Mail:</td>
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<td>Professor Production Ecology &amp; Agrosystems Modelling</td>
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State of the art including main achievements in MACSUR until now:
The complexity of climate change (CC) impacts and adaptations for managing climate risks and improving food security calls for more integrated modelling and quantitative assessment approaches that go beyond the sole biophysical aspects of crop and cropping systems as recently stressed by Wheeler and von Braun (2013) and the IPCC 2014 Working Group II report (Porter et al. 2014). Various modelling tools are used to support the decision making and planning in agriculture (Van Ittersum et al. 2008, Brouwer and Van Ittersum 2010, Ewert et al. 2011). Crop growth simulation models are widely applied and considered most suitable for assessments of CC impacts on and adaptation of agricultural systems (Rötter et al. 2011, White et al. 2011, Rosenzweig et al. 2013, Challinor et al. 2014).

The key challenges that CropM tried to address in the first phase of MACSUR (also referred to as MACSUR1) were: (i) crop model intercomparison and improvement, (ii) data management, (iii) methods of scaling and model linking, (iv) scenario development and impact uncertainty evaluation, (v) capacity building and (vi) the development of methodological case and integrated pilot studies on impact assessment.

Substantial progress has been achieved on these challenges in MACSUR1 as reported below for the various WPs: Highlights from WP C1 are the set-up and execution of a comprehensive, unique model comparison study on simulating crop rotations using long term trial data from various locations in Europe and looking at various output variables; also an inventory has been made on the available crop models and modelled cropping systems for Europe by the MACSUR CropM partners. WP C2 has developed extensive databases on important on-going and future modelling studies in Europe (already feeding high impact publications), and it also embarked on developing a centralized system for data storage, distribution and visualization of model results. Highlights of WP C3 constitute the systematic analysis of scaling methods with focus of scaling up weather and soil information for regional and ( supra-) national CC impact assessments and related uncertainties for a range of crop models. In WP C4 highlights have been the use of a large ensemble of 26 crop models for a systematic climate sensitivity analysis using impact response surface method, the development of new CC scenario data for selected locations and regional case studies in Europe and use of agroclimatic indicator approaches to indicate shifts in (multiple) risks to wheat production in the EU. WP C5 excelled in successful implementation of five well-attended PhD courses dealing with various issues of generating data and applying modelling techniques for assessing CC impacts and adaptations. Finally, WP C6 has enabled the transfer of knowledge and data as required to generate preliminary results for three show-cases (Austria, Italy and Finland) of integrated regional assessment. While there have been substantial improvements of methods and tools as documented in a considerable number of publications, there also have been limitations, e.g. a relatively small number of simulated crops, etc. (see, hereunder). Most notably, the various demands of multi-scale and integrated assessment and modelling (IAM) of agricultural systems as needed for meaningful analysis of adaptation to CC are as of yet only partially fulfilled.

Scientific/Technological challenges and scientific/technological approach
Recently, an overview has been presented as part of the work in MACSUR on the state of the art of crop modelling to assess CC risks to food production and to which extent crop models comply
with IAM demands (Ewert et al. 2014a). From this overview it became evident that considerable progress has been made in modelling effects of climate variables, where crop models best satisfy IAM demands. Demands are partly satisfied for simulating commonly required assessment variables. However, progress on the number of simulated crops, uncertainty propagation related to model parameters and structure, adaptations and scaling are less advanced and lagging behind IAM demands. The limitations are considered substantial and apply to a different extent to all crop models. Overcoming these limitations will require joint efforts, particularly for multi-model ensemble simulations and consideration of novel modelling approaches.

Accordingly, the key challenges of CropM are to further advance crop modelling for improved assessment of CC impacts on food security. Particular emphasis will be on cross-cutting activities to advance crop modelling as integrated part of IAM. Like in MACSUR1, the knowledge hub strategy includes the stimulation of excellent science, the support of capacity and network building activities and combining and harnessing these for supporting the ambition to jointly work on specific current challenges for agriculture and on explicit and comprehensive case studies on integrated regional and Europe-wide climate risk assessment in close interaction with stakeholders.

In concrete terms, CropM in MACSUR2 will pay attention to neglected research areas, for example, considering ways of improving models to better capture variability and extremes (WP C1), performing empirical crop-weather analysis to complement knowledge from dynamic process-based crop modelling (WP C2), or to consider management variables in the scaling exercises (WP C3) as well as the full range of methods for analysing uncertainty and error propagation in climate impact assessments (WP C4). Moreover, both in capacity building (WP C5) and in the cross-cutting activities (WP C6), there will be more emphasis on multi-scale and integrated analysis of adapting to CC by alternative genotypes (G), management practices (M), systemic changes (e.g. new technologies) and structural changes/transformations of agrifood systems at farm and regional scales. In a concerted effort by MACSUR partners, this should lead to robust European-wide impact assessments and evaluations of adaptation options as part of a global analysis on CC and food security.

CropM theme in MACSUR2 is thus structured in 7 work packages (WPs) each coordinated by 1 to 3 scientists depending on the number of tasks and partners of the WP. The WPs are:
- WP C0: Coordination of CropM
- WP C1: Model intercomparison and improvement
- WP C2: Data management
- WP C3: Methods of scaling
- WP C4: Uncertainty and risk assessment
- WP C5: Capacity building
- WP C6: Cross-cutting activities on specific challenges and regional case studies

Across all WPs of CropM and the Knowledge Hub, a data committee will be active, chaired by P195 WUR, Sander Janssen, that facilitates all aspects related to data sharing across the WPs. It aims to improve data sharing mechanisms across partners as part of CropM and MACSUR, and make data sets publicly available when possible. This data committee does not concern itself with technical implementation of infrastructures, but instead focuses on organizational issues, IPR and advocacy work in relation to data as a resource for future use. Relevant activities are thus: 1. Identifying relevant data sources across WPs either as model inputs or outputs that can benefit from curation; 2. Supporting data owners to publish data sets according to appropriate channels for
them; 3. Studying possible points on IPR as they appear during the functioning of MACSUR CropM; 4. Coordination with LiveM, TradeM and cross-cutting activities on relevant aspects related to data. The most relevant infrastructures the committee has at hand are the Open Data Journal for Agricultural Research (www.odjar.org) and the geonetwork-enabled data repository developed by Aarhus University during the first phase of MACSUR. This data committee is closely linked to operational activities in WPs C1, C2, C3 and C4.
This work package facilitates a successful co-ordination, implementation and management of the theme. It will further improve and maintain an efficient and effective structure for management, co-ordination and planning. In order to achieve the successful coordination and management, the following tasks are formulated:

- Provide and maintain an infrastructure that will ensure the scientific integration of the different work packages including the delivery of the achievements according to specified quality and timeframe.
- Facilitate communication within the theme and across the themes and particularly the cross-cutting activities, including the dissemination of results.
- Monitor project progress on a permanent basis.

Task C0.1: Provide infrastructure for scientific integration of work packages and delivery of results  
(Task leader: F Ewert (115) R Rötter (92), partners involved: Kersebaum (147), Bindi (62), Mathews (150), Olesen (189), Porter (71), Roggero (62), Trnka (17), Janssen (195), Semenov (25), Wallach (175)),  
Duration: Month 1-24

This task will provide the infrastructure to ensure scientific integration of the research in the different WPs and cross-cutting activities and the consistency of their outputs. It will further ensure the effective information flow across WPs and between CropM and the other themes and the timely delivery of results.

Task C0.2: Facilitation of communication within and across themes  
(Task leader: F Ewert (115) R Rötter (92), partners involved: Kersebaum (147), Bindi (62), Mathews (150), Olesen (189), Trnka (17), van Ittersum/Janssen (195), Semenov (25), Wallach (175), Porter (71), Roggero (62)),  
Duration: Month 1-24

The main aim of this task is to facilitate the communication within CropM and the other themes. This includes the organisation of (i) workshops, (ii) demonstrations of results and (iii) dissemination of results (e.g. scientific articles, books, proceedings, website, policy briefs, newsletters, etc.)

Task C0.3: Monitoring project progress  
(Task leader: F Ewert (115) R Rötter (92), partners involved: Kersebaum (147), Bindi (62), Mathews (150), Olesen (189), Trnka (17), Janssen (195), Semenov (25), Wallach (175), Porter (71), Roggero (62)),  
Duration: Month 1-24

This task ensures the monitoring of the work progress within CropM. The theme website will be used to document the progress in CropM, specifically to provide:

- An overview of work packages and activities
- An overview of institutions and people involved in CropM
The task will produce a report about the achievements and future directions for research in crop modelling for assessing the risks of climate change on food security (D-C0.3)

**Deliverables:**
- **D-C0.1:** CropM website (contribution to website of Knowledge Hub) (from Month 1 on with regular updates)
- **D-C0.2:** Regular (3-monthly) newsletters (contribution to newsletters of the Knowledge Hub)
- **D-C0.3:** Report about the achievements of crop modelling for assessing the risks of climate change on food security in MACSUR2 and next steps to be taken (Month 22)

**Milestones:**
- **M-C0.1:** Kick-off meeting of CropM (Month 1)
- **M-C0.2:** CropM progress workshop (Month 5)
- **M-C0.3:** CropM progress workshop (Month 12)
- **M-C0.4:** CropM final workshop (Month 21)

**Risks and contingency:** CropM has a large number of (about 34) partners which are diverse with respect to their national financial support and their scientific experiences. These differences require sensible management to utilize the available capacity to achieve scientific advancement most effectively while at the same time ensuring network and capacity building. In addition CropM integrates a number of cross-cutting activities. CropM will thus support key scientific activities on model intercomparison, scaling and model linking and uncertainty analysis guided by leading European groups in the field. These activities will act as central nodes for network and capacity building to engage and link the entire CropM partner community. The cross-cutting activities will ensure the link to other themes. Case studies and research on specific challenges to be able to address relevant societal debates play an important role in this respect to demonstrate and disseminate results to other partners across themes and engage them in the research in this field.
In the first phase of MACSUR WP C1 developed data requirements as well as data and model evaluation schemes and compared crop models regarding their applicability for various crops and treatments integrated in crop rotations. Experimental data for 303 crop seasons were collected and stored in the WP2 database. Models showed different capability to simulate complex crop rotations transiently. Transient simulations of crop rotations revealed mostly significantly lower deviations to measured crop yields than single year runs (Kollas et al. 2015, in preparation). Since crop rotations and management are important measures to adapt to climate change, further efforts are required to expand the spectrum of crops, which can be handled by the models. Carry over effects between seasons have even higher impact on other outputs, such as seepage or N leaching. Model results for crop variables have to be consistent to other outputs especially regarding water, nitrogen and carbon dynamics have to be analyzed to tackle societal challenges, e.g. water protection. Consequently, the focus of WP C1 in MACSUR2 is to continue comparing models on common data sets to a) identify inconsistencies and gaps of models, b) to analyze their suitability to reflect different site conditions and treatment effects, c) to compare and exchange approaches between models, d) to implement new approaches for extreme events, pests and diseases, e) to expand their spectrum of applicability regarding more crops, cropping systems and relevant ecosystem services. WP C1 aims to improve crop models for a better assessment of climate change impacts on crop production and ecosystem services with reduced uncertainty. Models will be analyzed regarding various outputs of crop growth and ecosystem services, especially such contributing to societal-relevant programs like the Water Framework Directive. This includes the investigation of long term effects of different crop rotations and management systems (energy crops, organic farming) on soil properties and their feedback to crop production. Model response to different site conditions using spatial variable data sets will be analyzed. The impact of extremes and pest and diseases on current and future crop production will be addressed by linking models for occurrence and distribution of extremes, pest and diseases to dynamic crop models. Data sets for model inter-comparison and improvement will be delivered by WP C2, which will get feedback on beneficial effects of additional data for model improvement using data evaluation schemes developed in phase 1 (task C2.5). Model improvements regarding their site sensitivity will be used for a re-analysis of scaling effects and model uncertainty in WP C3 and WP C4. Improved and validated capabilities of models to simulate short and long term effects of cropping and management systems on crop growth and ecosystem services are contributing to XC1 and are essential to perform integrated cross-cutting case studies (XC6) in WP C6, which will integrate crop production, ecosystem services (XC14) and socio-economic analyses and the analysis of yield gaps (XC9). Implementing effects of extremes on crop production and ecosystem services will help XC8 to assess the impact of extreme events.
**Task C1.1: Model response to variable site conditions on crop production and ecosystem services**  
(Task leader: Kersebaum (147), partners involved: Trnka (17), Bindi/Ventrella (62), Wu (65), Müller (83), Palosuo/Rötter (92), (Haas/Kiese (101), Ewert (115), Kozyra(125), Nendel (147), Eckersten/Lewan/Smith/Bodin (163), Olesen (189), Lazar (191), Kroes (195), Loit (202), Eitzinger/Manschadi (208)), **Duration:** Month 1 – 20

Impacts of climate change on crop production depend strongly on the site conditions and properties (Kersebaum and Nendel 2014). Vulnerability of crop production to changing climate conditions is highly determined by the ability of the site to buffer periods of adverse climatic situations like water scarcity or excessive rainfall. Moreover, seepage, nutrient losses and greenhouse gas emissions are affected, which might pollute natural resources and contribute to climate change. Therefore, the capability of models to reflect crop responses and water and nutrient dynamics under different site conditions is essential to assess climate impact on a regional scale. To test and improve sensitivity of models to various site properties such as soil variability and hydrological boundary conditions, spatial variable data sets from precision farming will be provided to modelers and model outputs will be compared to spatial crop and soil observations. Model gaps will be identified and models will be improved by exchanging well performing approaches. Data sets will be included in the MACSUR data base (WP C2) for further model development. Impact of improved validated models regarding scaling effects and uncertainty will be analyzed in WP C3 and C4. Improvements will contribute to XC1 and related outputs of selected ecosystem services to XC14.

**Task C1.2: Implementation of extreme events in crop models**  
(Task leader: Trnka (17), partners involved: Trnka/Hlavinka (17), Bindi/Acutis/Ventrella (62), Wu (65), Müller (83), Rötter/Palosuo/Tao (92), Smith/Bodin (163), Haas/Kiese (101), Smith/Kuhnert (117), Kozyra(125), Höglind/Persson (128), Kersebaum/Nendel (147), Martre/Garcia de Cortazar-Atauri/Launay/Ripoche (175), Olesen (189), Lazar (191), Eitzinger/Manschadi (208)), **Duration:** Month 1- 24

Although inter-annual weather variability is well captured by crop models, extreme adverse weather conditions which are projected to increase across Europe (Trnka et al. 2014) are often not sufficiently considered in dynamic crop modeling. While in some cases processes such as extreme heat effects are still not fully understood, other extremes affect crop growth more physically than physiologically and reduce crop yield not only by real biomass losses, but additionally by impeding harvest processes (e.g. lodging). Additionally, weather situations adverse to perform optimal crop management such as sowing or harvest might affect crop production negatively. Additional to model improvements to capture some extremes physiologically, the implementation of agro-climatic indices and probabilistic approaches into crop models are required for a better assessment of climate change impact. Algorithms will be developed and tested to consider adverse situations for cultivation such as sowing, harvest or fertilization to assess changes of management in climate change scenarios implied by these events. Since shifting of cultivation might also affect other crops within a cropping system, the concept of the first MACSUR phase to run models along whole crop rotations will be consequently continued. Model derived management schedules can be checked with regional data in WP C3 and C2 depending on scale, in regional case studies in WP C6 (XC6) and for uncertainty analysis in WP C4 and XC3. Further, the task will contribute to the workshops in XC8 on the impact of extreme events.

**Task C1.3: Long term effects of management and cropping systems on crop production and ecosystem services**  
(Task leader: Olesen (189), partners involved: Trnka/Hlavinka (17), Bindi/Ventrella (62), Müller (83), Palosuo/Rötter (92), (Haas/Kiese (101), Ewert (115), Smith/Kuhnert (117), Kozyra(125), Kersebaum/Nendel (147), Eckersten/Lewan/Smith/Bodin (163), Armas-
While simulation of cropping systems over a few years might reflect well the short term effects of management and cultivation, long term effects on soil properties and their consequences for crop growth and matter fluxes are not captured (11 year crop rotation of till and no till variants analyzed in MACSUR1 revealed no differences in simulations as well as in observations). Especially the effect on soil carbon sequestration/depletion will be addressed by this task. The intention of this task is to improve predictions from organic matter models through a closer interaction between soil processes and crop growth. Data from long term experiments (> 30 years) of arable cropping systems with different treatments (fertilizer and water supply, tillage, crop rotation) will be used to compared model results and performance regarding long term changes in the soil carbon and nitrogen stocks and their feedback to crop production and matter fluxes. Simulations will be performed as transient runs over the whole period of the experiment and for transient long time climate change scenarios (100 years) to assess the effect of different cropping and management systems on carbon sequestration, matter fluxes and crop production in an integrative way. Calibrated and validated models will be applied in WP C3 and XC2 to assess scaling effects of management for regions and effects of different management options will be checked in WP C4 for perturbed scenarios. Ecosystem services are provided for XC14.

Task C1.4: Extend crop model assessments to more cropping systems
(Task leader Bindi (62), partners involved: Trnka/Potop (17), Acutis (62), Tao (92), Smith/Bodin (163), Haas/Kiese (101), Kersebaum/Nendel (147), Garcia de Cortazar-Atauri/Ferchaud (175), Lazar (191), Loit (202)),

Duration: Month 1 – 24

The AR4 and AR5 of IPCC highlighted the need to provide assessments of climate change impacts for other crops than the major cereals (wheat, maize, rice, etc.). Moreover, the expansion of biomass crops cultivation for biofuel production and the important roles of local cropping systems (in MACSUR1 WP6), confirmed the need to develop, test and compare crop simulation models for these cropping systems. In particular, in some areas fruit tree crops and vegetables represent the main incomes for farmers. Therefore, for the major fruit trees, vegetables and biomass crops a testing of crop simulation performances will be carried out, collecting experimental data (together with WP C2) and analyzing also climate change impacts and adaptation strategies (WP C4) in different regional contests (WP C6, XC6) and for different spatial aggregation (WP C3)

Task C1.5: Incorporation of diseases and pests in crop models
(Task leader: Savary (175), partners involved: Trnka/Svobodová (17), Fereres/Moreno/Dader (24), Rossi/Bregaglio (62) Tao/Rötter (92), Haas/Kiese (101), Höglind/Ficke (128), Kersebaum (147), Eckersten/Yuen (163), Willocquet (175)),

Duration: Month 1 – 24

The effect of pests and diseases has so far not been well integrated in most crop models. Within this task existing pest and disease models and relevant regional specific pest and disease risks for crop production will be identified for important crops. A survey of the most important diseases and pests on major crops will also entail a meta-analysis from WP C2 from existing data from variety trials across Europe. From the survey the most widespread and important pests and diseases across Europe and suitable models will be selected. Data sets which are suitable to quantify the effect of the selected pest will be explored together with WP C2. The aim is to develop appropriate links of models for the occurrence of harmful organisms with crop models to quantify their negative effect on crop production. Regional application will be tested within case studies XC6.

CropM-led tasks contributing to XC activity 1. For further details see XC activity 1 in Form A:
Task C1.6/XC1.1 Survey on model improvement needs (Task leader: Bindi (P62), partners
Task C1.7 (XC1.3) Establishing links to other research activities in the field of model comparison and improvement (Task leader: Haas (P101), partners involved: Semenov (P25), Bindi/Cassardo (P62), Bojar/Knopik/Żarski (P100), Slawinski (P139), Kersebaum (P147), Bellocchi/Jayet/Perez-Barahona (P175), Lazar (P191), Helming (P192))

Milestones:

M-C1.1.1: Model performance on spatial variable inputs (Month 20)
Multi-model results are available for spatially variable input data and spatial results of crop yield; biomass, N uptake, water and mineral N content after harvest are compared with measured values.

M-C1.2.1: Approaches for extreme events are integrated in crop models (Month 9)
The most relevant effects of adverse weather conditions are identified, algorithms are developed

M-C1.2.2: Validated models implementing approaches for selected extremes (Month 22)
Approaches are integrated in selected models and tested with example data sets.

M-C1.3.1: Comparison of models applied to long-term experiments (Month 15)
Results of long term runs of a multi-model ensemble for selected long-term experiments are available.

M-C1.3.2: Long term effects of cropping and management systems under current and future climate conditions from transient runs of a model ensemble (Month 20)
Long term runs of a model ensemble for selected crop rotations and management systems are performed for a current baseline climate scenario and selected climate change scenarios and results for selected ecosystem services are compared.

M-C1.4.1: Data sets for selected cropping systems available for modelers (Month 9)

M-C1.4.2: Inter-comparison of models for new cropping system available (Month 22)
Results of a model ensemble for selected new cropping systems are compared to observations.

M-C1.5.1: Survey of relevant pest and diseases in European regions (Month 5)
A review of relevant pests and diseases for regional cropping systems across Europe is available identifying the most affected crops in different regions.

M-C1.5.2: Approaches for pests and diseases available for implementation (Month 12)
Approaches for occurrence of selected pests and diseases and damage effects on crops are identified.

M-C1.5.3: Verification of models implementing pest and diseases effects (Month 22)
The model approaches for selected pests and diseases are implemented in selected models and have been tested with available data.

Deliverables:

D-C1.1.1: Data sets of spatial variable data from Precision Agriculture data (Month 4)
D-C1.1.2: Paper on site sensitivity of models regarding yields and water and N dynamics (Month 24)
D-C1.2: Paper on model responses to selected adverse weather conditions (Month 24)
D-C1.3: Paper on long term effects of cropping and managements systems on soil organic matter, C/N dynamics and crop growth (Month 24)
D-C1.4: Paper on modeling different cropping systems
D-C1.5: Paper on integration of pest and disease models into crop models

Risks and contingency:
Data to perform a minimum analysis are available for each task. However, the extent of research depends on availability of funded research and data in each partner country.
WP C2 will provide the data management needed to make assessments of crop models at different scales and to present results to users and stakeholders. In this context it links closely to WP C1, WP C3 and WP C4. Such assessments require availability of good datasets of weather as well as of crop growth and development and of a range of other soil and environmental variables. MACSUR1 CropM has been collecting datasets from across Europe focusing on crop rotations, and these data have been made available for modellers via the web-based database hosted at AU that also handles IPR issues. This database also stores model outputs for use in visualizing results. There remains a need for improving access to high quality datasets. However, data sets need to be expanded beyond crop yield to also cover other aspects related to ecosystem services such as water use, nitrogen leaching, soil carbon change, greenhouse gas emission etc. There is also a need to expand the datasets regarding effects of different genotypes of crops with respect to various characteristics such as phenology, crop yield and quality. Both these aspects should cover a range of crops across Europe. Some of these data will come from long-term experiments or large-scale facilities such as those under the newly proposed ANAEE European Research Infrastructure. Links will therefore be maintained with the efforts under ANAEE. MACSUR1 has developed a data journal to publish such datasets, and this will be further expanded in this project. In addition to the experimental data, WP C2 will also collate and distribute climate change scenarios as well as simulation results of such scenarios. These data and results will include results from both European wide studies as well as regional case studies, depending input from other WPs. Some new datasets developed during MACSUR1 CropM will be used to test the effect of using different levels of detail with respect to measurements and crop and soil management for calibration on ability of models to simulate extrapolated conditions, thus testing the hypothesis that better data improve modelling skills. WP C2 will analyse data gaps in terms of data needed for improving crop modelling, as well as perform statistical analyses of responses of genotypes of different crops to climatic variation across Europe. It will also collect and analyse evidence of adaptation to climate change from across Europe. Finally it will develop procedures to visualize model input and output from CropM activities.

Task C2.1: Data compilation, management and presentation (Task leader: Janssen (95), partners involved: Trnka (17), Fereres, Moreno, Dader, Iglesias (24), Topp (47), Minet (51), Bindi, Quaranta (62), Teodor (85), Höhn (92), Gebbert, Grosz (202), Ewert (115), Kozyra (125), Kersebaum (147), Olesen, Hansen (189), Loit (202), Manschadi (208)), Duration: Month 1 – 24
This task will collect data from all other WPs, including both experimental data, data from regional pilot studies as well as model simulated results and will draw on experience gained during past activities, including during MACSUR1. The database developed under MACSUR1 with handling of IPR will be modified to cover the needs of this phase to better include regional pilot studies. The design of the database and the criteria for interface will be evaluated by a data committee with
participation from other WPs (as well as representatives from TradeM and LiveM programs). Data will be stored in the database with respect to geographical location, time of data collection, type of data, crops covered etc. Some data will be stored for direct retrieval across experiments, while other datasets most likely will require specific storage of individual experimental data. To present the model outputs, input data as well as results from WP C1, WP C3 and WP C4 in form of maps and graphically a system for data visualization will be adopted. This will be based on experiences from MACSUR1 as well as from other projects, e.g. Global Yield Gap Atlas. Efforts will be given to also visualise results from regional pilot studies in additional to European scale studies.

**Task C2.2: Climate change scenarios (Task leader: Semenov (25)), Duration: Month 1 –12**
This task will make available local-scale climate change scenarios based on the CMIP5 multi-model ensemble for RCP4.5 and RCP8.5 for the experimental sites and pilot regions (limited number of sites) included in the C2.1 database.

**Task C2.3: Quantify data gaps for crop modelling (Task leader: Olesen (189), partners involved: Trnka (17), Minet (51), Bindi, Orlandini, Quaranta (62), Rötter/Höhn (92), Kersebaum (147), Olesen (189), Weihermüller (159), Smith (117)), Duration: Month 1-22**
Based on the critical assessment of the data collected and prepared in C2.1-2.3 a review of available datasets will be prepared. This will be extended to identify data gaps for crop modelling and steps will be proposed to fill these gaps either by using existing or starting new experiments. The results should be directly made available to the ANAEE program and interaction between MACSUR and ANAEE started. During MACSUR1 additional high quality data has been collected for supporting crop modelling. A model intercomparison and improvement exercise will be set up to use these high quality data for analyzing the effect of having access to additional information during the crop model calibration and adjustment on modelled responses of crop yield and quality to variation in weather and management.

**Task C2.4: Observed adaptation options and their efficacy (Task leader: Trnka (17), partners involved: Bindi, Quaranta (62), Peltonen/Sainio (92), Kozyra (125), Kersebaum (147), Olesen (189), Lazar (191)), Duration: Month 7 – 24**
There are number of potential adaptation measures being discussed and many of them are being adopted by the farmers. We will use the collaboration with national experts to collect data on observed adaptive strategies being employed using on-line interactive questionnaire that will be linked to previous studies (e.g. Olesen et al. 2011). This will provide an important background for the crop modellers to define their hypothesis regarding adaptation in agreement with already observed changes. The set of research hypothesis regarding efficacy of most frequently used adaptive measures will be defined and proposed for testing to modelling groups.

**Task C2.5: Empirical analyses of crop responses to climatic variation (Task leader: Olesen (189), partners involved: Trnka (17), Bindi (62), Kahiluoto/Kaseva (92), Kozyra (125), Kersebaum (147), Lipiec (158), Lazar (191)), Duration: Month 1 – 24**
Data on crop phenology and yield will be collected for key crops for a range of varieties across Europe, primarily from variety trials. These data will be used to analyse responses of crop phenology and yield to both average climatic conditions and to variation in the conditions. Responses of individual varieties as well as the range of varietal responses to climatic variables will be studied as a basis for improved understanding of the use of varieties for adaptation to climatic variability and change. The analyses will be coordinated with the simulation modelling of varieties in WP C1.

**Milestones:**
**M-C2.1**: All datasets of partners critically reviewed and list of those available for modelling exercises in MACSUR catalogued and accessible to the project partners (Month 12)

**M-C2.2**: A document describing methodology of preparing local-scale climate change scenarios based on the CMIP5 multi-model ensemble for RCP4.5 and RCP8.5 for the experimental sites and pilot regions (Month 12)

**M-C2.3**: Data gaps for crop modelling identified (Month 14)

**M-C2.4**: Impact of data quality on crop model simulations quantified (Month 16)

**M-C2.5**: On-line web tool for visualizing experimental and modelling results. (Month 12)

**M-C2.6**: Europe-wide distribution of an electronic questionnaire dealing with the observed adaptation measures in the European agriculture. (Month 10)

**M-C2.7**: Crop yield responses of key crops to climatic variation quantified (Month 12)

**Deliverables:**

**D-C2.1**: Overview of datasets available for modelling in MACSUR (Month 14)

Report on the various datasets that have been made available in MACSUR and links to publications describing the data.

**D-C2.2**: Local-scale climate scenarios (Month 12)

Local-scale climate change scenarios based on the CMIP5 multi-model ensemble for RCP4.5 and RCP8.5 for the experimental sites and pilot regions (limited number of sites).

**D-C2.3**: Data gaps for crop modelling (Month 20)

Review report on data gaps for crop modelling and proposals for filling these gaps.

**D-C2.4**: Evaluation of impact of data quality on crop model simulations (Month 24)

Report on effect of increasing availability of detailed data for calibration of crop simulation models on quality of model predictions.

**D-C2.5**: Observed adaptations (Month 24)

Report on observed adaptations and their applicability and efficiency under different agro-environmental conditions.

**D-C2.6**: Empirical crop yield responses to climatic variation (Month 24)

Report on crop yield responses to changes in mean and variability of climatic variables.

**Risks and contingency:**

A lack of provision of data by partners in the theme: IPR issues will be monitored by a data committee and we will use the IPR policy developed in MACSUR1. Difficulty in maintaining common formats and data standards over the massive diversity of crops, soils, management, and experiments: Flexibility will be built into the database through optional choices. The method adopted will build on experiences from other projects and a continuous review of the scheme will be made.
The application of field-scale crop models for larger areas and time periods is an essential part of climate change impact assessments that is not well understood. Several methods of scaling up crop models from the field to the larger spatial (e.g. farm, region, continent) and temporal (e.g. decades) scales are available (Ewert et al. 2011) but errors and uncertainties in using these methods have just begun to be analysed systematically. Substantial progress has been made in this WP under MACSUR1 to advance this understanding. In several multi-model exercises the effects of aggregating input data related to weather variables and partly to soil characteristics have been analysed for a region in Germany, i.e. the state of North-Rhine Westphalia and for two crops winter wheat and maize. First results of this analysis are in the process of being published; (Ewert et al. 2014b, Hoffmann et al. 2014 in preparation, Zhao et al. 2014). In addition, MACSUR partners have also been involved in a multi-model scaling exercise within the AgMIP project performed in conjunction with MACSUR to specifically investigate the errors in upscaling using the method of stratified sampling (Ewert et al. 2014b, Van Bussel et al. 2014).

Complementary to this, research was performed to specifically understand errors in upscaling a crop model for estimating effects of extreme events due to heat and drought stress on wheat (Rezaei et al. 2014) and to better understand the spatial variability in upscaling errors (Zhao et al. 2015). Although initial investigations were also made for a different region in Europe (Jokinen, Finland) and another crop (spring barley) (Angulo et al. 2013), the general applicability of the obtained results in MACSUR1 to other regions and crops needs further attention in MACSUR2.

Scaling activities in MACSUR1 have started to address the impact of soil data aggregation on model simulations. This exercise has been initiated as a joint activity between MACSUR and AgMIP. Initial results are available and interactions between scaling of weather and soil input data appear particularly relevant when applying crop models at larger areas (Hoffmann, personal communication; MACSUR-AgMIP crop model scaling newsletter, 2014) which stress the need to complete this exercise in MACSUR2.

The consideration of management data for the upscaling of crop models demands specific attention and will be an important focus of MACSUR2 including investigations of interaction with the upscaling of weather and soil data. Initial exercises have been designed in MACSUR1 and will be implemented in MACSUR2.

Emphasis in improving the scaling up of crop models has been mainly focused on crop yield. Initial efforts have been made to also analyse effects on other variables related to water, carbon and nitrogen dynamics but need further attention in MACSUR2. This should clarify to which extent insights about the upscaling of crop models for yield simulations are also applicable to other impact variables.

The obtained information will be essential when it comes to the linking of crop models with farm,
market and livestock models. Here an initial effort has been made in a regional and European wide study (Wolf et al. 2014) which will be further advanced in MACSUR2. As part of these uncertainties in scaling up crop models for future projections of climate change impacts will be quantified and reported.

The WP will closely cooperate with WP C4 on the propagation of model uncertainties due to upscaling, with WP C6 and related cross-cutting activities on integrated scaling methods, European-wide assessment and scenario development, with WP C1 on model improvement and with WP C2 on issues of data management, visualisation and presentation. There will also be a link to WP C5 to merge latest insights about the upscaling of crop models into capacity building and teaching activities.

Objectives:
1. To compile a review on the latest progress of scaling methods for large scale application of crop models for different purposes and impact variables (yield, water use, soil carbon, N emissions)
2. To compile data for the development and evaluation of scaling methods
3. To develop and evaluate scaling methods for soil characteristics and crop management in interaction with weather data to improve the application of crop models for larger area impact assessments
4. To generalise results for other regions, crops, and impact variables
5. To apply crop models in integrated assessment studies considering advances in upscaling methods and propagations of uncertainties from upscaling of crop models
6. Disseminate results from scaling exercise within FACCE-MACSUR

Task C3.1: Review progress in scaling methods and supervision of activities in WP C3 (Task leader: F. Ewert (115), partners involved: Challinor/Foyer (22), Janssen (195), Kersebaum/Nendel (147), Haas (101), Eckersten/Lewan (163), Raynal/Constantin/Wallach (175), Bindi/Roggero/Trombi (62), Weighmüller (159), Kuhnert (117), Dechow/Grosz (112), Duration: Month 1-24

Advances in understanding scaling methods for different data types (e.g. weather, soil, management), crops and impact variables (e.g. yield, water use, soil carbon, N emissions) and the related requirements have been made and need to be synthesised in an overview. For this purpose, the following activities will be performed:
C3.1.1: Synthesis of requirements and suitable scaling methods in crop modelling for different data types, crops and impact variables
C3.1.2: Define further case studies for validation of scaling methods
C3.1.3: Evaluation and visualization of uncertainties from scaling method.

Task C3.2: Development of a joint data sharing mechanism for scaling exercises (Task leader: S. Janssen (195), partners involved: Ewert (115)), Duration: Month 1-24

This task will establish a method to easily share larger and smaller data sets for multi-model exercises. It will be explored whether this needs to be formalized in a bigger infrastructure, or whether more loose distribution methods are preferred using ftp-servers. It will be investigated whether the crop-model translators, developed as part of AgMIP can be of use here. Also, data sets will be sought that can be published under the Open Data Journal for Agricultural Research, which is supported by MACSUR
C3.2.2: proposed solutions for sharing data, establishing standards, and relevant data sets to be
in the Open Data Journal.

C3.2.3: if feasible, implementation of sharing mechanisms.

**Task C3.3: Comparison of scaling methods** (Task leader: F. Ewert (115), partners involved: Janssen (195), Kersebaum/Nendel (147), Haas (101), Eckersten/Lewan (163), Raynal/Constantin/Wallach (175), Bindi/Roggero/Trombi (62), Tao/Rötter (92), Lazar (191), Van Oijen/Cameron (255)), **Duration:** Month 1-24

In this task, scaling methods will be compared and evaluated. Different scaling exercises will be identified referring to different data types.

Scaling methods are evaluated by analysing the uncertainty related to aggregating crop model input data (loss of accuracy) vs. obtaining averaged yields at aggregated resolution (no loss of accuracy).

C3.3.1: (Activity leader: P175). Comparison of scaling methods related to aggregation for different weather, soil data and management data

C3.3.2: (Activity leader: P115). Comparison of scaling methods related to sampling for different weather, soil data and management data

C3.3.3: (Activity leader: P147). Assessment of errors due to upscaling related to transient and non-transient simulations and with regard to spin-up phases to specifically evaluate time-cumulative errors. Findings from WP1 (crop rotation) will be integrated.

**Task C3.4: Evaluation of scaling methods for other crops, regions and impact variables** (Task leader: F. Ewert (115), partners involved: Janssen (195), Kersebaum/Nendel (147), Raynal/Constantin/Wallach (175), Haas (101), Kuhnert (117), Bindi/Roggero/Trombi (62), Dechow/Grosz (112), Eckersten/Lewan (163), Weihermüller (159), Van Oijen/Cameron (255)), **Duration:** Month 1-24

This task explore will further explore the implications of the key findings of MACSUR1 CropM WP3 and MACSUR2 Task C3.3 by evaluating hypotheses derived from those findings for a broader range of crops, regions and impact variables.

C3.4.1: (Activity leader: P115). Evaluation of scaling uncertainties and generalization of findings by comparison of scaling methods for the simulation of crop growth in different regions in Italy and Germany.

C3.4.2: (Activity leader: P115). Evaluation of crop specific input data aggregation effects. Crop model – crop interactions related to aggregation effects will be explored and linked to key crop and model parameters.

C3.4.3: (Activity leader: P101). Evaluation of scaling methods concerning the N-cycle. This activity will analyse spatial scaling effects at daily resolution and identify model differences in aggregation effects in N-cycling and related pulse emissions of N2O and NO3 leaching.

C3.4.4: (Activity leader: P117). Evaluation of scaling methods concerning the C-cycle. This activity will analyse spatial scaling effects and identify model differences in aggregation effects in carbon-related variables as net primary production (crop) or organic carbon (soil). Findings from C3.3.3 for spin-up phases will be integrated.

**Task C3.5: Application of scaling crop models for integrated assessment of climate change impacts in Europe** (Task leader: F. Ewert (115), partners involved: Janssen (195), Raynal/Constantin/Wallach (175), Eckersten/Lewan (163), Kuhnert (117), Bindi/Roggero/Trombi (62), Haas/Kiese (101), Dechow/Grosz (112), Weihermüller (159), Lazar (191)), **Duration:** Month 1-24

This task will merge advances in crop model scaling into integrated studies. The assessment of
European climate change impacts is a major concern when simulating yields at larger scales and will thus serve as a benchmark for model comparison addressed in the respective cross-cutting activity (XC7) to which this task contributes.

C3.5.1: (Activity leader: P115). Assessment and documentation of uncertainty from scaling on projections of climate change impacts in European using different crop models.

C3.5.2: (Activity leader: P115). Assessment of the relative sensitivities of cropping systems to changes in climate mean and climate variability and as influenced by the production situation (potential, water limited, N- and water limited).

C3.5.4: (Activity leader: P62). Assessment of the relative sensitivities of crop land soils organic carbon to changes in climate mean and climate variability and as influenced by the production situation (potential, water limited, N- and water limited).

**Task C3.6/XC2.1: Inventory of scaling methods across crop, farm and economic models**

CropM-led task contributing to XC activity 2. For further details see XC activity 2 in Form A (Task leaders: Ewert/Hoffmann (115), partners involved: Roberts/Eory/Stott (P47), Minet/François (P51), Rolinski (P83), Tao/Rötter (P92), Kiese/Haas/Arneth (P101), Dechow/Grosz (P112), Sands (P143), Kersbaum/Nendel (P147), Saetnan (P148), Weihermüller (P159), Eckersten/Lewan (P163), Klumpp (P175), Dalgaard (P189), Curnel (P252), van Oijen/Cameron (P255))

**Milestones:**

- **M-C3.1**: Overview of progress in scaling methods (Month 12)
  - Scaling methods evaluated in the different MACSUR exercises are listed for different data types, crops and impact variables and known advantages and disadvantages are described.

- **M-C3.2**: Decision of data sharing mechanism for scaling exercise and determination of relevant data sets for OdJAR.org (Month 6)

- **M-C3.3**: Completion of Protocol for upscaling methods to be compared (Month 6)

- **M-C3.4**: Decision on regions, crops and impact variables to be considered in the comparison of upscaling methods (Month 6)

- **M-C3.5**: Decision on models and scaling methods to be used in integrated assessment study (Month 6)

**Deliverables:**

- **D-C3.1**: Overview of progress in scaling methods (Month 12)
  - The deliverable provides an overview of scaling methods used in crop modeling for the specific domains input data types, crops and impact variables and documents their advantages and disadvantages.

- **D-C3.2**: Datasets published as part of ODJAR, and description of decision on sharing mechanism plus implementation (Month 12)

- **D-C3.3**: Report on results of scaling exercises (Month 18)
  - The deliverable evaluates different scaling methods related to weather, soil and management data. Crop model and scaling methods interactions are described.

- **D-C3.4**: Evaluation of scaling methods for other crops, regions and impact variables (Month18)
  - The deliverable describes and synthesizes results about the generalization of scaling methods for defined case studies of varying/different crops, regions and impact variables. Interactions between crop models and scaling methods are described.

- **D-C3.5**: Report on results of application of scaling methods for integrated modelling (Month 18)
  - The deliverable reports the uncertainty associated with the upscaling of crop model for different input data (weather, soil, management) for yield projections with a range of crop models.
**Risks and contingency**
Large data synchronization task and high number of simulations are time and computing intensive, leading to complex outputs. The attribution of effects including statistical analyses needs to range from physically traceable processes in the models up to n-dimensional purely statistical methods. Focusing the analysis on selected methods, impact variables, crops and regions will reduce this problem if apparent.
Framing food availability requires adequate agricultural production planning. Decision-making can benefit from improved understanding of the uncertainties involved, and from comprehensive information on how agro-climatic risks change under future conditions. Until recently, uncertainty in climate change impact projections and adaptation effect studies for agriculture had not received adequate attention. Yet, to inform decision making there is need to identify, describe, quantify and communicate the sources of uncertainty in making projections of future crop responses to climate change. Major sources of uncertainty in climate impact projections are found in climate projections, scaling/regionalisation and impact modelling, whereby model-related uncertainties are due to model inputs, parameters and structure (Walker et al. 2003, Rötter et al. 2012). During phase 1 of MACSUR considerable progress has been made in this WP towards developing a common set of methods for assessing and communicating uncertainties (Wallach et al. 2013, Wallach et al., in prep), in novel ways of assessing shifts in climate-induced risks to crop production (Rötter et al. 2013, Trnka et al. 2014), and in pioneering work of model-aided design of high-yielding wheat ideotypes (Semenov et al. 2014). Considerable advancements also have been made in uncertainty evaluation, i.e. in quantifying uncertainties (using multi-model ensembles) and improving understanding of what is driving uncertainty in impact assessments. Specific attention has been paid to describing the method of impact response surface (IRS) analysis (using large model ensembles), of which first results will be published soon (e.g. Pirttioja et al. in prep.). This IRS method has a huge potential for use in probabilistic assessment of climate change impacts – going clearly beyond mere biophysical impact assessments. Many of the activities have been conducted in close collaboration with the AgMIP-Wheat & uncertainty groups.

In MACSUR1 emphasis has been on describing and classifying behaviour of a large ensemble of crop models to changes in temperature (T) and precipitation (Precip) in contrasting environments (Fronzek et al. in prep.). However, too little attention has been on (i) establishing a comprehensive framework for assessing error and uncertainty in crop model estimates considering the various approaches that exist, and (ii) to fully exploit the potential of IRS and other techniques for the probabilistic assessment of a whole range of (region-specific) adaptation options. The major goal of WP C4 for MACSUR2 is to address these two broad research gaps by six specific activities (Tasks) further described hereunder. WP C4 as a whole is linked and will closely collaborate with WP C3 related to errors and uncertainties from (up-) scaling methods. Furthermore, there are very close ties to WP C1, e.g. to reducing uncertainties through model improvement and to WP C2, by informing this WP on the prioritization of data gaps to be filled (i.e. task C2.4) to reduce model input or parameter-related uncertainties and, in turn, learn from the empirical analysis of this WP, e.g. use improved information on crop cultivar differences in modelling the effect of adaptation options for reducing climate change risks. There are also close links to WP C6 and related activities on cross-cutting uncertainties (XC3),
Task C4.1: Comprehensive framework for assessment of error and uncertainty in crop model predictions
(Task leader(s): Daniel Wallach (175)/Davide Cammarano (150), partners involved: Rivington (150), Rötter/Palosuo (92), Porter (71), Bindi/Acutis (62), Haas/Kiese (101), Olesen (189), Kauer/Kadaja/Loit (202, Van Ittersum (195)), Duration: Month 01 – 18; Task description: There have been multiple studies aimed at evaluating crop models, based on the comparison of simulated and observed values, on the propagation through the model of uncertainties in model inputs and/or parameters, or on the variability in results of multi-model ensembles. Each of these approaches gives somewhat different information about model uncertainty. It is important to clarify how these approaches are related and how they can be used together to give a better vision of crop model uncertainty. Of particular interest is the relative importance of different contributions to uncertainty.

Task C4.2: Best practices for building and analyzing the results of multi-model ensembles
(Task leader: Daniel Wallach (175), partners involved: Rötter/Carter (92), Ewert/Hoffmann (115), Porter (71), Bindi/Acutis (62), Trnka (17), Olesen (189), Haas/Kiese (101), Kauer/Loit (202), Cammarano/Rivington (150)), Duration: Month 01 – 24
Comparison of the results of multiple crop models is a powerful new technique for evaluating crop model uncertainty, and is the basis of much of the work in MACSUR CropM. However, the results depend strongly on the details of the ensemble, and the way the results are interpreted. It is important to explicitly identify the questions and choices involved in creating and interpreting multi-model ensemble (MME) results, and to codify best practices and needed research. It is particularly important to take advantage of the experience in the climate modelling community, where MME studies have a longer history than for crop modelling.

Task C4.3: Analysing model sensitivity to perturbations in climate variables with a large crop model ensemble using impact response surfaces
(Task leader: Reimund Rötter (92), involved partners: Pirttioja/Fronzek/Carter/Palosuo/Tao (92), Ruiz-Ramos, Minguez, Lorite, Rodriguez (24), Bindi/Acutis/Ferrise (62), Mueller (83), Kersebaum and Nendel (147), Hoffmann/Ewert (115), Trnka/Hlavinka (17) Olesen (189), Porter/Montesino (71), Wallach (175), Haas/Kiese (101), Eckersten/Lewan (163), van Ittersum/Wolf (195), Kadaja (202), Cammarano/Rivington (150), Buis/Ruget (175)), Duration: Month 01 – 24
Analysing the sensitivity of process-based crop models that are of different origin and complexity and have been developed for different purposes to changes in key climatic variables (such as T and Precip) is not trivial but a crucial step for identifying smart applications of ensemble modelling. Impact response surfaces (IRSs) depict the response of an impact variable to changes in two explanatory variables as a plotted surface. In MACSUR1, IRS analysis has been used to investigate sensitivities in crop yield estimations and compare model behaviour under a range of climates in Europe. With the aim to distinguish differences in model response attributable to climate, Pirttioja et al (in preparation) constructed IRSs of spring and winter wheat yields from a 26-member ensemble of crop models and examined for these the sensitivity of modelled yield to changes in T (from -2 to +9 ºC) and Precip (from -50 to +50%). As direct follow-up, in MACSUR2 we aim to classify the ensemble members by their model behaviour, and eventually perform a deeper analysis of the underlying reasons - as a prerequisite to building more robust crop models/modelling approaches for use in assessing climate risks to crop production.

Task C4.4: Probabilistic ensemble-based assessment of region-specific adaptation options
(Task leader(s): Daniel Wallach (175)/Davide Cammarano (150), partners involved: Rivington (150), Rötter/Palosuo (92), Porter (71), Bindi/Acutis (62), Haas/Kiese (101), Olesen (189), Kauer/Kadaja/Loit (202), Van Ittersum (195), Duration: Month 01 – 18; Task description: There have been multiple studies aimed at assessing crop models, based on the comparison of simulated and observed values, on the propagation through the model of uncertainties in model inputs and/or parameters, or on the variability in results of multi-model ensembles. Each of these approaches gives somewhat different information about model uncertainty. It is important to clarify how these approaches are related and how they can be used together to give a better vision of crop model uncertainty. Of particular interest is the relative importance of different contributions to uncertainty.
In order to complement the IRS analyses performed under task 4.3, here we will focus on local or region-specific adaptation options. To evaluate different adaptation options it is not sufficient to only distinguish differences in model response to climate, but soil differences and various management variables need to be taken into account. To use a probabilistic ensemble-based approach for meaningful evaluation of effects of adaptations (in contrasting environments), IRS1 analysis needed to be expanded by simulating different future CO2 levels, contrasting soil profiles, and more options in relation to management, in particular to adaptation. The analysis cannot be universal but tailored to target environments.

Task C4.5: Crop ideotyping for future conditions using single/multiple crop models. (Task leader: Mikhail Semenov (25), involved partners: Tao/Palosuo/Höhn/Rötter (92), Bindi/Ferrise (62), Ruiz-Ramos, Minguez (24) Trnka/Hlavinka (17), Kersebaum/Nendel (147), Hoffmann/Ewert (115), Lazar (191), Loit (202), Martre (175)), Duration: Month 1 – 24

Expected more frequent/severe weather extremes and uncertainty in climate projections are posing particular challenges to plant breeders and crop scientists (Semenov et al. 2014). While most crop models are not yet fit and need improvement for accurately capturing effects of adverse weather/extremes, since the 1980s crop simulation has proven to be an important tool for supporting plant breeding and assessing climate risks to crop production. Purpose of this task is to examine the potential of combining ensemble modelling with simulation model-aided ideotyping of new cultivars for future climates. In a pilot study, model-supported ideotyping for barley will be performed using a number of widely applied crop models at two contrasting sites. The work on designing high-yielding wheat ideotypes, which started in MACSUR1, will be continued. Responses to extreme events, e.g. high temperature during anthesis and grain filling, will be incorporated in the Sirius wheat model and tested against existing field experiments. The importance of heat and drought tolerance for future wheat ideotypes under CMIP5-based climate scenarios will be examined across Europe.

Task C4.6: Model uncertainty quantification (Task leader: Edwin Haas (101); Involved partners: Wallach (175), Kuhnert (117), Rötter (92) Cammarano/Yelupati (150)), Duration: Month 01 – 24

In this task we aim to fully quantify uncertainty of i) yield, ii) carbon cycling and iii) nitrogen cycling predictions of one of the MACSUR regional study case (XC6) using different model approaches (WP1 CropM) crop models including carbon & nitrogen cycling. We address model induced uncertainty by contrasting the different models involved in this task (LandscapeDNDC, STICS, DAYCENT) on simulation objectives yield/carbon cycle/nitrogen cycle. We will perform parameter induced uncertainty assessments by performing Bayesian parameter calibrations. The analysis will attribute a “probability of correctness” (the opposite of uncertainty) to each of the models when simulating one of the regional case study sites. Statistical analysis of the simulation results will be used to quantify the overall full uncertainty of the modelling.

CropM-led tasks contributing to XC activity 3. For further details see XC activity 3 in Form A: The IRS approach (see, Tasks 4.3 & 4.4) can be combined with probabilistic climate projections to facilitate consideration of impact risks (for example, estimating likelihoods of failing to exceed certain yield levels). As environments, cropping practices and climate projections are region-specific, this analysis cannot be universal but must be tailored to target environments.
Task C 4.7/XC3.1: Overview on studies and research activities relevant to uncertainty
(Task leaders: Haas (101), Trnka (17), involved partners: Severini/Dono/Cortignani (62), Porter (71), Rötter/Palosuo (92), Arneth (101), Höglind (128), Wallach (175))

Task 4.8/XC3.2: Establishing links to other research activities in the field of uncertainty assessment and quantification (Task leader: Haas (101), Partners involved: Severini/Quaranta (62), Rötter (92), Bojar (100), Arneth (101), Hoveid (128), Wallach (175))

Milestones:
M-C4.1.1 A library of previous studies of model comparison, based on the wealth of experience represented by the partners of MACSUR (Month 12).
M-C4.1.2 A document that shows how different approaches to model evaluation are related, how best to apply each approach (protocols), and how to use them together to obtain a better overall picture of crop model uncertainty and the contributions to that uncertainty (Month 12).
M-C4.1.3 Results of applying these protocols in different situations, with an analysis of uncertainty and its components and how they depend on the context of prediction or projection, and on output being simulated (Month 12).
M-C4.2.1 Document that identifies the questions and choices involved in building and analyzing MMEs, based on the experience in both the crop modeling and climate modeling communities (Month 12).
M-C4.2.2 Document that makes recommendations of best practices for creating and analyzing MMEs (Month 12).
M-C4.2.3 Document that identifies important future research directions in this area (Month 15).
M-C4.3.1 Documentation of model sensitivity for an ensemble of 26 models that distinguishes differences in model response attributable to climate – with a classification scheme for different model behaviour (Month 15).
M-C4.3.2. Document on future research needs in this area (Month 15).
M-C4.4.1. Documentation of selected climate change adaptation options for cereal cultivation regions in the Mediterranean (exemplified for N Spain), Nordic (Finland) and central parts (Germany) of Europe (Month 18)
M-C4.4.2 Document on differences in crop model behaviour of simulating effects of adaptation in contrasting agro-environments - with an outlook on future research needs in this area (Month 18).
M-C4.5 Document on differences in crop model behaviour in designing new, more climate resilient crop cultivars - with an outlook on future research needs in this area (Month 18).
M-C4.6.1 Parameter induced uncertainty quantification for simulating yield, carbon and nitrogen cycling for the MACSUR test site (Month 18)
M-C4.6.2 Uncertainty quantification for simulating yield, C and N cycling for a MACSUR test site (Month 18)

Deliverables:
D-C4.1: Overview paper submitted: on comprehensive framework for assessment of error and uncertainty in crop model predictions (Month 12)
D-C4.2: Refereed article submitted: use of multi-model ensembles to simulate climate impacts on crop production (Month 18)
D-C4.3.1: Refereed article submitted: on classifying crop model behaviour of a large ensemble ; lead: Fronzek (Month 12)
D-C4.3.2: Refereed overview article submitted: on reasons for different crop model behaviour - genealogy, process descriptions, etc., lead: Rötter (Month 18)
**D-C4.4:** Refereed article submitted: Crop model sensitivity to climate, CO2 and adaptations in a Mediterranean region Europe, lead: Ruiz-Ramos (Month 24)

**D-C4.5:** Refereed article submitted: Performance of ensemble model-designed future barley cultivars at two contrasting sites in Europe, lead: Tao (Month 18)

**D-C4.6:** A manuscript submitted to a referee journal on high-yielding wheat ideotypes across Europe by the refined Sirius model incorporated responses to extreme events, lead: Semenov (Month 18)

**Risks and contingency:** Huge amount of simulations and related quality checks are time-consuming; also, data to perform a minimum analysis must be available for each task. The extent of research eventually depends on availability of funded research in each partner country.
Modelling has become a widespread tool for understanding complex dynamic systems. In particular, modelling plays an important role in understanding climate change impacts within agricultural systems, with a wide range of modelling strategies across a broad spectrum of scientific fields. Many scientists who develop or use these models have only limited formal training in model development. Any experience with models from a wider range of fields is even more limited, which can be a significant barrier to model integration and cross-theme working. An important aspect of MACSUR CropM is therefore to provide training and capacity building, both for early career scientists and more established researchers who wish to expand their capacity for integrated research. Post-graduate training courses in various aspects of modelling are therefore important to improve the capacity of scientists working in this field. Much effort has already been put into development of theme-specific courses. Training courses, both on-line and in-person, have also been developed at various partner institutions and as part of other projects. We will continue to build the experiences gained by partners so far within the three themes. Possible options for future training include training for practitioners, e-learning development and use, PhD courses and more. Experience with training development, approaches to training, and training needs may be very different between themes and the aim of this activity is to bring together the range of possibilities and experiences gained for presentation and discussion.

**Task C5.1: Continuation of provision of PhD courses for interested students and post-docs.** (Task leader: John R Porter (71); partners involved: Bindi (62), van Ittersum (195) Wallach (175)),

**Duration:** Month 1 – 24.

Following the successful series of PhD schools organized under CropM that covered many aspects of modelling and climate change and involved teachers from Europe and elsewhere (mainly USA via AgMIP), we recognize that fresh cohorts of PhD students will need training. The teams we built under CropM are both experienced and keen to offer high quality PhD training using the high quality researchers working in MACSUR. Future courses will give priority to inter-MACSUR courses that overlap between the three Themes of MACSUR.

**Task C5.2/XC 4.2: Development of a multidisciplinary e-learning course aimed at MSc and PhD students** CropM-led task contributing to XC activity 4. For further details see XC activity 4 in Form A (Task leader: Porter (P71), partners involved: Bindi/Dono/Cortignani (62), Saetnan (148), Wallach (175), van Ittersum (195), Manschadi/Schmid (208)), **Duration:** Month 1 – 24

**Milestones:**

M-C5.1.1: Series of online planning meetings necessary to establish the delivery of four PhD schools in the 24 months of MACSUR2. (Month 3)

M-C5.1.2: Delivery of PhD schools at approximately six month intervals (Months 6, 12, 18 and 24)

**Deliverables:**

D-C5.1: Learning material of the PhD schools and qualified students (Months 6, 12, 18 and 24).

**Risks and contingency:** There are very few risks with this activity given the activities completed in MACSUR1. Operational aspects are well known and practised by the WP partners, who are experienced and senior researchers and teachers. Partner 71 has eight years experience with the delivery of global e-learning courses and other partners are exploring these methods. The main issue will be how to collaborate with other MACSUR2 Themes and that can only be achieved by discussions as in milestone M-C5.1.1
The main aim of **WP C6** is to link CropM activities to Hub XC activities by providing specific crop-related skills, knowledge, tools, datasets, model outputs and climate scenarios from an agronomic and climate sciences perspective. **WP C6** will also provide a contribution to the development of a cross-theme framework for integrated analysis and stakeholder engagement, in which new learning spaces will be designed for interactions between CropM, LiveM and TradeM modellers and with stakeholders to provide specific contributions to the XC activities designed at the Hub level.

The development of effective adaptive responses to the complex and uncertain nature of climate change impacts in agriculture requires an integrated, transdisciplinary and quantitative assessment. Therefore, the work in this WP will combine biophysical and economic modeling, multi-stakeholder engagement, and scenario analyses. Models will be used not only for quantitative assessments, but also to de-construct and re-build the climate change-related issues of agricultural systems by integrating multiple perspectives of scientists and other key stakeholders.

Specifically, **WP C6** will contribute to Hub XC activities by:

- conducting regional case studies in different EU agricultural and socio-economic contexts,
- conducting a European wide/global assessment of climate change impacts on crop yield changes,
- conducting a pan-European yield gap analysis,
- conducting a socio-ecological evaluation of GHG emission mitigation options for agriculture,
- establishing links between GHG emission reduction activities in MACSUR2 and other similar research networks,
- ensuring that methods for assessing cross-cutting uncertainties and risks are properly applied in integrated assessment studies.

Work in MACSUR1 is already providing a preliminary framework for cross-cutting assessment of CC impacts and stakeholder engagement at different levels (district, region, agro-food sector and hi-level policy making). Three regional case studies (in Austria, Finland and Italy) have been identified, assessments are in progress, and a stakeholder engagement strategy is being designed and is being implemented. The impact study at pan European level will use ensembles of crop growth models combined with CAPRI simulations and linked to activities run in XC2 and XC3. As such, **WP C6** in the context of MACSUR2 is expected to make a significant step forward towards the analysis of complex and uncertain situations generated by CC in different EU contexts.

**WP C6** is designed as a list of tasks corresponding to the tasks of the XC activities in which there is a contribution from CropM. In this section, we report only the title, leader and partners with PM of the tasks.
tasks led by CropM researchers.

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<th>Task: C6.1/XC6.3: Synopsis of case studies from a European perspective and comparison with results by XC7</th>
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<tr>
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<td>CropM-led task contributing to XC activity 9. For further details see XC activity 9 in Form A. Task leader: Van Ittersum/Schils, in collaboration with regional coordinators: Marrou (Mediterranean), Kozyra (East), Rötter (Nordic), Schils (West); partners involved: Schils (195), Ruiz Ramos (24), Kersebaum (147), Marrou (175), Kozyra (125), Höglind (128), Nendel (147), Rötter (92), Eckersten (163), Doro (62), Bradley (154), Heckelei (115), Lazar (191)</td>
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<td>CropM-led task contributing to XC activity 15. For further details see XC activity 15 in Form A. Task leader: Haas (101), partners involved: Arneth (101), Porter (71), Grosz (112), Osterburg (112), Vallejo/Sanz/del Prado/Pardo (24), Schönhart (208), Amon (147), Zander (147), Rusu (85), Seddaiu (62), Lacetera (62), Klumpp (175), Bannink (173), Philippides (36), Matthews/Yeluripathi (150), Misselbrook (65), Olesen (189), Lazar (191)</td>
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<th>Task: C6.5/XC15.3: Establishing links to other GHG mitigation activities</th>
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<tr>
<td>CropM-led task contributing to XC activity 15. For further details see XC activity 15 in Form A. Task leader: Haas (101), partners involved: Rivera (24), Seddaiu and Lacetera (62), Bannink (173), Klumpp (175), Kozyra (125), Philippides (36)</td>
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**Milestones:** See corresponding XC tasks in Form A  
**Deliverables:** See corresponding XC tasks in Form A  
**Risks and contingency:** The modelling activities run in WP C6 will require reliable and contextualized input datasets (e.g., soil, climate, crop management) for model calibration of a wide range of crops depending on the context of interest. Most of these datasets are already available and have been checked and validated, so it is not expected that they should pose much risk to the overall project. WP C6 is highly dependent on XC activities and hence on the effective integration of the contributions provided by researchers coming from a wide range of different experiences and perspectives. The challenge of integrating different approaches generates the risk of spending time in sharing views on the nature of the issues and in using and developing tools that can be combined together. This is particularly true for the regional case studies (XC6) in which we designed to combine Climate+Crop+Live+Trade models. The plan to address this risk is to rely on the interdisciplinary collaboration already developed in the context of MACSUR1 regional case studies and to develop motivation of researchers from the three themes by designing a common knowledge pathway driven by the strong research demand of integrated assessments of climate change impacts.
References:


Agricultural Systems 96:150-165.


FACCE JPI pilot action call for “The FACCE JPI Knowledge Hub” on “A detailed climate change risk assessment for European agriculture and food security, in collaboration with international projects”

MACSUR2 FULL PROPOSAL
MACSUR - Second Phase
FORM B LiveM

Submission of the full proposal by the Main Coordinator on www.submission-faccejpi.com
Deadline: December 03rd, 2014 15:00 CET

For further information, please visit us on the website http://www.faccejpi.com
or contact the Call Office:
Nicolas TINOIS
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(+49) 2461 61-2422
# B1 – Coordination

## LiveM Coordinator

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<tr>
<th>Partner number:</th>
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<tr>
<td>Legal name of organization:</td>
<td>Aberystwyth University</td>
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<td>Country:</td>
<td>United Kingdom</td>
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## B2 - Theme partners:

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<td>Mikhael Semenov</td>
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<td>Giovanna Seddaïu¹, Nicola Lacetera²</td>
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<td>255</td>
<td>UK</td>
<td>Centre for Ecology and Hydrology</td>
<td>Marcel van Oijen</td>
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State of the art including main achievements for your theme in MACSUR until now (describe the state of the art of the challenges you intend to tackle within your theme):

Climate change is likely to have a serious impact on global crop and livestock production and food security, altering how and where we produce our food (Beddington 2011; Wheeler and von Braun 2013). Agriculture is also a major contributant to GHG emissions (Smith et al, 2008) so that for the agricultural sector both adaptation to climate change and mitigation of agricultural emissions is necessary. At the same time, world population is expected to reach nine billion by 2050 (Godfray et al. 2010) with the biggest increases occurring in the developing world (Guyomard et al. 2013; Thornton 2010). This is likely to increase demand for meat and animal products (Tilman et al. 2002) with the FAO (2011) predicting that by 2050, 73 % more meat and 58 % more milk will be required than was produced in 2010. It has been suggested that the supply of livestock products must rise to an extent comparable with that of the ‘Green Revolution’ in order to meet this growing demand (Tilman et al., 2002). The agricultural sector, and the livestock sector in particular, must manage these challenges in the context of serious global issues related to resource availability, inequality, and biodiversity loss (Beddington, 2011).

The FACCE-JPI Strategic Research Agenda (SRA) (McKhann et al. 2012) sets out five core themes (CTs) for research to tackle the challenges facing the agricultural sector (Fig. 1). CT1 will be applied across all other CTs (McKhann et. al. 2012) so that bringing together activities from CT2-5 is an inherent part of the MACSUR remit. The LiveM theme will undertake workshop-based activities to produce inputs relevant to all five FACCE-JPI CTs (Fig. 2), providing contributions from grassland and livestock modellers to the climate change risk assessment for European agriculture. The aim for LiveM is to provide a structure that will enable livestock and grassland modellers to build the capacity to meet the demands for modelling within the FACCE-JPI SRA.

![Diagram of the five FACCE-JPI CTs and their linkages](image-url)
Fig. 2: How grassland and livestock modelling activities can contribute to the five FACCE-JPI CTs

Capacity in grassland modelling has been significantly increased in MACSUR phase 1, through the development of a model inter-comparison protocol and the running of un-calibrated and calibrated model inter-comparisons. Data protocols have been developed with CropM, and the modelling group has strong links with AgMIP (Agricultural Model Intercomparison and Improvement Programme). Challenges in MACSUR2 will build on this progress, and include the development of understanding of the vulnerability of grasslands to climate change (including Carbon sequestration potential), work to address gaps in knowledge in modelling grassland quality, and the development and exploration of techniques to improve the characterisation of grasslands in farm-scale models.

Farm-scale modellers have undertaken model inter-comparisons in MACSUR1, and the variety of available models has been explored in the context of climate change adaptation and mitigation. Modellers have been involved in the development of modelling mitigation options through projects such as AnimalChange. Building on these achievements, tasks in MACSUR2 will work to improve the ways that farm-scale modelling utilises grassland modelling expertise, as well as evaluating the potential for model linkages that bring together modelling of livestock, manure management and farm management. The exploration of these approaches to model linkage will facilitate the development of models that are more suited to the evaluation of adaptation and mitigation strategies, and can more effectively bring together different aspects of climate change impact at the farm-scale. Application of these approaches will occur through engagement with regional case studies and other cross-cutting activities, as well as through synthesis within the theme.

In MACSUR1, modelling of livestock productivity focused on the impacts of changing climatic conditions on dairy cow health, mortality and milk quantity and quality, and provided contributions to regional case study research. Datasets were identified relating to animal health and disease, and gaps in knowledge were explored at a broad level. MACSUR2 will see a renewed focus on these areas, bringing modelling and experimental research efforts on the impact of climate change on animal health, disease and productivity together with work that links these
impacts to changes in GHG emissions. Links with the GRA animal health and GHG emissions intensity network, as well as other external initiatives, will be important to this activity. With the addition of modelling of the impacts of climate change on disease and parasite risk, the aim will be to gain an overview of this diverse area of modelling. These activities will link modellers more effectively to experimental researchers and veterinarians, and use this improved connectivity and understanding to contribute to regional case studies and cross-cutting activities.

Across the areas of activity described above, understanding and developing the capacity of models to evaluate strategies for climate change adaptation, and the exploration of interactions with mitigation measures, will unite the different pillars of the theme, and reach out to other themes and external initiatives. A second aspect of synthesis will be to explore the up-scaling of task outputs to the regional level, building on the review of farming systems models for regional scale impact assessment carried out in MACSUR1; this will occur through XC2.

Effective dissemination of outputs and the linkage of thematic work to CropM and TradeM, cross-cutting activities and a range of regional and global initiatives and projects will increase the impact of modelling at the policy and farm-scales. This will connect modelling activities effectively to real-world solutions and develop a robust and adaptive modelling community, based on the foundations of MACSUR1, with a long-term vision for continued cooperation, model development and capacity building beyond 2017.

**Scientific/Technological challenges & your scientific/technological approach (explain how you will address the specificities of your theme):**

The LiveM theme structure for MACSUR2 can be mapped onto the five FACCE-JPI CTs (Fig. 3). All tasks contribute to the CT1 aim of developing a climate change risk assessment for Europe. Grassland tasks L1.1 and L1.2 contribute directly to CT1 by investigating climate change impacts on grassland vulnerability and the quality of grass produced for livestock intake under climate change. L1.3 looks at approaches for making the essential link between grassland modelling and the modelling of whole farm systems, enabling advances in the one to be effectively translated into an improved understanding of the economic and environmental risks of climate change at the farm-scale. L1.4 builds modelling capacity by exploring model linkage. L2.1 and L2.2 put together the chain from environmental change to livestock health and disease to productivity and GHG emissions, while L2.4 puts together the outputs of WP1 and 2 tasks at the farm-scale.

A knowledge hub is a novel instrument, and requires novel structures for research and networking if the diversity and scale of its membership is to be effectively leveraged. The LiveM structure presented (Fig. 4) reflects the diversity of the theme (encompassing grassland, livestock and farm-scale modelling applied to a range of production systems and geographical areas), the requirement to make progress utilising network funding, and the potential to gather expertise from a diverse and wide range of modelling work. In 2014, LiveM undertook an extensive consultation with partners to understand their view on issues such as: how to make effective use of the knowledge hub structure; how to approach training and capacity building; how to leverage external funds. This exercise including individual Skype calls to all partners and the creation of topical discussion groups contributing to shared documents. It culminated in seven hours of facilitated discussion sessions during the Bilbao International Livestock Modelling and Research Colloquium.
As a result of the consultations described, an open structure has been created for LiveM, which allows the synthesis of current modelling knowledge and expertise to dictate the focus and nature of subsequent activity. In this way, direction will be developed organically in collaboration and consultation with external initiatives and stakeholders, focusing on the priority areas identified in
phase 1. This approach makes use of the diversity of the consortium to explore the novel opportunities offered by inter-disciplinary collaboration (which often arise spontaneously through interaction) while ensuring that such exploration is grounded in the reality of the societal challenges we seek to address. LiveM task activities also complement the suite of XC activities taking place in MACSUR 2, with many partners engaged at theme and cross-theme level in order to ensure that advances are shared.

The aim is to build on MACSUR1 by continuing the deepen and enrich the links between modelling groups, to develop shared resources and to facilitate the use of these tools in external projects, the outcomes of which can be synthesized and disseminated via the theme and wider knowledge hub network. Meeting the complex societal challenge of the impacts of climate change on agriculture and food security will require sustained scientific activity over many years. LiveM represents a positive step in these efforts, and must lay the foundations for further and wider activities beyond 2017. Tasks will produce overviews of different modelling challenges, and focus on specific areas for more detailed activity according to the expertise and resources of the consortium. However, many important gaps in understanding will remain in need of further study after 2017 – task overviews (and resulting papers) will describe these gaps, and findings will highlight areas requiring improvement and exploration.

In order to be successful, it is recognised that LiveM must engage actively with external initiatives such as ATF, EAAP, GRA and AgMIP. A discourse that links modellers to experimental researchers, European modellers and experimental researchers to global partners, and the research community to stakeholders at all levels is essential, and can only be achieved in partnership with other groups. LiveM complements and adds value to the outputs of external research projects by providing an arena for the comparison and synthesis of their modelling work (from either an applied or technical perspective), while at the same time building the capacity required to achieve improved project outputs through the provision of strategic resources and the networking activities of the modellers involved.

References
B4 – Theme structure

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LiveM in MACSUR2 has been designed to allow partners to build on MACSUR1 activities in facilitating the development of a community of agricultural modellers, with a structure that can maximise this integration of expertise and experience. Theme coordination, with support from the hub, will raise awareness of thematic activities within and beyond the consortium, and, with interested partners, develop relationships with external initiatives, adding value to LiveM activities and ensuring the relevance of outputs to the wider research and stakeholder communities. The coordination team will continue to improve structures for communication and to provide shared resources within the theme, in response to partners’ requests and to complement and contribute to whole-project development. Along with the hub and other themes, LiveM coordinators will explore how the network and resources created in MACSUR can contribute to increasing the capacity of agricultural modelling to tackle societal challenges beyond 2017.

**Task L0.1: Facilitation** (Task leader: Richard Kipling, involved partners: 148, 173) - Duration (Month 1 – Month 24)

Two-weekly/monthly meetings of coordination and WP leaders will be used (along with effective ongoing email exchanges) to ensure that activities are well coordinated across the theme. WP leaders should meet with their task leaders to ensure tasks are on track, to maintain the flow of information between all tasks, and so that the information received by coordination is up to date.

A regular newsletter will share information on progress within the WPs and recent papers/external activities produced by/involving LiveM partners. Upcoming events and opportunities will also be communicated.

The coordination team will consider the options for a resource for identifying collaborative partners (in response to partner comments in MACSUR1). The facility could make use of available online resources for modellers developed at hub level.

Theme coordination will offer support to facilitate thematic task workshop organisation. Links to external initiatives (L0.2) will be developed to identify events that workshops could attach to, within and beyond the MACSUR consortium, including events organised jointly with external initiatives.

The coordination team will organise events bringing together all LiveM partners, either through a stand-alone conference, meetings connected to a hub conference, or in conjunction with external, CropM, TradeM or XC activity events.

The coordination team will work with interested LiveM partners to develop training and facilitate research exchanges. These activities will aim to build capacity, raise stakeholder awareness of livestock and grassland modelling and add value to specific task level activities. As much as possible, this activity will be integrated with a MACSUR training strategy designed within XC4 Capacity Building. The level of integration of LiveM capacity building work into the hub strategy will be determined in consultation with interested partners as part of XC4 Capacity Building.
Task L0.2: External Links (Task leader: Richard Kipling, involved partners: 148, 173) - Duration (Month 1 – Month 24)

Along with WP and task leaders, the coordination team will build links and explore collaboration with the Animal Task Force (ATF), the European Federation of Animal Science (EAAP), the Global Research Alliance (GRA) and the Agricultural Modelling Improvement Programme (AgMIP), as well as sector-specific initiatives such as the European Grassland Federation (EGF) and the veterinary community. These efforts will potentially include the organisation of joint workshops and events, the coupling of LiveM and external conferences, and joint contributions to tasks within LiveM and activities in these external groups. A record will be kept of shared information, contributions to consultations and bids arising from these interactions. Dissemination of new research, training and engagement with stakeholders offer further areas where joint or coordinated activities could be beneficial.

The coordination team will collect information on funding calls and opportunities to contribute to consultations on relevant topics. This will be achieved alongside hub coordination activities in this area. Where appropriate, thematic or whole-project responses to consultations will be created with the support and input of relevant consortium partners.

Building on resources developed in MACSUR1, a system will be provided to allow partners to more easily communicate papers, conference presentations and other published resources to the consortium, through coordination activity to share links, documents and information as requested via email, newsletter and other media, within and beyond the project as required. The LiveM position paper scheduled to be available by the beginning of MACSUR2, will help the coordination team to promote and use a clear, shared vision of the theme to raise profile and allow effective integration with external groups. Options will be explored for the continuation of activities beyond 2017, given the long-term nature of the benefits from network development. This will be undertaken in close coordination with hub and other theme leaders.

Milestones:

M-L0.1.1: **System in place for communication** (month 1)
Description: including WP leaders meetings, newsletter production, sharing of funding/consultation opportunities

M-L0.1.2: **Resource for partners to identify researchers with similar or complementary skills and interests developed and available** (month 3)

M-L0.1.3: **Workshops for the first year developed and run** (month 12)
Description: Task workshops will be facilitated and supported

Deliverables:

D-L0.1.2: **Theme meetings held** (month 12 and 24)
Description: Coordination will deliver two theme level meetings to showcase theme outputs and facilitate networking. These may be linked to other theme or external events, or to whole-project meetings, as appropriate.
D-L0.2.1: **LiveM position paper submitted** (month 3)  
The writing process for a LiveM position paper has started in phase 1 of MACSUR; the position paper will facilitate communication by elucidating the aims of LiveM.

D-L0.2.2: **Report on strategy for the continuation of activities beyond 2017** (month 18)

**Risks and contingency**  
Careful management will be required to coordinate workshop activities and to link with external projects and initiatives, as well as with other theme events. The risks associated will be minimized through the employment of a dedicated project officer working with the rest of the coordination team to deliver day-to-day project management.
The value of grassland and farm-scale modelling is acknowledged in vulnerability assessments of climate change and in verifying the consequences of management changes on carbon sequestration and GHG emissions. In this way, grassland and farm-scale models are important as decision support tools for farmers, and there is a need for the careful design of such tools. The outcomes obtained from MACSUR model inter-comparison exercises in MACSUR1 emphasized the usefulness of grassland and farm-scale models to consider the impacts of management and systemic changes at the regional scale, while also supporting and providing advice to farmers and policy makers. Nonetheless, the problem of uncertainty contained in model outputs (and arising from model structure, parameterization, input data, and initialization) remains as a real challenge to the use of grassland and farm-scale models as part of decision making or informative processes, which marks the extent of our imperfect knowledge of processes (and their interactions) imbedded in models. How uncertainty manifests itself in the model estimates can be difficult to determine, but incorporation of expert stakeholder in model evaluation can help interpretation in relation with prospective visions at various scales: global (socio-economic scenarios), regional (land and soil uses) and field (agricultural systems, genotypes, practices).

In this context, it becomes a key issue to elaborate a coherent structure for vulnerability assessment of grassland-livestock systems (L1.1), which likely depends either on the scale or on the topic addressed. There is, in particular, a need to better understand not only how the quantity of herbage available to farmers is likely to change under climate change, but also the quality (L1.2). There are consequential impacts on livestock systems associated with changes in primary production of feed resources. So, decision-making is best studied at the whole-farm scale (L1.3) because farm scale represents the interface between biophysical processes and human intervention on plants and animals through management. This requires that a link of different models be made (L1.4). Analysis of farm-scale management decisions needs to be given a wider socio-economic context, particularly through considering the influence of public policy measures, markets and supply-chains, and this will be achieved by synthesis of outputs from WP L1 and WP L2 at the farm-scale in L2.4. Conversely, decisions at the farm-scale have important consequences for environmental protection and landscape quality that need to be considered at larger spatial scales (XC2). With case studies the trade-off will be established between the level of detail provided and how widely one can generalize from results.

### Task L1.1: Modelling grassland vulnerability to climate change
(Task leader: Gianni Bellocchi, involved partners: 47, 51, 62, 83, 92, 112, 128, 143, 147, 175, 251, 252, 253, 255) - Duration (Month 1 – Month 24)
Grasslands play an important role not only in livestock production, but also in carbon sequestration, the conservation of biodiversity, maintaining rural cultures and returning economic value from agriculturally marginal land. Vulnerability to Climate Change (CC) is a function of exposure, stability and adaptive capacity, with potential risks to grasslands and the livestock systems dependent upon them arising from increased temperatures, extreme events, and from indirect impacts on productivity, such as the spread and increase of parasite populations in pastures. In MACSUR1, much progress was made in grassland modelling capacity, through model evaluation and model inter-comparison exercises. This work forms a solid basis for progress in MACSUR2. Resources include involvement by partners in the MERINOVA project, and the on-going development of a vulnerability assessment method at INRA.

**Task L1.2: Modelling grassland quality under climate change** (Task leader: Perttu Virkajärvi, involved partners: 65, 92, 122, 128, 143, 147, 173, 175, 252, 255) - Duration (Month 1 – Month 24)

Climate change is likely to have an effect not just on the yield of grasslands, but also on their nutritional quality. For example, increases in direct sunlight increase water soluble carbohydrate production, which in turn increases forage digestibility, whereas increases in the frequency of summer heat waves decrease forage digestibility due to increased lignification. Changes in quality may also represent changes to whole-plant robustness, which may feed back into changes in expected yield responses to CC. Other important potential impacts of climate change are alterations to growing seasons and the speed of grass growth. This may affect the nutritional quality of spring grazing in extensive systems, as well as requiring changes to harvesting strategies. MACSUR1 focused mainly on the yield responses of grasslands to CC, so that grassland quality represents an important gap in our knowledge of the state-of-the-art in grassland modelling. Resources available to develop the modelling of grassland quality include a number of models within the MACSUR consortium, in particular BASGRA (Bioforsk), CATIMO (MTT/Luke), DairyWise (Wageningen UR Livestock Research) and MCPy (CRA-W).

**Task L1.3: Bringing together grassland and farm-scale modelling** (Task Leader: Mats Höglind, involved partners: 24, 40, 47, 51, 83, 92, 112, 122, 128, 143, 173, 175, 189, 253, 255) - Duration (Month 1 – Month 24)

With supplementary feeds representing major economic and environmental costs in farming, understanding better how the quantity and quality of grass available to farmers is likely to change under CC is a vital element to risk assessments of the impact of climate change on agriculture at the European and farm scales. Many farm-scale models include characterisations of grassland systems. Developing the capacity of these components through work with grassland modellers is of great importance in ensuring that grassland processes are accurately incorporated into farm-scale modelling of the economic and environmental outputs from livestock production systems. Potential resources include an initiative to link the BASGRA grassland model (Bioforsk) to the Holos_Nor farm-scale model (NMBU), modelling with DairyWise (Wageningen UR), Scotfarm and GLEAM (SRUC), MELODIE and STICS (INRA), CARAIB (University of Liege), ENREBEEF (MTT), LPJmL (PIK) and SIMSDAIRY (BC3). This task will build on the farm-scale modelling development in phase 1 and will be closely linked to L 1.4. Along with L 1.1, L1.2 and L 1.4, the task will contribute to L2.4, in
which methodological advances will be used to examine the impacts of CC on livestock productivity.

**Task L1.4: Reusing and linking models in livestock farming** (Task Leader: Nick Hutchings, involved partners: 24, 47, 128, 143, 147, 175, 189) - Duration (Month 1 – Month 24)

Models are built to encapsulate scientific knowledge and provide predictions of system behaviour. Within agriculture, there has been a long history of model building. This has left a legacy of models, most of which have functionality beyond the initial purpose for their development. Nevertheless, many models are not reused, representing an inefficient use of the considerable resources required to develop new models. Models can be reused by linking existing models; in agriculture, this can be considered as up-scaling. Linking models presents both scientific/conceptual and technical challenges. The former arise because different models may vary in their concepts of the same components. In technical terms, model documentation may be inadequate, models may be implemented in different programming languages/environments or there may be legal or property rights barriers. Past attempts to link models within agriculture have been either via bespoke or generic linkage systems. The former have the advantage that they can be closely tailored to a given objective, but involve a considerable cost. Generic linkage systems provide a framework that can potentially reduce the investment necessary to link models. However, using such linkage systems incurs a cost in terms of the time necessary to learn how to use them and may constrain the functionality that can be achieved. This task will strive to develop links with the AgMIP Livestock and Grasslands group, to ensure progress is well integrated between the initiatives.

The task will focus on linkages between models of different farm components, specifically grassland, livestock, manure and farm management models. The methodological aspects of linking grassland models should complement L1.3, and the task should also provide complementary outputs to XC2, given the described scaling inherent in model linkage. The objectives of this task are: i) to review the scientific/conceptual issues involved in model linkage and to describe the core flows of information between models, and ii) to review the technical challenge involved in model linkage and to describe how they can be met.

**Milestones:**

M-L1.1.1: Workshop (before month 7)
Description: to explore the state-of-the-art in modelling grassland vulnerability to climate change and produce a work-plan identifying the focus for future development within the task (including M-L1.1.2). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L1.1.2: Workshop (before month 18)
Description: to develop/report on activities in the focus topics identified in M-L 1.1.1.

M-L1.2.1: Workshop (before month 7)
Description: To explore the state-of-the-art in modelling grassland quality under climate change and to
produce a work-plan identifying the focus for future development within the task (including M-L1.2.2). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L1.2.2: **Workshop** (before month 18)
Description: to develop/report on activities in the focus topics identified in M-L1.2.1.

M-L1.3.1: **Workshop** (before month 7)
Description: To explore state-of-the-art in characterizing grasslands in farm-scale modelling and produce a work-plan identifying the focus for future development within the task (including M-L1.3.2). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L1.3.2: **Workshop** (before month 18)
Description: to develop/report on activities in the focus topics identified in M-L1.3.1.

M-L1.4.1: **Workshop** (before month 7)
Description: To discuss the conceptual linkage of models of components of agricultural systems

M-L1.4.2: **Workshop** (before month 18)
Description: to discuss the technical challenges involved in model linking

**Deliverables:**

D-L1.1.1: **Report** (before month 12)
Description: Leading to high impact paper on the state-of-the-art in modelling grassland vulnerability to climate change

D-L1.1.2: **Report** (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L1.1.1

D-L1.2.1: **Report** (before month 12)
Description: Leading to high impact paper on the state-of-the-art in modelling grassland quality under climate change

D-L1.2.2: **Report** (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L1.2.1

D-L1.3.1: **Report** (before month 12)
Description: Leading to high impact paper on the state-of-the-art in the characterisation of grasslands in farm-scale modelling

D-L1.3.2: **Report** (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L1.3.1
**D-L1.4.1: Report** (before month 12)
Description: Leading to a high impact paper on the state-of-the-art on model linkage for livestock systems

**D-L1.4.2: Report** (before month 20)
Description: leading to a technical paper describing the knowledge synthesized on model linkage in livestock systems

**Risks and contingency**
Funding uncertainty and limitations, and a resultant lack of engagement are potential pitfalls for knowledge hub activities. These tasks have been designed specifically to reduce these risks, through extensive consultations among partners and the adoption of task structures based on workshops and arranged to allow task groups to flexibly choose their own focus and approaches to achieve high impact, relevant outputs within the resources available (including linking to external project ventures). Work outside workshops will still be required to prepare for and to synthesize and develop the outputs of these events.

A further challenge will be to ensure good attendance at well-planned workshops. This will be achieved by running related workshops (within and cross-theme) back-to-back, by holding joint workshops with external projects, and by linking workshops to relevant conferences in the research sector.

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Climate change, including predicted increases in air temperature, is expected to have both direct and indirect negative effects on livestock production. Indirect effects are likely to include impacts on the availability of good quality feedstuffs and on the ecology and biology of pathogens and their vectors. Direct effects are linked to stress conditions resulting from high values of air temperature and humidity. The combination of these effects has the potential to increase GHG emissions from the livestock sector.

Collection and analysis of data carried out under MACSUR1, pointed out significant negative relationships between temperature and relative humidity of the air and health, welfare and productive parameters of dairy cows under intensive management conditions in a geographic area representative of the Mediterranean basin. Results differed for Mediterranean dairy cows under organic farming conditions and for cows living in northern European countries outside the Mediterranean region. Other activities carried out during MACSUR1, demonstrated that the negative effects of climate on animal health and productivity may have a significant impact on GHG emissions of dairy cows. Partners were
also engaged within the knowledge hub and in external projects to review adaptation strategies and their potential to limit the negative effects of climate change. In MACSUR2, activities in L2.1 will be aimed at expanding the analyses of MACSUR1 to additional health and productive parameters, at understanding the reasons for differences in results between different production systems and/or countries, and at modelling the impact of climate scenarios on the same parameters. Exploration of modelling of livestock disease and parasite risk under climate change will be an important addition to work on the direct health impacts of climate-related changes in THI. L2.2 will focus on modelling the relationships between ill health, declines in production efficiency and GHG emissions in livestock in different geographic areas and under different production systems. A further activity will focus on the modelling of adaptation strategies, taking into account different farming systems and interactions with mitigation strategies (L2.3). L2.4 undertake the synthesis of outputs from WP L1 and WP L2 at the farm-scale.

**Task L2.1 : Impacts of climate change on animal health, disease and productivity** (Task Leader: Nicola Lacetera, involved partners: 40, 47, 51, 62, 105, 122, 143, 148, 173, 175, 251) - Duration (Month 1 – Month 24)

Environmental changes such as increases in temperature can have direct impacts on animal health, susceptibility to disease and parasite infection, life expectancy and productivity. Bringing together expertise on these different impacts of climate change on animal health and productivity is one of the benefits of the knowledge hub approach, and should enable a broad overview of these topics and the relationships between them to be gained in this task. During MACSUR1, research characterised the impacts of Temperature Humidity Index (THI) on dairy cow health, mortality and productivity. In the context of the overview described above, focused activities in this task will include further development of this research, with work to create models which predict the impact of climate change on dairy cow health and productivity, as well as activities to explore the effects of climate on the incidence of mastitis and on reproductive efficiency under different production systems. Exploring the modelling predictions for disease and parasite risk will complement these activities to develop mutual understanding and connectedness between modellers and experimental researchers in these fields, while the formation of links with the veterinary research community will encourage future collaboration and progress. This task, alongside L2.2, should engage with stakeholders such as STAR-IDAZ, OIE, FAO and World Bank through GRA, to ensure that our approaches align with the global agenda in animal health and disease, and complement the activities of GRA.

**Task L2.2 : Impacts of impaired health, disease and productivity change on GHG emissions** (Task leader: Şeyda Özkan, involved partners: 47, 51, 62, 105, 112, 128, 143, 148, 173, 175) - Duration (Month 1 – Month 24)

CC is likely to have an impact on animal health and the efficiency with which livestock convert feed into meat and dairy products, with implications for economic productivity and environmentally damaging emissions. Health and productivity can be affected by climate change directly through environmental changes and indirectly through changes in disease and parasite types, risk, and severity (L2.1). This in turn can affect GHG emissions from animal production. In MACSUR1, partners were involved in collating data on animal disease, and a workshop addressed the state-of-the-art in disease...
and parasite modelling. Impacts are likely to vary with region and production system. Modelling resources will be used to investigate the effects of changes in animal health at the farm-scale on GHG emissions (for example through integration of these changes in models like Holos_Nor), as well as explorations of economic implications. This task, alongside L2.1, should engage with stakeholders such as STAR-IDAZ, OIE, FAO and World Bank through GRA, to ensure that our approaches align with the global agenda in animal health and disease, and complement the activities of GRA.

Task L2.3: Modelling adaptation to climate change (Task leader: Kairsty Topp, involved partners: 24, 40, 47, 51, 62, 83, 92, 105, 112, 122, 128, 143, 147, 148, 173, 175, 207) - Duration (Month 1 – Month 24)

Adaptation strategies alter the way that the direct and indirect impacts of climate change affect productivity in livestock systems. Effective modelling of such strategies is therefore key to predicting the impacts of climate change under different socio-economic and climatic scenarios. Adaptation can affect all parts of a production system, including inputs (feed, water, energy etc.) and livestock management (breeds, housing, grazing strategies etc.) and needs to be considered at different levels (field/animal and farm). Given the participation in MACSUR of groups involved in modelling both low input and high input production systems, comparing the priorities and adaptation strategies of these systems may be valuable in identifying options from each sector that could be applied in the other. Adaptation strategies may have positive or negative effects on CC mitigation, and considering these interactions will be an important aspect of this task. Among other sources of information, this task can draw upon the outputs of the AnimalChange project.

Task L2.4: Modelling the impact of climate change on livestock productivity at the farm-scale (Task leader: Jantine van Middelkoop and Anthony Wilson, involved partners: 24, 40, 47, 51, 62, 83, 92, 105, 112, 122, 128, 143, 147, 148, 173, 175, 207, 251, 253) - Duration (Month 10 – Month 24)

This task brings together the outputs of WP1 and WP2 in order to show how grassland vulnerability and quality and livestock health and disease under different adaptation scenarios might be expected to impact livestock productivity at the farm-scale. Livestock productivity is the main issue for cattle farmers when talking about adaptation to climate change, making this task a central stakeholder-relevant output of LiveM.

Milestones:

M-L2.1.1: Workshop (before month 7)
Description: To explore the state-of-the-art in modelling the impacts of climate change on animal health, disease and productivity and produce a work-plan identifying the focus for future development within the task (including M-L2.1.2). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L2.1.2: Workshop (before month 18)
Description: to develop/report on activities in the focus topics identified in D-L 2.1.2.

M-L2.2.1: Workshop (before month 7)
Description: To explore the state-of-the-art in modelling the impacts of impaired health, disease and productivity change on GHG emissions and produce a work-plan identifying the focus for future development within the task (including M-L2.2.2). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L2.2.2: Workshop (before month 18)
Description: to develop/report on activities in the focus topics identified in M-L 2.2.1.

M-L2.3.1: Workshop (before month 7)
Description: To explore the state-of-the-art in modelling adaptation strategies and produce a work-plan identifying the focus for future development within the task (including M-L2.3.3). The plan should include inputs to and collaboration with other activities such as relevant LiveM tasks, XC groups, regional pilot studies and external initiatives

M-L2.3.2: Report (before month 10)
Description: Recommended terminologies and timeframes for modelling adaptation and mitigation

M-L2.3.3: Workshop (before month 18)
Description: to develop/report on activities in the focus topics identified in M-L 2.3.1.

M-L2.4.1: Workshop (before month 20)
Description: to discuss the synthesis of outputs from WP L1 and WP L2 at the farm-scale, producing a plan to achieve this and beginning the process.

Deliverables:

D-L2.1.1: Report (before month 12)
Description: Leading to high impact paper on the state-of-the-art in modelling the impacts of climate change on animal health, disease and productivity

D-L2.1.2: Report (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L2.1.1

D-L2.2.1: Report (before month 12)
Description: Leading to high impact paper on the state-of-the-art in modelling the impacts of impaired health, disease and productivity change on GHG emissions

D-L2.2.2: Report (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L2.2.1

D-L2.3.1: Report (before month 12)
Description: Leading to high impact paper on the state-of-the-art in modelling adaptation and mitigation strategies
D-L2.3.2: **Report** (before month 20)
Description: leading to high impact paper(s) on the focused topics identified in M-L2.3.1

D-L2.4.1: **Report** (before month 20)
Description: Leading to high impact paper describing the synthesis of modelling and research from WP L1 and WP L2 at the farm-scale, including the barriers to greater integration and future challenges
### Task L3.1/XC1.2: General framework for model evaluation and comparison

(Task leader: Bellocci (P175), partners involved: Acutis/Bindi/Cassardo/Doro (P62), Slawinski (P139), Sandars (P143), Kersebaum (P147), Sinabell (P209)) - Duration (M1 – M24)

A benefit can be obtained if model evaluation is conceived in a decisional perspective and evaluation techniques are developed at the same pace with which the models themselves are created and improved. Thanks to CropM-LiveM cross-cutting activity on model evaluation, a framework for crop and grassland model evaluation was developed (based on a weighting system of preferences and perceptions, and on lower and upper fuzzy bounds) during the first phase of MACSUR (D-L2.2), which also allows to attach a value to a model in a comparative work. It allows attach value in MACSUR2, we will keep on developing and generalizing a framework for evaluation where we define settings for C-L-T models. The ultimate objective is to improve reliability and robustness of models in order to attain valid results that are useful for decision makers. To develop common judgment criteria over disciplines is an important step. While reviewing the use of metrics for model evaluation, emphasis will be put on the involvement of stakeholders to expand horizons beyond structured, numeric analyses. Two major topics will be discussed: (1) the importance of deliberative processes for model evaluation, and (2) the role computer-aided techniques may play to integrate deliberative processes into the evaluation of C-L-T models. We utilize the most important metrics and weighting factors to evaluate models with respect to the needs identified in task XC1.1. Hence more explicit link will be established between model evaluation, model development and model-based decision-making. In this task we focus on the plausibility of evaluation settings for operational purposes and good modelling practice.

### Task L3.2/XC4.1: Development of integrated training strategy

(Task leader: Saetnan (P147), involved: members of CropM, LiveM, TradeM) - Duration (M1 – M24)

Developing new training courses requires a clear strategy, and considerable time and resources. It is therefore important to clarify which training resources are currently available, provide appropriate signposting for relevant training, and identify gaps in training needs. Possible options for future training include training for practitioners, e-learning development and use, PhD courses and more. Training courses can range widely in the intended audience (from novice to advanced, developer to user), focus (general to specific), and format (in person or on-line). For MACSUR to function as an effective knowledge hub, it is important to consider not only theme specific needs, but also the needs of the wider community in order to develop an effective training strategy.

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Task L3.3/XC6.2: Comparison of case studies including development of criteria of comparison (L3.3) (Task leader: Dalgaard (P189), partners involved: Lorite/Ruiz-Ramos/Gabaldón (P24), Roggero/Dono/Ventrella/Viagi (P62), Rusu (P85), Lehtonen (P92), Bojar/Knopik/Żarski (P100), Kozyra (P125), Mittenzwei (P128), Sławinski (P139), Zander (P147), Hoffmann (P154), Schönhart (P208)) - Duration (M1 – M24)

The task is intended to answer the following question: what are the commonalities and divergences among the different impacts of CC in agricultural systems under different EU contexts? The comparative analyses are designed to compare the same agro-food sector under different climatic, agricultural and socio-economic context but also to assess the expectations of the impacts of CC in different EU regions and districts. The comparative analysis will evidence the vulnerability of the relevant agricultural districts in EU in relation to the specific expectations on local climatic scenarios and the structure of the agro-food sectors in the different EU regions. The comparative analysis will provide a detailed and contextualized picture of issues and options for adaptive responses. A synthetic comparison may be designed through a multi-perspective SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis deriving from integrated modeling assessments (i.e. XC6.1) and scenario analyses developed through a sound design of stakeholder engagement strategies (developed in MACSUR1). The hypothesis underlying this task is the options for the development of site-specific adaptive responses will emerge from an integrated assessment by combining scientific and lay knowledge. However, the comparative analyses will also serve as a learning space to understand the demand of scientific knowledge and innovation in the governance of the CC adaptation strategy.

Task L3.4/XC7.3: Providing ensembles of EU-wide/global consistent sets of grassland yield changes (Task leader: Rolinski (P83), partners involved: François (P51), Haas (P101), Bellocchi (P175)) - Duration (M1 – M24)

Within this task, livestock modellers will cooperate to develop ensembles of EU-wide/global datasets on grassland yields simulated by livestock models for the RCP and SSP scenarios defined in XC16. These ensembles will systematically cover differences in grassland modelling, e.g. with regard to livestock densities. A common protocol will be developed to feed these ensembles into CAPRI which will use them in further simulations and provide key result variables (harmonized with task XC7.1), such as crop shares, animal herds, production, demand, trade and prices. The combination of the livestock modelling ensembles and matching CAPRI results are then input into a meta-analysis to assess impacts of grassland model characteristics/assumptions on the key variables.

Task L3.5/XC11.1: Overview on studies and research activities relevant for the animal feed story and development of region specific livestock diets (Task leader: Bannink (P173), partners involved: Amon (147), Marley (148)) - Duration (M1 – M24)

In this task, MACSUR partners collect information on feed quality and high quality feed sources for livestock in core European regions. Dairy cow diets vary in inclusion of roughage and milk yields that can be achieved. Data and research activities on feed utilisation and on alternative feeds and/or home grown protein sources will be reviewed and connected with recent model developments. The review will include recent activities such as e.g. the FP7 funded projects SOLID and Legumefutures. Projections of associated costs for roughage and animal breeding are taken into account to provide information for region based assessments (such as XC7). Further it will be
considered how yield and yield improvements alter land or nutrient requirements in order to generate data on resource use efficiencies and potential emissions which allow integration in agro-economic model assessments (XC16).

Based on the result of the review, region specific livestock diets in main European regions including contrasting levels of protein and roughage and novel protein sources will be suggested. Those diets will undergo an economic and LCA assessment. Task XC1.1 will receive input from L1.1. “Modelling grassland vulnerability to climate change”, L1.2 “modelling grassland quality under climate change”, L2.4 “modelling the impacts of changes in grassland on livestock productivity”. While past and some on-going work is doing similar work on current climate conditions, MACSUR2 will evaluate especially the role of climate change, as well as the global change (e.g. XC16 “Overall scenario development”).

Task L3.6/XC11.2. Suggestion of future livestock diets under conditions of climate change and reduction of protein imports (Task leader: Bannink (P173), partners involved: Amon (P147), Rolinski (P83), Lehtonen (P92), Dono/Cortignani (P62)) - Duration (M1 – M24)

This task goes one step beyond task XC11.1 by suggesting livestock diets considering future climate change scenarios and taking into account the effects on local farming conditions. The various region specific diets and alternative protein sources will be ranked and most promising diets be selected. Open questions and further research needs will be identified to meet challenges of sustainable livestock diets under conditions of climate change.

Task XC11.2 will receive input from XC2.1 “Scaling up”, and L2.3 “modelling adaptation to climate change”. It also considers cost effects and evaluates resource use efficiencies and emission potentials of roughage and livestock breeds. Task XC11.2 will use various farm-level models.

As in illustrative case of a sector level economic analysis of the competitiveness of increased clover grass forage production in Northern Europe is reported. Clover grasses may benefit more from the longer growing period and higher temperature sum than pure grasses cultivated intensively for grass silage. The competitiveness of the clover grass, providing higher protein content in the feed, is evaluated under different scenarios developed in XC16 “Overall scenario development”. Economic analysis is also linked to XC7 European wide assessment (esp. task XC7.5 “Deepening the EU wide analysis”). A regional or national economic sector level model is utilised. The model accounts for competition for land.

Task L3.7/XC14.4. Development of options to improve ecosystem service assessments in MACSUR scenario assessments (Task leader: Whitmore (P65), partners involved: Helming (P147), Seddaiu (P62)) - Duration (M1 – M24)

For this task we can follow two strategies. First, modellers will check options of extending/improving their models to cover indicators of the analytical framework. This can be done for each model individually but following a common protocol. Consequently, we will reveal the opportunities and challenges of modelers to cover particular ecosystem services. Second, we interact with ongoing research activities on ecosystem service assessments and seek for collaboration. This will improve our understanding on the benefits and challenges of combining quantitative integrated model outputs and other, eventually more qualitative, assessment methods.
Task L3.8/XC15.2. Evaluation of mitigation vs. adaptation strategies (Task leader: Gengler (P51), partners involved: del Prado (P24), Orlandini (P25), Phillippides (P36), Topp (P47), Lacetera/Dono/Cortignani (P62), Haas (P101), Kozyra (P125), Matthews/Cammarano (P150), Bannink (P173), Olesen (P189), Schönhart (P208) - Duration (M1 – M24)

Task XC15.2 of the XC activity of GHG mitigation aims to link MACSUR2 to studies and research activities relating and comparing mitigation of climate change via GHG sources and sinks vs. planned adaptation to the impacts and vulnerabilities due to climate change strategies and considering them in appropriate manner in policy responses. Consequently, we will also focus on the synergies and trade-offs among mitigation and adaptation strategies. Task XC15.2 will focus on LiveM but will be open to contributions from CropM and TradeM. Based on the result of the review, a document evaluating mitigation vs. adaptation strategies will be written and shared across all MACSUR2 members.

Milestones:

M-XC1.2: Progress presentation at MACSUR2 conference (Oct 2016)

M-XC4.1: Workshop at Reading hub conference
The session will bring together interested partners to decide the focus, extent and structure of the MACSUR phase 2 training strategy, building on work developed within the knowledge hub in phase 1, the review paper on communicating modelling (Kipling & Özkan – in preparation), identified gaps in training, and the interests and capacity of partners.

M-XC7.3: Progress presentation at MACSUR2 conference (Oct 2016)

M-XC11.1: Workshop on the review of novel developments in livestock diets including alternative protein sources (Month 12)

M-XC11.2.1: Workshop on future livestock diets under conditions of climate change (Month 18)

M-XC11.2.2: First results on the integrated analysis on the competitiveness of feed protein production in regional level, to be cross-checked by the partners (Month 16)

M-XC14.4: Progress presentation at MACSUR2 conference (Oct 2016)

M-XC15.2: Draft of document about “Evaluation of mitigation vs. adaptation strategies“ to be shared among MACSUR2 (Jan 2016)

Deliverables:

D-XC1.2.1: Review of metrics for model evaluation (June 2016)

D-XC1.2.2: Common protocol for model evaluation (April 2017)

D-XC4.1.1: Report describing the MACSUR phase 2 training strategy, including a timeline for and the focus and extent of training resources, and a plan for attracting funding for continuation of training structures beyond 2017 (July 2015)
D-XC4.1.2: An on-line signposting resource assembled and made available for scientist and students working in the field of agricultural modelling.

D-XC7.3.1: Deliver ensembles of EU-wide/global consistent set(s) of grassland yield changes in common protocol format to XC7.4 (June 2016)

D-XC7.3.2: Chapter on the involved models and modelling results in the joint publication ‘comprehensive assessment of climate change impacts on European agriculture’ (April 2017)

D-XC11.1: review paper and/or special issue on of novel developments in livestock diets including alternative protein sources (Month 18)

D-XC11.2.1: Paper on future livestock diets for main European regions under conditions of climate change and reduction of protein imports including aspects of on competitiveness and land use implications of protein feed production (Month 24)

D-XC14.4: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on results

D-XC15.2: Document about “Evaluation of mitigation vs. adaptation strategies“ to be shared among MACSUR2 (Sept. 2016)
FACCE JPI pilot action call for “The FACCE JPI Knowledge Hub” on “A detailed climate change risk assessment for European agriculture and food security, in collaboration with international projects”

MACSUR2 FULL PROPOSAL
MACSUR - Second Phase
FORM B TradeM

Submission of the full proposal by the Main Coordinator on www.submission-faccejpi.com
Deadline: December 03rd, 2014 15:00 CET

For further information, please visit us on the website http://www.faccejpi.com
or contact the Call Office:
ptj-faccejpi@fz-juelich.de
(+49) 2461 61-2422
## B1 – Coordination

### TradeMCoordinator

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<tr>
<th>Partner number:</th>
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<tr>
<td>Legal name of organization:</td>
<td>Wageningen UR</td>
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<tr>
<td>Country:</td>
<td>The Netherlands</td>
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<td>ZIP code*:</td>
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<td>Title:</td>
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### B2 - Theme partners:

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<td>International Institute for Applied System Analysis (IIASA)</td>
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State of the art including main achievements for your theme in MACSUR until now (describe the state of the art of the challenges you intend to tackle within your theme):

Population and income are key drivers of global emissions of greenhouse gases. According to estimates of FAO, the absolute increments of global population tends to go down, and this process will accelerate in the coming decades. Harmonization of key socio-economic and demographic factors, differences in global model results were reduced (Nelson et al., 2014). Population of Russia, for example, could go down from the current 140 million inhabitants to reach 110 million inhabitants. Nowadays, urban population has exceeded rural population and an absolute decline is envisaged for global population living in rural areas. Although large parts of the world envisage a decline of their population (e.g. including large parts of Asia), population in Africa is foreseen to increase from the current one to reach two billion inhabitants in 2050. Such a doubling of population would put the natural resource base at risk. This might be the case in countries like Niger. Overall demand of food is foreseen to increase by 60%. Increase in demand of food is 77% in developing countries and 24% in developed countries.

Global trends in cropland showed minimal increases during the past half century, and agricultural land could even go down after 2050. Additional production will therefore mainly originate from incremental productivity increases.

Some countries could benefit from climate change, in case average temperatures would increase by less than 2°C. However, this picture of beneficiaries from climate change could be very different, taking into account extreme climatic events. Understanding the link between climate change and food security would therefore require to improve the knowledge of the impacts of extreme climate events. More serious effects (e.g. periods of several droughts) could happen with considerable larger change in temperature.

The on-going activities of AgMIP (the Agricultural Model Intercomparison and Improvement Project) highlighted the need to improve the relevance, credibility and accessibility of global and regional integrated assessments. Von Lampe et al. (2014), for example, emphasize the need for advanced studies to analyse economic behavior and biophysical drivers. Increased interdisciplinary modelling efforts across different spatial scales are needed in order to reach this. The above indicates that socio-economic and demographic trends and conditions would be at least as important as climate change on issues related to human’s well-being. We currently know projections of global food production, areas of land used agriculturally, consumption, prices and patterns of international trade. The global and regional assessments already provide evidence that further research efforts are needed in the following areas:

- The impact of variability and extreme climatic conditions on agriculture, both globally and regionally.
- Understand the differences between models and strengthen the knowledge on dynamics and equilibria in economic modelling and integrated assessment approaches.
- Better understand distributional effects and vulnerability of adaptation to climate change, including the adoption of new technologies.
- Understand the importance of management practices to cope with climate change. Future changes in management practices are currently not considered in global economic models.
The Representative Agricultural Pathways (RAPS) enable to match the Shared Socio-economic Pathways (SSP) more operational towards the dynamics of farming. While improving the RAPS (highlighting productivity trends, agricultural and environmental policy measures that are put in place, farm support programs, and other payment schemes targeted at the farm sector, use of inputs and costs of production). In addition to the identification of RAPS, there is an urgent need to strengthen environmental linkages in modelling farm size, structure change in farming and infrastructure. Compared to other (mainly socio-economic and demographic) changes, the long-term impacts of climate change in Northern Europe could be relatively small, and proper adaptation practices may even reduce costs (Lehtonen et al., 2014). There might be reasonable more focus on extreme climatic events and variation in climate details. So far, we have limited understanding of trends in the development of crop yield. There are considerable regional differences in Europe, and technological progress seems to have bigger impacts on crop yields, compared to climate change. Linking bio-physical model output with an economic land use optimization model would allow to take account for opportunity costs limiting adaptation responses (Schönhart et al., 2014). Current research highlights we remain limited in our understanding of yield development. There might be even be regions with market effects to decline farm income as well as crop yields to be reduced from climate change. Such regions would face double effects in the coming decades.

Change in food diets in Europe could considerably reduce food-related greenhouse gas emissions (e.g. reducing consumption of dairy products and meat).

The regional pilot studies developed in MACSUR are flexible (also in terms of modelling approaches), multi-scale (farm, region, sector), cross-disciplinary (drawing from economic, crop and livestock modelling) and interactive (including stakeholder interaction). Upscaling of the regional case studies to the European level could identify options for climate smart agriculture, balance mitigation and adaptation strategies and maintain productivity of European agriculture (Banse et al., 2014). Future work in the regional pilot studies will address whether future climate conditions will increase the interest by farmers for adaptation strategies like insurance instruments (Dono et al., 2014).

Scientific/Technological challenges & your scientific/technological approach (explain how you will address the specificities of your theme):

The scientific challenges to be tackled in the second phase of MACSUR are mainly interdisciplinary ones. Among the most important from the perspective of stakeholders are those related to the adaptation and mitigation of farmers and related policy responses. Previous work (e.g. Below et al., 2012; Bennet et al., 2013; Kahiluoto et al., 2014) identified various technical and managerial options and strategies of farmers to cope with climate change. More resilient production systems are necessary and further research is necessary to extend the scope of approaches. The interdisciplinary setting shows that many processes in production technologies are much better understood than the interaction of market conditions and management responses of farmers. How the behavior of famers is affected by policies and how policies should be designed to enhance the adaptation capacity of farmers is also not yet well understood (eg. Sieber et al., 2013 and Shrestha, et al., 2013). The main challenge here is to harness the broad expertise of highly specialized researchers to deliver practical solutions for farmers who are experts in running farms and not necessarily experts in just one task. The approach taken in TradeM is firstly, to
develop Representative Agricultural Pathways that set the frame to identify future threats and opportunities and thus allow to identify an ensemble of adaptation options that include plant, livestock production options as well as economic adjustments. The work on the regional pilot studies that is carried out in interdisciplinary teams in concrete policy settings will demonstrate the usefulness of this approach. This work will benefit from experience made by researchers of AgMIP (Valdivia, 2014) and considerable resources will be mobilized to strengthen the interaction with this and other international networks.

Another major scientific challenge of the work in TradeM relates to better understanding models and to enhance existing ones. Even if it seems to be trivial to understand existing models, it is a fact that the large heterogeneity of existing models imposes a challenge when it comes to understand and explain diverging results when similar scenarios are analysed (Nelson et al., 2014). This is not only relevant for global models but the behavior of models at lower regional scales is even less well understood. In order to overcome this situation new approaches are necessary that are not limited to economic models (see e.g. Refsgaard et al., 2014 and Popp et al., 2014). The main challenge here is to extend the scope of model comparison from discipline specific models to inter- and transdisciplinary models. The approach taken in TradeM is firstly, to maintain the work on model inter-comparisons and to extend the scope. Of particular interest is how enhanced models will behave in regional pilot studies that are planned to tap the expertise of all relevant disciplines represented in MACSUR. Previous work on specific aspects as exemplified by Müller and Robertson (2014); Bojar, Knoik and Żarski, 2013; and Cantelaube et al. (2012) show that meteorological advancements will be necessary to meet the challenges of inter-disciplinary cooperation across MACSUR Themes. Economists certainly cannot contribute to tackling meteorological problems but are those who analyse the economic consequences of extreme events and other climatic phenomena.

The typical diet of a European citizen is neither healthy nor is its climate footprint small. For Austria - which is representative for high income countries in the EU - it is known that the nutrition related carbon emission could be reduced by one third if consumers would change the diet in a way to meet health recommendations (Zessner, et.al., 2011). After the dismantling of policy induced interventions in agricultural markets during the last decades, it are consumers who determine the composition of the food basket produced by farmers. The main challenge with respect to consumer behavior is that global population and income dynamics make it very hard to anticipate future consumption patterns. The approach taken in the planned work is to build on the previous analyses but to extend the work. A better understanding of (changing) consumption patterns will mainly be sought for in TradeM. The findings will be discussed with scientists from CropM and TradeM because for them deeper insights into likely demand scenarios are important as well.

It will be a challenge to consolidate the knowledge accumulated in a way so that it is accessible to students or to scientists who are new to interdisciplinary modeling work in the field of climate change and food security. The approach taken to achieve this: specialized courses will be developed and offered during the phase of MACSUR2. In order to cover a broad spectrum of content in the planned courses, attempts will be made to get experienced researchers from the theme involved as lecturers. In addition, attempts will be made to make available existing courses that have been developed for an international scientific community for participants from MACSUR.
References


Bojar W., Knopik L., Żarski J. 2013. Analiza wpływu warunków klimatycznych na plonowanie roślin uprawnych w regionie kujawsko-pomorskim. „Analysis of impact of climate conditions on yielding of crops in Kujavian & Pomeranian region” Studies & Proceedings of Polish Association for Knowledge Management No 64. S.31-44.


B4 – Theme structure

WP0 Leader: Floor Brouwer

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This work package facilitates coordination of the TradeM activities, which are coordinated with CropM and LiveM and targeted to contribute to the success of FACCE-MACSUR. WP-T0 will establish an efficient and effective management and coordination structure including planning, monitoring, feedback and if necessary adjustments. The coordination of TradeM contributes to:

a. establish management infrastructure: provide a technical and managerial infrastructure that will allow the scientific integration of the work packages including the delivery of the achievements according to specified quality and timeframe;

b. assist in the coordination of joint activities with LiveM and CropM, as well as with the work packages and tasks of TradeM;

c. provide clearing-house function: facilitate communication within TradeM, across the FACCE-MACSUR activities and with other interested parties. This clearing house also include the dissemination of results;

d. monitoring: monitoring of progress in activities, providing feedback to partners and adjust plans, if required to meet the project goals;

e. quality assurance: facilitate feedback to the partners in TradeM, and to the partners in CropM and LiveM. We will implement procedures for quality control; and minimize the administrative burden of work-package and task coordinators in order to allow them to concentrate their efforts on the scientific content of the work.

Task T0.1: Implementation and facilitation (Task leader: Brouwer (P192), partners involved: Sinabell (P209) - Duration (Month 01 – Month 24)

The structure of TradeM builds on the organisation of regular workshops, with a frequency of approximately every 6 months (October 2015; April 2016; October 2016; April 2017). Such frequent meetings will strengthen collaboration among the partners that was achieved during the earlier work in MACSUR. The workshops will be linked-up to the regular workshops related to the cross-cutting activities. A main advantage of the frequent meetings is that the integration of CropM and LiveM activities in the work of TradeM will be easier to manage with a given structure. The workshops will serve several goals:

a. Presentation and discussion of on-going work, with feedback from the experts in TradeM.

b. Implement and enhance the dissemination activities and work towards quality assurance.

c. Planning of future activities.

The task coordination will also promote networking activities of partners that go beyond the partners in TradeM and the other themes. The organisation of special sessions at international conferences is one example of such activities. In addition, we seek for joint activities through the involvement of AgMIP. WP T0 will facilitate the management of data delivered by TradeM partners. Among others, a baseline scenario for the regional pilot studies is available for use in the modelling efforts of TradeM partners. This work will linked to the data management activities in LiveM and CropM (e.g. Task C2.1
Task T0.2: Administrative tasks and reports (Task leader: Brouwer (P192), partners involved: Sinabell (P209) - Duration (Month 01 – Month 24)

Among the roles of the task management will be to write protocols of the meetings and report deliverables to the main coordinator, and provide justification for the expenses in TradeM. Based on standardized procedures to be defined by the Project Steering Committee (PSC) an agreement with the partners in TradeM is implemented to guarantee that the necessary administrative tasks will be carried out swiftly and effectively. The task leaders will keep the administrative burden of the partners as low as possible without jeopardizing accountability.

Milestones:
M-T0.1: TradeM workshop (October 2015)
M-T0.2: TradeM workshop (April 2016)
M-T0.3: TradeM workshop (October 2016)
M-T0.4: TradeM final workshop (April 2017)

Deliverables:
D-T0.1: Regular (6-monthly) progress report (Month: 06, 12, 18, 24)
Regular (6-monthly) progress report after the kick-off-meeting, each workshop and the congress. All products of TradeM are planned to be published at the website and related pieces of work will be linked to. The working-papers, presentations and posters which were presented at the workshops, the kick-off meetings and the congress will be the largest part. Data sets or results of model will be an additional output and these data will be made directly available through the website or indirectly via a link to the website of the partners. The progress reports will be an input to the newsletters of FACCE-MACSUR and published at the website and sent to the partners. The progress reports will be summarizing the activities carried out during the past.

D-T0.2: Regular reports to the Knowledge Hub management (Month: 06, 12, 18, 24)
The main focus of the reports and documents is to inform the partners of TradeM and other sub-themes or the wider public about activities, the progress and outputs of TradeM. Reports necessary for the overall administration of FACCE-MACSUR will be based on these documents and further administrative information will be provided as needed. The task coordination will implement the required reporting procedures to guarantee an effective and efficient management.

Risks and contingency:
Typical risks of this type involve unclear and ambiguous responsibilities and roles, lack of coordination between partners and tasks the missing of deadlines, lower quality of outputs and in the worst case the fail of providing the deliverables. In order to minimize these kinds of risks, the coordination of TradeM will implement a quality assurance system. Regular progress reports (every 6 months) is the framework to swiftly identify deviations from the planned status and the regular and relatively frequent meetings (every 6 months) make it easier to respond to deviations.

The experience of the TradeM coordinators in many scientific projects shows that a swift and hassle free project coordination and the provision of valuable public goods (e.g. newsletter, website, information on related project and activities, access to data and models, access to partners) for the
partners is the best motivation for them to deliver excellent work. Minimizing the administrative burden of partners combined with clear signals when adjustments are needed in the case of deviations of agreed-upon plans and positive feed-backs in the other case are usually sufficient to motivate partners to give their best. Given that all partners involved in TradeM have a high reputation this type of risk seem to be small.

The risk of failing to reach the goals of the FACCE knowledge hub: The project aims – among others - at increasing the scientific and technological excellence, at facilitating the transfer of knowledge, a facilitating data access and data sharing across the scientific community, at enhancing the visibility of European research in the international arena and at supporting policy decision making.

An important safeguard in order to minimize the risk not to reach these objectives is to implement a functional project management. The second is to give researchers the freedom to put most efforts into doing what they are best at doing. The team of researchers in TradeM has a broad background of experience in modelling (at different scales from farm to global), policy advice (at different levels from national, European to international) and interdisciplinary work and all of them have a reputation to be able to transfer knowledge from the field of science to the practical needs of national stakeholders. The activities in TradeM will give partners the opportunity to learn from others, to report their own findings in a stimulating environment and occasions to meet experts from other fields of expertise (LiveM and CropM) and to learn from them. For those partners not yet part of the international community of researchers in this field, the project will be a hub to become part of it and for those already established the project offers additional resources to strengthen the own role. The management strategy to make this possible is to organize relatively frequent meetings (every 6 months) which gives ample opportunities for personal contacts and learning from each other. The aim is to organize the workshops in a way so they are open for other interested researchers to attend in order to maximise network effects. The plan to develop a quality assurance system and to promote the production of scientific journal papers is an effort to reach scientific excellence.
WP-T1 Model comparison and improvement (Lead: Franz Sinabell) Start Month: 01 End Month: 24

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The main objective of MACSUR/TradeM is to enhance and improve existing models of agriculture, climate change and food security and to stimulate the development of new ones. During the first phase of MACSUR scientists in each theme (LiveM, CropM and TradeM) developed inventories of existing models and worked on identifying ways to improve them. In MACSUR2 these efforts will be continued but the emphasis will be on integrated models which build on the expertise of not just one discipline. This goal is motivated by the fact that practical problems of stakeholders and decision makers in economics and politics face complex tasks that cannot be tackled by one-dimensional solutions.

In order to achieve this general goal, it is necessary to develop a common understanding among modelers from various disciplines on criteria to judge the reliability and robustness of models. The ultimate objective of each applied modeling task is to attain valid results that are useful for decision makers. A necessary step is to develop judgment criteria for validity that are shared among researchers of various disciplines. Trust among researchers that everyone is doing the right things may be sufficient to work together to develop multi-disciplinary quantitative models. But in order to provide valid results criteria that can be measured need to be developed and assessed.

Decision makers and stakeholders are not necessarily interested in the ways how valid results are obtained. Nevertheless, they also need to make judgments on the validity of model results in order to form rational expectations. Many of them prefer not to deal with all the complexities of future states of the world but are interested in knowing the range of outcomes of plausible scenarios. They are also interested in the share of uncertainty related to the models that are employed and to other sources of uncertainty. Developing a set of scenarios and analysing them with improved models is therefore an essential element of this work package.

Work on these topics is not only going on in MACSUR/TradeM but also in other international projects, among them AgMIP. Among the objectives of this work package is to link the tasks of TradeM partners to the work being done in other networks. The planned activities go beyond participating in events of other research groups. In addition to this attempts will be made in order to develop scientific gatherings that are organized together.

According to the experience made during MACSUR1 most of the partners use well established channels of dissemination in order to publish result of their work. Nevertheless it became also evident that special initiatives are necessary to collect a critical number of papers that can be published together in order to show the broad range of results that can be attained by the whole theme. Building on the experience made during the first phase of MACSUR/TradeM such initiatives to will be further developed.
**Task T1.1 merged with XC activity 1**

**Task T1.2/XC16.1: Stakeholder-centered expectations** (Task leader: Brouwer (P192), involved partners Carter (P92)) - Duration (Month 1 – Month 6)

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Stakeholder interaction is essential in order to achieve credibility of any scenarios. In this task stakeholders from the case study regions are therefore interviewed about their views and priorities with respect to adaptation challenges in different RAPs. We envisage to interview representatives from Commission Services (e.g. DG CLIMA, DG AGRI; JRC) and some national and regional authorities from 2 EU member states (i.e. Finland and the Netherlands). One open regional workshop will be held collecting the views on the specific regional needs for adaptation. Taking regional stakeholders onboard in the scenario development is one way of identifying the weak points in regional adaptation capacity that require attention.

**Task T1.2/XC16.2: Developing a general framework for RAPs** (Task leader: Biewald (P83), involved partners: Müller/Lotze-Campen (P83), Lehtonen (P92), Zimmermann/Ewert (P115), Dalgaard (P189), Holman (P143)) - Duration (Month 1 – Month 8)

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Based on AgMIP activities we will develop a framework where we define the RAPs based on different SSPs. We will determine a climate path representing a certain development of yield and water availability for each SSP-RCP. The RAPs will include aspects of EU-policies, including trade, agricultural and environmental policies, including the available funding in each area of CAP (pillars 1 and 2). Besides interest in regional agricultural productivity, RAPs have to be clear about the development of land resources (e.g. land use change from and to agriculture). Some selected regional pilot studies, for which RAPs are already exist for 1 or more SSP scenarios, are used as examples for the general framework design.

**Task T1.2/XC16.4: Specifying the scenarios for the case studies** (Task leaders: Schönhart (P208), partners involved: Lehtonen (P92), Roggero/Dono/Cortignani (P62), Bellocci (P175)) - Duration (Month 6 – Month 18)

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The RAPs developed in the general framework will be specified in more detail for the purposes of the regional case studies. This is achieved by the individual research teams in each case study. Hence more
explicit policy alternatives are to be developed in the case of each SSP-RCP combination for the case study regions. The achievements and challenges of this process at the level of each regional case study will be documented in D-XC16.4 to guide future RAPs comparisons.

**Task T1.3: Interaction with international networks** (Task leader: Brouwer (192), partners involved: Sinabell (P209), Bojar (100)) - Duration (Month 1 – Month 24)

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This task will promote and further develop a close interaction with the AgMIP and other international communities. One element is to participating in AgMIP activities and joining AgMIP conferences. This will allow us to bring expertise from the AgMIP context into MACSUR and vice versa. We will also present the framework for RAPs and the outcomes of the tasks developed in XC16 in MACSUR at economic conferences (e.g. at the meetings of the IAAE, EAERE) and disseminate it through publications in different peer reviewed journals. The organisation of special sessions at international conferences is another example of such activities. In addition, we seek for joint activities through the involvement of AgMIP. A major theme of such a conference could be economics in integrated assessment tools. Workshops and discussions with participants from science, practitioners and policymakers would contribute to the primary goals of this work package. Possible topics are: (i) agricultural policy with global food security and climate change; (ii) searching for innovative land management practices, and (iii) coping with long-term and short-term risks.

**Task T1.4: Dissemination activities** (Task leader: Brouwer (P192), partners involved: Dono/Cortignani (P62), Sinabell (P209)) - Duration (Month 1 – Month 24)

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The objective of this task is to facilitate dissemination of the outputs of the network-activities: presentations, papers, data, and results of (amended) models and facilitating collaboration with other relevant European and international organisations and networks. A major element of this work will be the formulation of a dissemination strategy of TradeM. It will be defined during the first workshop based on a proposal made by the task coordination considering the relevant activities in the cross cutting activities and in other themes. The partners involved will take the role of initiators and a clearing house of dissemination activities of other partners. Among the aims is to develop two proposals for a book of TradeM achievements and those of other themes. Making arrangements for a call for papers, selection of proposals, review process and editing of contributions is among the activities of this task.

**Milestones:**
- M-T1.2/XC16.1: Presentation of progress at MACSUR conference (October 2015)
- M-T1.2/XC16.2: Presentation of progress at MACSUR conference (October 2015)
- M-T1.2/XC16.4: Regionalized RAPs available (M16)
FACCE JPI Knowledge Hub full proposal – Form B – TradeM

| M-T1.3.1 | participation of TradeM partners at various conferences (on-going) |
| M-T1.3.2 | proposals for organized sessions at international conferences are submitted (M12) |
| M-T1.3.3 | proposals a joint conference with AgMIP and other networks is completed (M12) |
| M-T1.4.1 | Dissemination strategy is developed (M01) |
| M-T1.4.2 | Dissemination strategy is communicated and accepted by partners (M06) |
| M-T1.4.3 | Call for papers are finished (M10) |
| M-T1.4.4 | Agreement with publisher is found (M12) |
| M-T1.4.5 | Manuscripts are ready for publication (M18) |

**Deliverables:**
- D-T1.2/XC16.1: Paper on challenges to European farmers to address global food security (M8)
- D-T1.2/XC16.2: Framework report (M8) Description of the different RAPs and definition of necessary data input.
- D-T1.2/XC16.4: RAPs documentation (M8)
- D-T1.3.1: presentations at international conferences are made
- D-T1.3.2: organized session at conferences take place
- D-T1.3.3: conference is taking place
- D-T1.4.1: Outlines of chapters (M12)
- D-T1.4.2: manuscripts are ready for publication (M18)
- D-T1.4.3: published book (M24)

**Risks and contingency:**
This task related to XC16 rely on the interaction of many people. A lack of communication about intermediate results and plans could lead to duplication of work or loose ends that may cause disappointment of the scientists. Therefore, structured communication is pivotal, and task leaders are encouraged to regularly contribute to internal newsletters and present their progress at the central meetings.

The risks and contingencies of T1.3 and T1.4 are very similar: When it comes to developing publication plans one has to bear in mind that each partner has preferences towards dissemination channels that may not necessarily be in line with those of others. It may therefore involve work to outline special issues or book proposals but two factors are beyond the control of the task leaders: a) the willingness to write manuscripts or to prepare presentations and b) the willingness of conference organizers, editors or publishers to accept submitted scientific work. During the first phase of MACSUR the partners involved in developing dissemination strategies and working on them made some experience that may help to minimize the risks of failure. Important steps in order to overcome the problems involve the following: a) focus on outputs right from the beginning, b) co-ordinate the activities with partners from other themes in order to benefit from their momentum, c) seek for partnership with researchers from other scientific networks being active in the same field and d) making attempts to attract awareness of the work among international bodies like OECD.
WP-T2 Scientific advancements supporting integrated assessment approaches (Lead: Øyvind Hoveid)

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WP-T2 will build on the achievements in MACSUR (2012-2015) and will incorporate the contributions of TradeM into two cross-cutting activities (XC9 and XC14), as well as assessments of farm level risk. The results of modeling activities within CropM and LiveM will be directly and indirectly incorporated in our work. Experiences from the AgMIP model comparison will also be used here. With respect to model improvements, the relevant starting point is economic system models like CAPRI and others which do a great job in capturing dependencies between food production, consumption and trade, and their dependencies on policies and production conditions. It is difficult to see that any progress can be made in the research on food security and climate change without a related foundation. One can and should, however, address critically how these dependencies can best be modeled, in particular the dependence on climatic conditions. Two striking features of economic system models are (1) they have limited representation of farms, while farm modeling is a natural area of cooperation between crop and livestock scientists and economists, (2) they are largely deterministic, while climate and food security are stochastic phenomena. The climate dependency of yields should be constructed in close cooperation with crop and livestock networks.

The outcome of our modeling will be contingent predictions of the expected food economy given predicted climate, technology, policy and food demand. Within policy analysis one typically makes predictions for various policies ignoring the eventual impact of policy on the technology representation. Similar predictions can be made with climate and policy. The problem of predictions at far horizons is obviously to account for emergence of new technologies and preferences induced by climate change. The reliability of the predictions can be assessed with simulations over probability distributions of uncertain parameters.

**Task T2.4/XC9.2: Explaining yield gaps in Europe** (Task leader: Zimmermann (P115), Mediterranean: Marrou (P175), East: Kozyra (125), Nordic: Rötter (92), West: Schils (P195), partners involved: Garrido (P24), Lehtonen (P92), Heckelei (P115), Nendel (P147), Olesen (P189), van Ittersum (P195)) - Duration (Month 1 – Month 24)

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Multi factorial assessment of underlying drivers for yield gaps, covering the major cereal growing regions in Europe. Yield gaps will be taken from the GYGA atlas and other available sources, while quantitative information on underlying factors will be extracted from existing biophysical and socioeconomic databases with sufficient spatial resolution. In analogy with the GYGA bottom-up approach, we will build on local expertise as well.
Task T2.4/XC9.3: Sustainable options to reduce yield gaps (Task leader: Lehtonen (P92), partners involved: Kozyra (P125), Bradley (P154), Marrou (P175)) - Duration (Month 1 – Month 24)

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Development of 3-4 regional cases in which we describe scenarios towards a sustainable yield gap reduction. Regions will be selected with relative high yield gaps. The analysis builds upon the outcome of tasks XC9.1 and XC9.2, leading to a set of proposed measures. Relevant stakeholders will be invited to present their views and optimise the proposed measures. Special attention will be given to assessing the environmental effects (e.g., GHG emissions, soil NP-surpluses, nitrate leaching) and climate adaptation potential of measures to decrease yield gaps. We will use integrated models that are able to simulate the relevant bio-physical and financial processes in the soil-crop-farm domains.

- One example is the dynamic model of farm management and crop rotation already implemented at two farm types with different socio-economic attributes in North Savo regional pilot in Finland. In the model the yield (gap) is largely endogenised. The realized and future yield development can be simulated under different climate and global scenarios (link to XC16 Overall scenario development).
- For the Mediterranean region, Tuscany (IT) and Plateau de Valensole (FR) may be available as case study region.

Task T2.5: Farm-scale risk assessment (Task leader: to be announced, partners involved: Dono/Cortignani/Quaranta/Severini (P62)) - Duration (Month 1 – Month 24)

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The impacts of climate change on production systems at the farm-scale will be multi-faceted, and predicting vulnerability to these changes will require the application of expertise from all three themes. While the proposed Europe-wide risk assessment of the impacts of climate change on agriculture brings together MACSUR modelling outputs at the regional level for policy-makers, assessing farm-scale vulnerability brings together those outputs at a level relevant to farmers and farm advisors. As such, the topic will be a synthesis of MACSUR (and wider) research and modelling, for example into the impacts of climate change on crop and grassland productivity and quality, of research into animal disease and health, of explorations of adaptation and mitigation options for different production systems, and of economic modelling of changes in the prices and composition of farming inputs and outputs. The outputs of this activity will also need to draw on methodological advances, such as approaches to dealing with uncertainty in modelling. If findings are to be of use to farmers, they must be translated into a format that is understandable to non-modellers, and in their content reflect the most important concerns of stakeholders at the farm-scale; this aspect of the activity will draw on work by cross-cutting groups on stakeholder engagement. This task will co-operate with Task C2.4 (Observed adaptation options and their efficacy), as well as Task L1.1 and Task L1.2.
Task T2.6/XC14.1: Analytical framework and indicators for ecosystem service assessment (Task leader: Helming (P147), partners involved: Whitmore (P65), Amon (P147), Schönhart (P208), Roggero/Seddaiu (P62)) - Duration (Month 1 – Month 24)

Partner number 147 208 65 62  
Person-Months 1.5 0.5 1 2

Since the Millennium Assessment, ecosystem services is a prominent concept to assess the value of ecosystems for human well-being. Recent examples have shown the potential of the concept for the assessment of agricultural management. We will integrate this into the procedural steps of impact assessment, and develop an analytical framework. The outcome will be a consistent indicator framework linking output of MACSUR modelling activities to ecosystem services and rural development at European and regional case study level.

Task T2.6/XC14.2: Mapping of model outputs from the European Assessment and from the regional case studies (Task leader: Schönhart (P208), partners involved: Bannink (P173), Dono/Cortignani/Roggero (P62)) - Duration (Month 1 – Month 24)

Partner number 208 173 62  
Person-Months 1 1 3.8

From the models used in all themes, modellers of each case study region will be asked to map those output variables that indicate ecosystem services according to cross-cutting activity XC14.1. The ambition is to identify most suitable ways for the transformation of model outputs towards a coherent indicator framework across all regional case studies and the European-level assessment. We identify analytical gaps to be closed in future model developments or by expert-based evaluation systems. To show a possible application and advantage of such mapping, one outcome of this task will be a list of typical synergies and trade-offs among ecosystem services linked to agricultural land use based on regional case study results.

Task T2.6/XC14.3: Definition of gaps in ecosystem service assessment (Task leader: Whitmore (P65), partners involved: Helming (P147), Schönhart (P208), Seddaiu (P62)) - Duration (Month 1 – Month 24)

Partner number 65 147 208 62  
Person-Months 1 1 0.5 0.5

By matching the results of the model mapping of XC14.2 with the indicator framework of XC14.1 we will distill the reciprocal, which are ecosystem services that are not addressed with the models in MACSUR. This gap analysis is the starting point for a strategic search for possible partners and other research communities (ESP, IPBES) to seek collaboration in the ecosystem service assessment.

Milestones:
M-T2.4/XC9.2: Progress presentation at MACSUR2 conference (Oct 2016)
M-T.2.4/XC9.3.1: First results from integrated models, for evaluation for the project team (Month 12).
M-T2.4/XC9.3.2: Progress presentation at MACSUR2 conference (Oct 2016)
M-T2.5: Presentation on the achievements (October 2016)
M-T2.6/XC14.1: Indicator framework for ecosystem service assessment of MACSUR scenarios (Month 18)
M-T2.6/XC14.2: Overview of the potential of existing MACSUR modelling for ecosystem service assessment (October 2016)
M-T2.6/XC14.3: Progress presentation at MACSUR2 conference (Oct 2016)
M-T2.6/XC14.3 Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on gap analysis in assessment methods

Deliverables:
D-T2.4/XC9.2.1: Underlying drivers for yield gaps of cereals in Europe (draft publication) (April 2017)
D-T2.4/XC9.2.2: On-line maps of cereal production, yield gaps and underlying drivers are presented in the Wageningen UR (+ partners) Benchmarking Atlas (April 2017)
D-T2.4/XC9.3.1: Sustainable options to decrease yield gaps of cereals in Europe (draft publication) (April 2017)
D-T2.4/XC9.3.2: Storylines of cases are presented in the Wageningen UR (+ partners) Benchmarking Atlas, together with the related maps (April 2017)
D-T2.4/XC9.3.3: Report on the integrated model based analysis on the implications and sustainability of the decreased yield gaps on selected case study cases (April 2017)
D-T2.5: Report on the findings (October 2016)
D-T2.6/XC14.1: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on analytical framework (October 2016)
D-T2.6/XC14.2: Draft publication on “impacts of agricultural adaptation scenarios on ecosystem services and rural development”: chapter on model competences (October 2016)

Risks and contingency:
Several tasks in T2 will be carried out parallel to each other and there are two major types of risks: a) managerial risk of losing an overview of the many tasks carried and b) the risk not to reaching the scientific objective. In order to addressing risk type a) it will be necessary to develop a coherent plan of work with the partners working on the tasks (some of them are involved in more than one). The coordinators of TradeM will design a strategy with task coordinators in order to tackle this problem. Addressing the second type of risk will be more difficult. However, major achievements are made in MACSUR for partners to collaborate. Economic models are working in a set of clearly defined surrounding conditions and exogenously given parameters. Yield responses to climate conditions are derived from specialised models and their results will be integrated in the models employed in T2. Economic factors (e.g. prices, constraints on land use, risk attitudes of agents) and political factors will have effects as well. Therefore, work will be focus on the direct consequences of changing climate conditions one by one (e.g.: consequences on yield responses, on yield variability, on price changes due to global supply effects, on price variability due to supply effects). The mapping of ecosystem service indicators depends on the willingness of MACSUR modellers to contribute. They are those knowing their models best and consequently have to provide information on their output indicators.
Tools are implemented for use in hot-spot areas, focusing on geographical areas (in Europe and elsewhere), natural resources (e.g. water, soils and recreational values), human resources (access to work, household structures) and farming systems. This will contribute to the studies, linked with CropM and LiveM. The geographical dimension is linked with the key natural resources (e.g. water, soil). Focus is on places where the impacts of climate change are felt and/or where we can identify mitigation potential and promising adaptation strategies. Some examples of analysis are:

- How does climate change impact international trade, both within Europe and with third countries?
- What are the key mitigation and adaptation strategies? What are the costs involved to the agricultural sector and what kind of responses are envisaged in European agriculture?
- What is the impact of a European strategy for smart, green and inclusive growth for climate mitigation and adaptation strategies, agriculture in Europe and food security in the globe?

Models, farming systems and challenges are identified for the different layers (geographical areas versus natural resources). The aspects of climate change scenarios (e.g. weather component, period of the year phenomenon, time horizon for climate modification) with respect to the simulations are defined, including responses of farming systems, productivity and agricultural sectors. Likewise, market and institutional conditions and policy (e.g. the EU Common Agricultural Policy) are well defined.
Task T3.1/XC6.1: Integrated assessment modelling at the regional case study scale (Temporary task leader: Mittenzwei (P128), Roggero (P62), involved persons: Acutis/Bindi/Cassardo/Dono/Cortignani/Doro/Lacetera/Pasqui/Ponti/Quaranta/Toderi/Ventrella (P62), Dalgaard (P189), Höglind/Özkan/Mittenzwei (P128), Holman/Sandars (P143), Sieber/Zander (P147), Lazar (191), Sinabell (P209)) - Duration (Month 1 – Month 24)

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The hypothesis underlying this task is that the available data at each MACSUR regional case study is sufficient for the calibration and validation of Crop and/or Live and/or Trade models able to assess the impact of climate change on crops and/or livestock and grasslands and consequently on trade systems. The regional case studies are intended to provide a contextualized assessment of the CC impact to address adaptive responses at different levels (farm to district). The modelling will integrate the downscaled climatic scenarios with crop or livestock and grassland models and the Crop/Livestock model outputs will be input for economic assessments. Various models and approaches will be used in the different case studies, depending on specific tools and input datasets available. This activity will be closely correlated with those theme activities on models development in the three MACSUR themes. The case study in Sub-Sahara Africa (Tanzania) will identify efficient Upgrading Strategies (UPS) to improve food security along Food Value Chains (FVC). It will explore how on-farm tested UPS contribute to which extent to better adapt to climate change and to improve food security at local level, and which set of methods, tools and model systems support adequately impact assessment, implementation, evaluation? Moreover, we indicate whether a participative approach with stakeholder involvement might ensure success considering a number of criteria (e.g. adoption of target group, efficiency, effectiveness, sustainability etc.), and whether the knowledge gap between research and practice be bridged in pilot studies (action research) by analyzing success and failure? Which kind of fostering and hindering factors influence the efficiency and feasibility of implementation UPS and CC-adaptation measures?

Task T3.2/XC7.1/XC16.3: Common baselines for integrated EU-wide impact assessment (Task leader: Zimmermann/Heckelei (P115), partners involved: Havlík (P251)) - Duration (Month 1 – Month 24)

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This task is exactly the same as proposed in XC16-Scenario development. For completeness and consistency it is repeated here. Consistent with AgMIP, SSP2 was introduced as baseline scenario in MACSUR1. In close cooperation with the global land use model GLOBIOM, the economic agricultural sector model CAPRI generated producer and consumer prices, agricultural production and yields for the years 2010, 2030 and 2050 based on the SSP2 baseline at regional level for the EU. The results were provided as input for the three regional pilot studies. For MACSUR2, the coordinated GLOBIOM-CAPRI baseline will be updated considering recent policy developments, data, and methodological advancements. Results will be made available for all regional pilot studies in MACSUR2 and serve as reference run for the EU-wide impact assessment.
**Task T3.2/XC7.4: Integrated EU-wide impact assessment of ensemble runs** (Task leader: Zimmermann/Britz (P115), partners involved: François (P51), Rolinski (P83), Ewert (P115), Mittenzwei (P128), Holman (P143), Helming (P192)) - Duration (Month 1 – Month 24)

**Partner number** 115 83 128 51 143 192  
**Person-Months** 4.5 0.5 1 1 1 1

Within this task, the actual integrated EU-wide impact assessment will take place. As described above, the ensemble runs of crop and livestock models will feed into CAPRI which will simulate these ensembles and provide key result variables (harmonized with task XC7.1), such as crop shares, animal herds, production, demand, trade and prices. In addition, an update and improvement regarding indicators describing food security will be undertaken. The combination of the crop and grassland modelling ensembles and matching CAPRI results are then input into a meta-analysis to assess impacts of crop/grassland model characteristics/assumptions on the key variables. The task is closely related to the XC activities scenario development, scaling, uncertainty, and animal feed (XC16, XC2, XC3, XC11). The ensemble runs provide also important input for the regional case studies in XC6, which can chose the best fitting ensemble runs as input for their analysis, e.g. to drive national/regional economic models with price changes.

**Task T3.2/XC7.5: Deepening of the EU-wide analysis with regional/national crop, livestock and economic models (cross-checking results with XC7.4)** (Task leader: Lehtonen (P92), partners involved: Ruiz Ramos (P24), François (P51), Dono/Cortignani (P62), Rötter (P92), Mittenzwei (P128), Holman (P143), Reidsma/van Ittersum (P195), Tiffin (P154), Havlík (P251)) - Duration (Month 1 – Month 24)

**Partner number** 92 143 24 195 51 128 251 62 154  
**Person-Months** 4 1 2 1 1 1 1 0.4 2

This task summarizes the results from smaller-scale (national, regional, local) integrated models from XC6, to be compared with the results of the EU-wide analysis in XC7.4. In XC6 selected region and country specific crop level adaptation options (e.g. crop yield and nutrient use of new cultivars, split fertilization) will be implemented and evaluated based on the interaction between crop, livestock and economic modellers. This will be done for different scenarios, including different EU/global price levels and most relevant policy incentives and restrictions specified in RAP-scenarios developed in XC6 and XC16. In the end, regional case studies participating task XC7.5 validate their results using the outcomes of the EU-wide impact assessments. Results on the regional crop, farm and sector level adaptations, focusing on the multi-scale propagation of the impacts under different SSP and RAP scenarios, are reported and summarized. Additionally, the EU-wide impact assessment will be framed and validated by outcomes of related projects at global and European level (e.g. from GLOBIOM and the IMPRESSIONS project).

**Task T3.2/XC7.6: Methodology and analysis of impacts that cannot be modelled**

*Task now partially covered by XC14.1 due to German budget considerations*
Task T3.3: Contributions of new technologies  (Task leader: to be announced, partners involved: Dono (P62)) – Duration (Month 01 – Month 24)

Partner number  62
Person-Months  1

New technologies or improvements of existing technologies might contribute to adaptation and mitigation strategies. This activity will coordinate across Themes approaches and methods to implement and quantify the potential contribution of new or improved technologies in crop, livestock, farm or economic models, for use within MACSUR and a wider audience.

Task T3.6: Impact of consumer behaviour (Task leader: Milford (P128), partners involved: Banse (P112)) – Duration (M1 – M24)

Partner number  128  112
Person-Months  3  1

Our food choices have an impact not only on our health and well-being, but also on the environment. We are faced with the double challenge of reducing GHG emissions, while still producing enough food for our growing population. We will analyse how the current trends in food consumption patterns (stagnating meat consumption, ageing population etc.) are likely to affect European food market balances. Modelling tools will be applied to analyse the consequences of these trends. The potential for different policy instruments (e.g. taxes and subsidies) to reduce greenhouse gas emissions by changing diets will be evaluated.

MACSUR1 paved the way for an integrated assessment of the impact of climate change on European agriculture. Activities focused on the impacts of climate change on production and food security, including modelling of adaptation and mitigation strategies. However, this combined modelling effort provided only limited insights into how the behaviour of consumers might affect climate change and how climate change will impact consumer behaviour in Europe. This ‘missing part’ of MACSUR will be explicitly addressed in MACSUR2. The modelling tools available from on-going research will be applied to analyse the consequences of different trends, for example to compare the environmental effects of reductions in meat consumption with the effects of implementing climate change mitigation strategies in the livestock production sector. Climate change is likely to have an impact on many factors which can affect consumer behaviour, including fluctuations in food prices, changes in government policy and public advices, general awareness of environmental issues, and cultural changes resulting from inward migration to the EU. Our activities will contribute to assessing how the consequences of climate change might affect the demand for food in Europe. Work on this topic will complement and support thematic activities such as modelling of food price fluctuations in TradeM, as well as associated cross-cutting work on topics such as the mitigation of GHG emissions from agriculture, and feed quality and utilisation.

Milestones:
M-XC6.1.1: Workshop. Design the minimum datasets required for a case study to be eligible, including climatic datasets and to make an inventory of the models and methods of integrated assessment used for each case study (October 2015)
M-XC6.1.2: Exchange (via shared platform) of outcomes on preliminary assessment of CC impacts on crops and/or livestock/grasslands (April 2016)
M-XC6.1.3: Exchange (via shared platform and skype conferences) of outcomes about the preliminary assessments of CC impacts at farm/district scale using trade models (October 2016)
M-XC6.1.4: Final workshop on the results of the Integrated assessment by combining biophysical and economic models (October 2016)
M-XC7.1.1/M-XC16.3.1: Delivery of data to regional pilot studies (June 2016)
M-XC7.1.2/M-XC16.3.2: Progress presentation at MACSUR2 conference (October 2016)
M-XC7.4.1: Progress presentation at MACSUR2 conference (October 2016)
M-XC7.4.2: Protocol for data exchange with XC7.2 and XC7.3 (December 2015)
M-XC7.4.3: Integrated ensemble runs (August 2016)
M-XC7.4.4: Meta-analysis of integrated ensemble runs (December 2016)
M-XC7.5: Progress presentation at MACSUR2 conference (October 2016)
M-T3.3: Presentation of the achievements (October 2016)
M-T3.6: Presentation of the achievements (October 2016)

**Deliverables:**
D-XC6.1.1: List of case studies, archives of datasets for model calibration, models and integrated assessment procedures for each case study (December 2015)
D-XC6.1.2: Report on preliminary assessment of climate change on relevant crops/live/grasslands
D-XC6.1.3: Report on preliminary assessment of climate change at case study (i.e. food chain, farm type or district scales) (December 2016)
D-XC6.1.4: Paper(s) on case study assessments (June 2017)
D-XC7.1.1/D-XC16.3.1 Result tables (June 2016)
D-XC7.1.2/D-XC16.3.2 Chapter on the baseline in the joint publication ‘Comprehensive assessment of climate change impacts on European agriculture’ (April 2017)
D-XC7.4.1: Protocol for data exchange with XC7.2 and XC7.3 (December 2015)
D-XC7.4.2: Chapter on the integrated analysis in the joint publication (April 2017)
D-XC7.5.1: Main conclusions from the regional case studies for the European level impact analysis (February 2017)
D-XC7.5.2: Chapter on regional validation in the joint publication ‘comprehensive assessment of climate change impacts on European agriculture’ (April 2017)
D-T3.6: Draft paper (October 2016)

**Risks and contingency:**
As in the previous work packages, many tasks will be carried out parallel to each other in T3. T3 will develop and apply improved and amended models on a broad set of problems. As in T2 there are a) managerial risk of losing an overview of the many tasks carried and b) the risk not to reaching the scientific objective. In order to addressing risk type a) it will be necessary to develop a coherent plan of work with the partners working on the different tasks. We define guiding principles for the work, in order to guarantee that a consistent comparative analysis of hot spot case studies will be possible. Addressing the second type of risk will be difficult because similar general scenarios must be developed to allow different teams to define specific scenarios for the respective hot spot analysis. Given that at the current state there are too many open questions (capabilities of models and likely economic and climate conditions projected in two years from now, etc.) it is not yet possible to identify the most relevant risks and offer solutions to minimize the potential failure to reach the objectives of T3.
Among the objectives of the TradeM is to disseminate results of models, to enhance the knowledge of already experienced researchers and to spread the knowledge of how to use and to build models beyond those already familiar with modelling. One motivation for this work package is that some recipients of model results frequently find it difficult to understand and to interpret the results given the complexity of interactions of many parameters and variables. A second motivation is that modellers need to understand formalized processes of decision making as well as decision makers needs for evidence in order to make their modelling appropriate for use in decision making. A third motivation is that students who want to become familiar with modelling during their university education frequently get training only on specialized types of models (e.g. farm models, sector models) but not on integrated models. The partners involved in this work package have both substantial experience in modelling as well as in training and education.

The goals of the WP will be to contribute to the cross cutting capacity building efforts of MACSUR 2 by organizing education and training for partners involved in TradeM, CropM and LiveM who are interested in better understanding the economic dimensions of models. The capacity building activity will also be one element to strengthen the involvement of MACSUR in international networks by seeking for a co-operation with AgMIP (see also Task T1.3).

**Task T4.1/XC4.3: Course on agricultural production and environmental modeling** (Task leader: Schmid (P208), partners involved: Dono/Cortignani (P62)) - Duration (Month 01 – Month 24)

The objectives of the course are (i) to learn how to use GAMS (General Algebraic Modeling Systems) in building and solving programming models, (ii) to learn good model building in GAMS, (iii) to build and apply programming models, and (iv) to interpret, synthesize, and report model results. Students will be able to build and analyse farm, regional, and partial equilibrium programming models and to integrate risk in farm level analyses and trade in regional analyses. Strategies to integrate environmental indicators and to link different types of models (e.g. biophysical models and economic models) will be demonstrated in the context of land use model analyses. Selected scenarios developed in T1 will be discussed during the course and working on them give the students the opportunity to get involved in an international project. The focus group of the course will be students but will be open for partners of the Knowledge Hub to attend.

**Task T4.2/XC4.4: Co-operation in capacity building activities with international partners** (Task leader: Schmid (P208)) - Duration (Month 01 – Month 24)

The objective of this task is to establish links to international partners (e.g. AgMIP) working in related fields and to seek for co-operation in capacity building activities. One element of such a co-operation could be to hosting courses for international partners, a second element could be to making arrangements that researchers among the partners of the MACSUR network are invited to get involved in such activities. The final attainment in this task is beyond the control of TradeM because it also
depends on the willingness of international partners to get involved in such an activity.

**Milestones:**
- M-T4.1.1/XC4.3.1: Training course on policy impact assessment announced (M4)
- M-T4.1.2/XC4.3.2: Training courses on policy impact assessment finalised (M20)
- M-T4.1.3/XC4.3.3: Participants receive ECTS points for their attainments (M22)
- M-T4.2.1/XC4.4.1: International modelling course is announced (M6)
- M-T4.2.2/XC4.4.2: International workshop takes place (M18)

**Deliverables:**
- D-T4.1.1/XC4.3.1: Curriculum and announcement for course on policy impact assessment (M02)
- D-T4.1.2/XC4.3.2: Report on achievements of modelling course (M24)
- D-T4.2.1/XC4.4.1: Curriculum and announcement for international modelling workshop (M02)
- D-T4.2.2/XC4.4.2: Report on achievements of modelling course (M24)

**Risks and contingency:**
The tasks involved in Task T4.1/XC4 offer little risk. The course will be offered in the standard curriculum of the university of partner P208 and the university offers an exchange programs that makes it very likely that exchange students and guest researchers may attend the course even without tuition (given the current legislation in Austria). The tasks involved in Task T4.2/XC4 that is linked to Task T4.1 is contingent upon an agreement with an international partner to get involved in a common capacity building activity. Apart from difficulties of finding partners willing to offer their resources for a course or workshop it is also necessary to get on board participants from outside the MACSUR network. Therefore the risk of not achieving the goals of in Task T4.2/XC4 is considerable higher than in in Task T4.1/XC4.