Proposal for

CGIAR Research Program 7:

Climate Change, Agriculture and Food Security (CCAFS)

Lead Center: Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture – CIAT)

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Abstract

Achieving sustainable food security in a world of growing population and changing diets is a major challenge under climate change. Successful mitigation and adaptation will entail changes in behavior, technology, institutions and food production systems. These changes cannot be achieved without improving interactions among scientists, policy makers and civil society. This CGIAR Research Program (CRP7) will build on the new strategic collaboration between the Consultative Group on International Agricultural Research (CGIAR) and the Earth System Science Partnership (ESSP).

By 2020, CRP7 will contribute to increasing the incomes and well-being of millions of poor people dependent on rural livelihoods, contribute to a reduction in hunger, and contribute to climate change mitigation by enhancing carbon storage and/or reducing greenhouse gas emissions. The vision of success for CRP7 includes being recognized, together with the partners, as the foremost global source of relevant research that leads to strategies for tackling food insecurity in the face of climate change.

CRP7 will become a hub that facilitates collective action across multiple Centers/CRPs. The outcomes planned include (among others): technical and policy support for agricultural management strategies that buffer against climate shocks and enhance livelihood resilience in at least 20 countries; key agencies dealing with mitigation in at least 20 countries promoting new institutional arrangements and incentives that favor resource-poor farmers, particularly vulnerable groups and women; and tools for evaluating *ex-ante* returns to investments that enhance food security in the face of climate change.

The over-arching objectives of CRP7 are: (1) To identify and test pro-poor adaptation and mitigation practices, technologies and policies for food systems, adaptive capacity and rural livelihoods; and (2) To provide diagnosis and analysis that will ensure cost-effective investments, the inclusion of agriculture in climate change policies, and the inclusion of climate issues in agricultural policies, from the sub-national to the global level in a way that brings benefits to the rural poor.

There are four Themes. Three "place-based" Themes will identify and test (through adaptive research) technologies, practices and policies, and will enhance capacity, to decrease the vulnerability of rural communities to a variable and changing climate: Theme 1 – Adaptation to Progressive Climate Change; Theme 2 – Adaptation through Managing Climate Risk; and Theme 3 – Pro-poor Climate Change Mitigation. The fourth Theme – Integration for Decision Making – provides a framework for the whole of CRP7, ensures effective engagement with rural communities and institutional and policy stakeholders, grounds CRP7 in the policy context, and provides, through a demand-driven process, downscaled analyses and tools for future climates. Much of the place-based work will be integrated within target regions, with activities starting in three target regions in 2011 and extending to eight regions by 2013.

CRP7 will make a lasting difference through a strategic focus on capacity enhancement. CRP7 research will improve understanding of the underlying drivers of social differentiation and gender disparities as influenced by climate change, formulate strategies to tackle these, and provide inclusive access to emerging investments (e.g. carbon payments), information and policies that deal with climate change. In recognition that impacts on poor communities and the environment will be achieved with and through partners on the ground, this program will have partnership strategies at its core. Specific activities and procedures are planned to ensure coherence among Themes, and to build links across all CRPs. Innovative knowledge sharing platforms and communication approaches will be explored. Regional work, such as scenario development, will link directly to global policy processes. Early "wins" include a planned major role for agriculture in the post-2012 international climate change regime, and a global network of sites collecting comparative data to identify plausible options for adapting to climate change.

The management system for CRP7 will consist of a Lead Center (and its Board), an Independent Scientific Panel (constituted from nominations by the CGIAR and ESSP, and comprising scientific and development expertise), Program Leader and Program Management Committee. Theme Leaders and Regional Facilitators will help to initiate and coordinate activities.

The program will be reviewed in Year 5 and 10. The budget and logframe are presented for Phase 1 (Year 1-5). A total budget of US$63.2 million in 2011 is proposed, of which US$41.4 million is requested from the CGIAR Fund. The budget is allocated to 15 Centers, and 30% to partners. Partner contributions through leveraged resources are expected to be considerable, with a target of $30 million per annum by Year 5.

Description of Program Portfolio for Phase 1 (Year 1-5)

Theme 1: Adaptation to Progressive Climate Change

Rationale

Climate change means that future farming and food systems will face substantially modified environments as they struggle to meet the demands of a changing global population. Efforts to cope with the stresses on the resource base caused by growth in demand for food and water will be confounded by a range of additional abiotic and biotic stresses consequent upon a progressively changing climate manifested by higher temperatures, altered precipitation patterns and rising sea levels. Adaptation will need to be supported by an integrated program of research that includes analysis of current farming systems and how they are likely to change, identification of technologies and practices, and understanding processes of institutional learning and adaptation. Some lines of research have shown promise. For example, germplasm improvement; improved crop, livestock, aquaculture, agroforestry and natural resource management; and enhanced agro-biodiversity have a proven track record of decreasing susceptibility to individual stresses, and will offer increasingly important solutions for adapting to progressive climate change (Jackson et al., 2007). Strengthening the adaptive capacities of farmers and other land and aquatic resource users requires a variety of strategies ranging from diversification of production systems to improved institutional settings and enabling policies (Tubiello et al. 2008; Beddington, 2010). The major challenge is to enable accelerated adaptation at a rate faster than the demands that will otherwise overtake them, and without threatening sensitive livelihood systems as they strive to cope with stress. Significant knowledge gaps exist as to what adaptations options are available, what their likely benefits or costs, where and when they should be deployed, and what the learning processes are that can support widespread change under uncertainty.

For example, least-developed countries are required to submit National Adaptation Plans of Action (NAPAs) to the UNFCCC, whose objectives are to identify priority activities that respond to their urgent and immediate needs to adapt to climate change. Many NAPAs do not present concrete proposals for agriculture and food security. Even basic aspects of food and water systems are dealt with separately, although both are likely to be affected by climate change. This is just one example of the low level of preparedness of national institutions and rural communities. Yet preparation in these and other organizations will be core to accelerated adaptation. Research for development must play a crucial role in providing cost-effective solutions that not only address current challenges facing rural development and poverty, but also ensure that – despite the uncertainties presented by climate change – society continues to develop and ensure food security at multiple scales from villages to the globe.

The challenges lie in the development of holistic approaches to support accelerated adaptation to progressive climate change (Challinor et al. 2009), which consider the interactions of different technical and policy sectors (including management innovation that increases diversification). Research must also work with the processes that support institutional learning, recognizing the potential threats that change (or lack of it) presents to people's livelihoods, particularly in already precarious situations. This would allow for the development of adaptation options that go beyond sector-specific management and lead to more systemic changes in resource management and allocation. This Theme sees adaptation as an opportunity to improve agricultural and food systems through facilitated and targeted change, tracking climate over the coming decades. Impacts are not always negative; hence adaptation is a question of both mitigating or eliminating the negative impacts and taking advantage of the opportunities. In some cases transformational change may be required in the food systems, and very little is understood about the means by which this can be sustained through institutional development.

Objectives

The overall aim of this Theme is to build adaptive capacity and food systems that are more resilient to progressive climate change through the provision of technologies, practices and policies. Promising adaptation options will be identified and evaluated, and through modeling approaches their efficacy will be quantified in relation to expected future conditions. Research will examine the processes required for promising adaptation options to function (i.e. understanding and harnessing of social, economic, cultural and institutional processes of adaptation), and together will be used to provide plans and strategies to establish detailed adaptation pathways of food systems at the national, regional and global level. The Theme will also provide a portfolio of adaptation options (including agricultural technologies, agronomic practices and community- to global- level policies) that typify how food systems will adapt to a 2030 world and beyond. Specifically, the Objectives (Table 11) are to:

- Analyze and design processes to support adaptation of farming systems in the face of future uncertainties of climate in space and time. A key new component will be the development of improved choices, and integration of crop, livestock, fish, agroforestry and natural resources management approaches;
- Develop breeding strategies for addressing abiotic and biotic stresses under future climate change, including changes in the mean and variability of climate. The intention here is to try and stay ahead of future change;
- Identify and enhance deployment and conservation of species and genetic diversity for increased resilience and productivity under conditions resulting from climate change. This has the additional benefit of protecting long-term biological and cultural diversity.

Research approach to International Public Goods

An essential aspect is to combine socio-economic with biophysical aspect of change processes in a multi-disciplinary approach. Through field-based evaluations of promising adaptation practices and technologies, and modeling and analysis of likely benefits of different adaptation options at the food-system level, detailed plans and strategies for adapting the food system over the coming decades can be developed to reduce the uncertainties of change. The principal research questions for this Theme include:

- How can global climate model (GCM)-based and regional climate model (RCM)-based, near-term (i.e., 1–2 decades) information be incorporated into support for adaptation processes that are both location specific yet robust enough to apply across the range of possible climate realizations?
- How can climate-driven shifts in the geographical domains of crop cultivars, crop wild relatives, pests and diseases, and beneficial soil biota be anticipated and best managed to protect food security, rural livelihoods and ecosystem services?
- Given a rapidly changing environment of non-climatic drivers, what is the best approach for integrating individual technological, biodiversity management, livelihood, market adaptation and policy options into comprehensive local-level adaptation packages?
- How do social, cultural, economic and institutional factors mediate adaptation processes at the local level and how can these be mobilized to improve resilience?

The kinds of research products envisaged include new modeling methodologies, new scientific insights into decision-making processes in the face of multiple uncertainties, tested adaptation practices, policies and technologies, and a more profound understanding of the role of socio-cultural factors in the process of enacting system level change.

Table 11. Objectives, Outcomes and Outputs for Theme 1 for Phase 1 (Year 1-5) (the full list of milestones is given in Annex 1). Outputs to be achieved by Year 5, Outcomes by Year 10.

Theme 1. Adaptation to Progressive Climate Change		
OBJECTIVES	**OUTCOMES**	**OUTPUTS**
Objective 1.1 Analyze and design processes to support adaptation of farming systems in the face of future uncertainties of climate in space and time	Outcome 1.1: Agricultural and food security strategies that are adapted towards predicted conditions of climate change promoted and communicated by the key development and funding agencies (national and international), civil society organizations and private sector in at least 20 countries	Output 1.1.1 Development of farming systems and production technologies adapted to climate change conditions in time and space through design of tools for improving crops, livestock, and agronomic and natural resource management practices
		Output 1.1.2 Building of regional and national capacities to produce and communicate appropriate adaptation and mitigation strategies for progressive climate change at the national level (e.g. through NAPAs)
		Output 1.1.3 New knowledge-synthesizing institutional arrangements, policies and mechanisms for improving the adaptive capacity of agricultural sector actors and those involved in managing the food system
		Output 1.1.4 Testing of participatory methods that are sensitive to gender, livelihoods categories and other social differentiators, to apply globally
Objective 1.2 Develop breeding strategies for addressing abiotic and biotic stresses induced by future climatic conditions, variability and extremes, including novel climates	Outcome 1.2: Strategies for addressing abiotic and biotic stresses induced by future climate change, variability and extremes, including novel climates mainstreamed among the majority of the international research agencies who engage with CCAFS, and by national agencies in at least 12 countries	Output 1.2.1 Understanding and evaluating the response of different varieties/crops to climate change in time and space, and generating comprehensive strategies for crop improvement through a combination of modelling, expert consultation and stakeholder dialogue
		Output 1.2.2 Breeding strategies disseminated to key national agencies and research partners
		Output 1.2.3 Differential impact on different social groups of strategies for addressing abiotic and biotic stresses induced by future climate change, variability and extremes are identified, evaluated and disseminated
Objective 1.3 Identify and enhance deployment and conservation of species and genetic diversity for increased resilience and productivity under conditions resulting from climate change	Outcome 1.3: Portfolio of information sources, guidelines and germplasm available for using genetic and species diversity to enhance adaptation and resilience to changing climate are adopted and up-scaled by national agencies in at least 20 countries and by international organization for the benefits of resource poor farmers	Output 1.3.1 New knowledge, guidelines and access to germplasm are provided for using genetic and species diversity to enhance adaptation, productivity and resilience to changing climate
		Output 1.3.2: New information, knowledge, guidelines and germplasm are made available to farmers, breeders, local communities and scientists and promoted through knowledge sharing, peer reviewed articles, information systems and media
		Output 1.3.4: Identification and evaluation of the differential roles of women and men, and other social groups, in strategies for conservation and use of species and genetic diversity; and the impact of those strategies on those different groups, are integrated into knowledge sharing and other activities to achieve outcomes

New content and innovation

This Theme brings together state-of-the-art global-scale modeling with knowledge and research capacity in the many components of farming systems through collaboration between multiple CGIAR centers, ARIs, NARES, civil society and private sector. This multi-disciplinary, multi-sectoral and multi-institutional approach to develop resilient farming systems that maintain or enhance food security and sustain the food delivery system despite a fundamentally changing climate is novel, needed and achievable. The use of solid climate science to provide projections of climate change with all uncertainties quantified, coupled with agricultural science modeling tools, and explicit expert knowledge of crops, agricultural production systems, food systems and food security has not yet been harnessed and used to truly understand how we can adapt to a 2030 climate and beyond.

Risks

The risks involved are due chiefly to the need for strong integration and significant collaboration with others. For example, as noted in the logframe, Milestone 1.1.1.1 cannot be achieved without the willingness of partners to carry out the trials and share the trial data; and Milestone 1.1.1.6 cannot be achieved without uptake of tools and guidelines. Collaboration across themes in CRP7 and to the other CRPs is also important, as it will ensure that synergies are exploited. This risk will be managed through proactive efforts to avoid Theme silos, including joint benchmark sites among Themes 1-3, joint field personnel, the coordinating functions of the Regional Facilitators in each target region, and regular inter-Theme and Management Team meetings. These mechanisms will be further supplemented by both appropriate governance structures and sustained communication efforts that go beyond CRP7.

There is also some risk associated with the underpinning science and the availability of data. For example, crop adaptation traits will need to be identifiable using available data (see Milestone 1.3.1.1). Sound climate projections to 2030 and beyond, together with an understanding of the inherent uncertainties, will be needed. The embedded involvement of the global change community, and the work of Theme 4, ensures access to cutting-edge science in this field. Whilst this does not mitigate entirely the danger of insufficiently precise predictions, it does maximize the chances of success.

Regional balance

This Theme is global in scope, with regional focus to address particular threats to livelihoods. Theme 4 will provide support to the process of defining regional specificities, but it is already fairly clear that the most vulnerable communities requiring support in adapting food systems are in many parts of Africa; and stresses systems in South and East Asia (Thornton et al. 2008). However, threats to biological and cultural diversity also exist in Mesoamerica, the Andes, the Middle East and North Africa, the Pacific Islands, and parts of Southeast Asia. Centers of origin for important wild and cultivated genetic resources do not necessarily occur in high-poverty regions, and hence some priorities for Objective 3 may lie in different areas to those of, say, Objective 1.

Linkages to other CRPs

This Theme is not designed to individually develop new adaptation technologies. Rather, it is designed to add value to technology development from other CRPs (CRP1, CRP3, CRP5, CRP6) by providing the climate change context for those CRPs and taking a holistic view to agricultural development plans and strategies under a changing climate. This will require close collaboration with all CRPs (Table 12), including:

- CRP 1: Major collaboration is envisaged (see Box 1 for operational details). System-specific technologies and management regimes will be tested for their efficacy in a 2030 world and beyond;

- CRP 2: Evaluation of adaptation options and strategies within value chains to enable coordinated adaptation from farm-gate to market, and evaluation of global policy contexts which may influence local-national level policy development addressing adaptation;
- CRP 3: Major collaboration envisaged, whereby Objective 2 supports the development of breeding strategies for major commodities in the face of climate change and subsequently evaluates, in Objective 3, specific technologies coming out of CRP3 for their efficacy in adapting to a 2030 world;
- CRP 4: Analysis of adaptation options that may feed back to nutrition and human health through shifts in the food system, and beneficial nutritional factors arising from diversification;
- CRP 5: Testing and evaluation of water and land management options for potential in enabling adaptation;
- CRP 6: Building on the lessons of forest-based mitigation and coupling mitigation plans with adaptation processes in forest margins and agroforestry systems.

Table 12 Interaction of CRP7 Theme 1 with other CRPs (Priority activities are indicated in bold).

CRP7 Objective # and Title	CRP1 – Integrated Systems	CRP2 - Policies, Institutions and Markets	CRP3 – Sustainable Production	CRP4 – Nutrition and Health	CRP5 – Water, Land and Ecosystems	CRP6 – Forests and Trees
1.1 Adapted farming systems to changing climate conditions through the integration of tested technologies, practices and policies	*In CRP7:* Evaluation of the resilience of technologies, practices and policies under climate change. *In CRP1:* Development of new production systems, technologies and policies appropriate for specific systems. *Collaboration:* Priority setting for technology, practice and policy development. ***Cofinancing:*** **Coordinated set of trial sites in target regions for technology testing.**	*In CRP7:* Evaluation of sub-national level climate change and market policy options *In CRP2:* Developing and evaluating changes in contract farming arrangements to promote adaptation under the value chain component. *Collaboration:* Organization of value-chain partnerships for holistic adaptation; development of models for evaluating adaptation policy options.	*In CRP7:* Priority setting for new technologies for adaptation and mitigation, provision of tools to address climate context. *In CRP3:* Development of new crop, livestock and fish varieties and management technologies. ***Cofinancing:*** **Testing of new technologies out of CRP3 within a region-specific context and in combination with other agricultural practices, policies and technologies to develop holistic adaptation/ mitigation strategies.**	*In CRP7:* Evaluation of future human and animal health challenges in food systems *In CRP4:* Health-related development of analytical approaches for food systems *Collaboration:* Evaluation of health implications in adaptation options.	*In CRP7:* Priority setting for new soil/water mgmt options under climate change *In CRP5:* Development of new soil/water mgmt options ***Cofinancing:*** **Testing of developed strategies and technologies with other agricultural practices, policies and technologies to develop holistic adaptation options.**	*In CRP7:* Evaluation of resilience of agroforestry systems to future climate changes, provision of tools. *In CRP6:* Agroforestry technology development. ***Cofinancing:*** **Testing of developed technologies with other agricultural practices, policies and technologies to develop holistic adaptation options.**
1.2 Breeding strategies for addressing abiotic and biotic stresses induced by future		*In CRP7:* Evaluation of new breeding technologies under climate change *In CRP2:*	*In CRP7:* Modelling of virtual crops[40] under a changing climate to identify future priority traits *In CRP3:* Development of new	*In CRP7:* Evaluation of new breeding technologies under future conditions *In CRP4:*		

[40] "Crops" created in software, using model parameters that represent desired crop traits that could be the objective of breeding programs.

CRP7 Objective # and Title	CRP1 – Integrated Systems	CRP2 - Policies, Institutions and Markets	CRP3 – Sustainable Production	CRP4 – Nutrition and Health	CRP5 – Water, Land and Ecosystems	CRP6 – Forests and Trees
climatic conditions, variability and extremes, including novel climates		Evaluation of new breeding technologies for impact under current climates and analysis of adoption constraints	crop technologies through climate-orientated breeding ***Collaboration:*** **Setting of breeding priorities** *Cofinancing:* Expert workshops, capacity enhancement NARS	Biofortification of major staples *Collaboration:* Inclusion of human health-related challenges in virtual crop modelling		
1.3 Targeted identification and enhanced deployment and conservation of species and genetic diversity for increased resilience and productivity under conditions resulting from climate change	*In CRP7:* Scoping of promising genetic resources for adaption options ***In CRP1:*** **Evaluation of genetic resources for improving farming systems.** Cofinancing: Trialing diversified systems in areas of high climate risk and evaluating benefits of diversity under future conditions.	*In CRP7:* Evaluation of changing policy needs for genetic resource access and benefit sharing under changed climate *In CRP2:* Evaluation of current status and needs for genetic resource access and benefit sharing policies.	*In CRP7:* Evaluation of potential neglected/under-utilized species for adapting to climate change. *In CRP3:* Development of agricultural technologies. *Cofinancing:* Co-development of adaptation options that increase on-farm diversity through inclusion of neglected and underutilized genetic resources.	*In CRP7:* Evaluation of potential of neglected/under-utilized species for adapting food systems to climate change. *In CRP4:* Evaluation of nutritional needs. *Collaboration:* Evaluation of nutritional benefits of identified adaptation options.		*In CRP7:* Evaluation of benefits of diversity in adaptation. *In CRP6:* Evaluation of tree use in increasing income and resilience. *Collaboration:* Identification of diversified agroforestry systems for climate change adaptation.

Theme 1 Objective 1: Adapted farming systems to changing climate conditions through the integration of tested technologies, practices and policies

Rationale and research questions

Today's farming systems are adapted, to the extent possible given resource endowments, to the current climate conditions they experience (Below et al. 2010), yet we know little about how well they will stand up to progressive climate change particularly as they come under increasing pressure from other global drivers Many broad-scale analyses identify potentially sensitive regions or crops under progressive climate change (Jones and Thornton, 2003; Parry, 2007; Jarvis et al,. 2008; Lobell et al., 2008; Waddington et al., 2010), but there is sparse knowledge at the field, community or sub-national scale as to how current farming systems can adapt, and what particular agricultural practices, technologies or policies are needed to enable adaptation, or how adaptation will occur.

This Objective is about identifying and testing candidate adaptation options in production systems, pulling these options together into holistic adaptation packages and supporting the cultural, social, economic and institutional factors that promote adaptation at the local to national level. Adaptation options to be studied include practices (e.g. agronomic innovations, planting strategies, improved livestock and fish management system, pest/disease management, agroforestry, diversification etc.), technologies (seed varieties, irrigation techniques such as supplemental irrigation and deficit irrigation, on-farm water harvesting etc.) and policies (local- to national-scale benefit-sharing, subsidies, trade agreements, investment packages, insurance schemes, private-sector business models, community-organization models etc.).

This Theme has neither the capacity nor the mandate to undertake large efforts for crop improvement or NRM; it is expected that new technologies and practices will largely be developed in CRPs 3 and 5, while CRP7, in conjunction with CRP1, will identify promising options for testing in target regions. One significant

novelty coming from this Objective will be the establishment of focus areas in target regions where policies, practices or technologies coming out of other Programs are evaluated, not in isolation but together. The strength of this Theme lies in the combination of individual adaptation options (social, policy-based, economic or technological innovations) into geographically explicit agricultural design processes and strategies to support adaptation of rural farming communities, development organizations and sub-national level bodies. CRP7 will work closely with CRP1 in the target regions, with CRP1 leading the implementation of integrated R&D, and with CRP7 adding the climate context and adding climate-related components into on-going testing of technologies, practices and institutional arrangements.

Research questions include:

- What are the likely future stresses and demands from climate change on geographically specific food systems? What are the implications of these, particularly for the poor and marginalized?
- Within the context of livelihood systems, what practices, technologies and institutions are likely to prove most effective in enabling adaptation for specific target regions, and what is needed to support their transfer?
- What new institutional arrangements are required to support transformational change in food systems?

Activities

Objective 1 will require the characterization of pressures and adaptation options in target regions. Analysis of pressures will draw from work in Theme 4 on scenario modeling to identify threats to land and water resources, livelihood systems analysis to identify the implications of stresses on particular groups; and analysis to describe performance factors of crop, livestock, and aquatic and agroforestry systems. Work on adaptation options will entail the compilation of existing databases from multiple sources. An example includes the collation of multi-site trial data of a range of crop varieties, which can then be used to examine varietal potential for different future climates across a range of target environments. Another activity will include analysis of institutional arrangements, policies and mechanisms that enhance the adaptive capacity of resource-poor households to adopt new (and existing) farming practices, strategies and behaviors. Objective 1 will require the testing of new technologies across a range of pilot sites, established in collaboration with other Themes in the CRP, and put into the context of farming systems with CRP1. Objective 1 will include modeling activities to out-scale potential adoption areas across a wide-range of geographies, and through the use of analogs, for example, support field validation of adaptation options for 2030 in today's climates. Community-based trialing of holistic adaptation options will be used to learn about the social, cultural, economic and institutional processes of adaptation, and to support the design of strategies for the implementation of adaptation in target regions.

Outputs/milestones

- Portfolio of adaptation options with likely changes in production systems identified, developed and/or tested;
- New and/or existing production system technologies tested which contribute directly to enhanced adaptive capacity in farming systems;
- Learning processes to support institutional development and behavioral change designed and evaluated
- Document synthesizing institutional arrangements, policies and mechanisms for improving the adaptive capacity of agricultural sector actors; what is working where, how and why, and what else is needed.

Partner roles

There is a strong emphasis of homeland CGIAR research in this Objective requiring the involvement of multiple centers, but strong collaboration with NARES is required, and with the ESSP in the generation of decadal climate forecasts among other things. The research within this Objective should be developed hand-in-hand with development practitioners interested in the dissemination and implementation of adaptation options at the community level, and so strong collaboration with development NGOs, civil society organizations and the private sector will be fostered.

Impact pathways for target environments

The aim is to support change processes therefore impact pathways will target (a) institutions already engaged in development who will use insight and learning processes to accelerate adaptation; (b) research organizations who need to identify promising enabling technologies and (c) NARES, Ministries and donor agencies who can use the insight to target or safeguard investment. Work will be conducted closely with development and funding agencies, so that development practitioners will be informed on the most promising adaptation options for specific geographies and socio-cultural and economic settings, and so that key decision makers will allocate resources for such options. Knowledge and insights into the most appropriate mechanisms of transference and successful adoption will support stakeholders such as development NGOs, civil society organizations and private sector companies. Impact strategies will be developed for specific countries in the target regions by working with a coalition of partners, especially the NARES (e.g. EIAR, NARO, ICAR, IARI, KARI, INRAN, ISRA, IER, INERA) and development NGOs (e.g. Oxfam, CARE). At global level, the work will feed into the global impact strategy to help shape how adaptation funds are allocated (Figure 9) and how the program influences the food security agenda (Figure 10).

Figure 9. Impact pathway for how CRP7 Theme 1, Objective 1 proposes to engage with the global adaptation funds, to ensure that fund guidelines are based on best practice information.

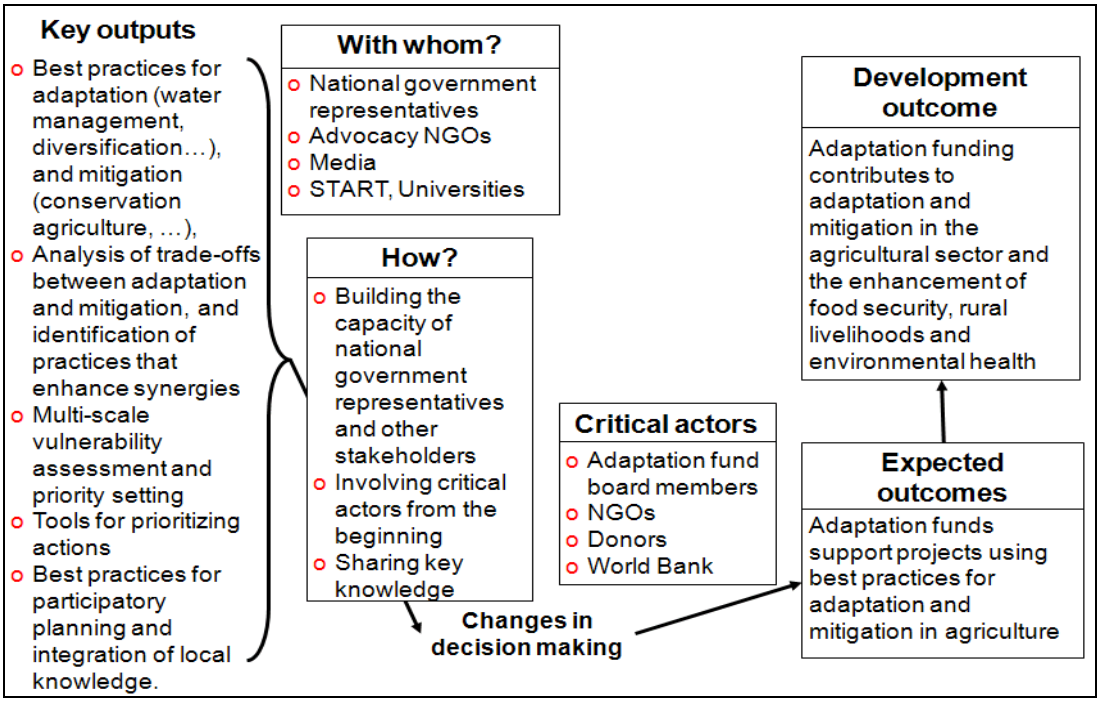
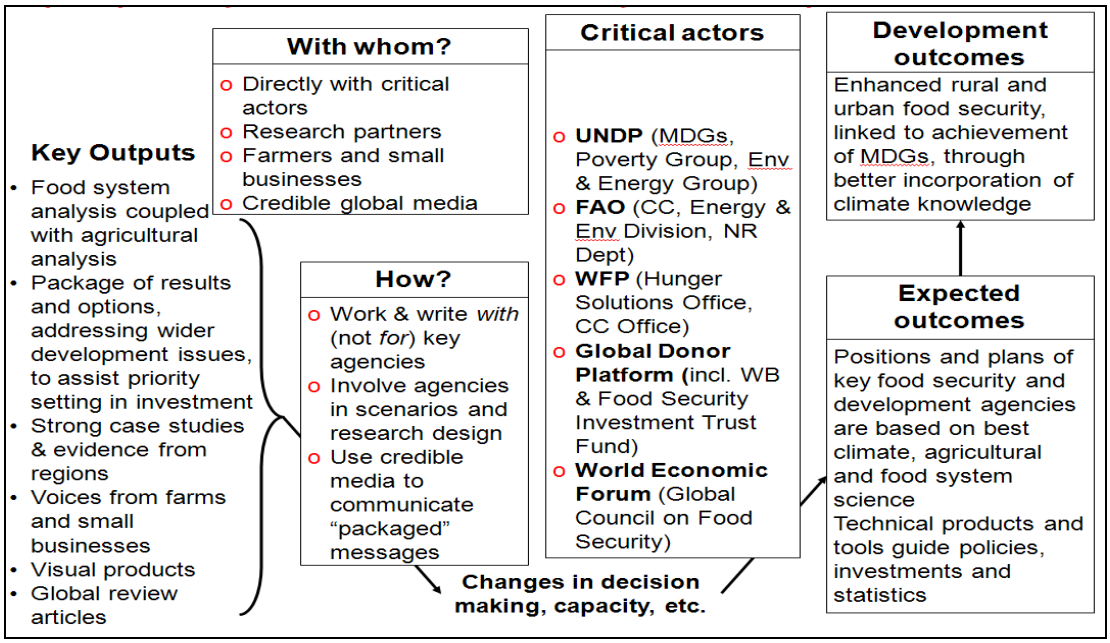


Figure 10. Impact pathway for how CRP7 Theme 1, Objective 1 proposes to engage with the global food security community, to ensure that strategies and plans are based on best climate change and other information. Similar engagement will be undertaken with regional, national and sub-national actors and processes.



Theme 1 Objective 2: Breeding strategies for addressing abiotic and biotic stresses induced by future climatic conditions, variability and extremes, including novel climates

Rationale and research questions

The expected increases in temperature and shifts in precipitation regimes are predicted to cause significant changes in crop productivity across the globe, through direct abiotic influence or through associated changes in pest and disease pressure. While significant adaptive capacity exists within agricultural and socio-economic systems, models suggest that the germplasm that currently underpins production is likely to be 'out-reached' in some places by change. Hence, crop improvement through conventional breeding or through biotechnological innovations is hailed as a crucial strategy to ensure long-term maintenance or gain in agricultural productivity (Tester and Langridge 2010). Given that projected demand for food is likely to increase by 60–70% from now to 2050 (Schmidhuber and Tubiello, 2007; World Bank, 2008), significant expectations are being placed on crop improvement to provide a large proportion of these gains, despite the complexities that climatic change bring to the problem. Given the long lead-time between commencement of a breeding program and the release and large-scale adoption of new cultivars in farmers' fields (minimum 8 years, although evidence suggests that true adoption can take as many as 20+ years to be successful), it is critical that breeding programs are initiated today to address future problems.

It is therefore key that priorities are developed for crop improvement programs based on sound *ex-ante* analysis of future benefits, and that coherent strategies across multiple countries and between institutions are adopted and implemented. International and national donor and government policies should be coordinated in enabling the conception and implementation of these strategies. This Objective is about generating comprehensive strategies for crop improvement through a combination of modeling, expert consultation and stakeholder dialogue, and translating these insights into coordinated global, regional and national research and technology investment policies.

Research question include:

- What are the most cost-effective crop improvement investments to enable tomorrow's crops to produce more food under a changed climate, with the additional consequences to resources that entails?
- What are the most appropriate modeling approaches to design "virtual crops" for the future that can then inform crop improvement programs on a crop-by-crop basis?
- Can currently farmed livestock and fish species cope with expected changes in temperature and salinity, and if not, how can new species or improved breeds be brought into production?

Activities

Activities for this Objective will use globally consistent models to identify future environments that will 'outreach' existing germplasm. Multi-site trial data will be collated as a critical input to calibrate and validate crop models. This will be done in collaboration with Objective 1 of this Theme. Objective 2 will then model biotic and abiotic constraints under decadal futures from 2020 to 2050 through the development of a range of crop modeling approaches. The modeling approaches will include the application of mechanistic crop models such as those within the Decision Support System for Agrotechnology Transfer (DSSAT) and the GLAM model (Challinor et al. 2004), niche-based approaches such as the modified EcoCrop model used by Lane and Jarvis (2007), as well as a number of models to quantify biotic elements. The models will provide the biophysical decision support for the scenario-based analysis of social, cultural and economic risks (in Theme 4, Objectives 1 and 3). Through the models, and in close consultation with crop-based experts, a set of "virtual crops" will be designed as targets for breeding programs. The efficacy of the virtual crops in addressing the likely conditions for 2020, 2030, 2040 and 2050 will be quantified in terms of the economic, social and cultural benefits expected. This will produce a set of concrete crop improvement strategies for further qualitative analysis. A series of activities will guarantee that research and policy organizations are actively engaged from the early stages of the research in both design and post-project implementation. They will also ensure that once a set of breeding strategies are identified, they will be socialized with funding bodies, national and international organizations, universities and other actors, and that concrete plans will be established. Additionally, strategies should be mainstreamed into workplans and existing breeding programs, e.g. for crop breeding. For the breeding elements, close collaboration with CRP3 is required so that outputs from this Objective inform breeding programs for each of the CRP3 components.

Outputs/milestones

- Detailed crop-by-crop strategies and plans of action for crop improvement that ensure future crops and agricultural systems are adapted to a progressively changing climate;
- Range of modeling approaches developed and validated for assessing future constraints to crop, livestock, fish and agroforestry production and the design of virtual crops;
- Global, regional and national policy briefs for investments in climate-proofed crop, livestock, fish and agroforestry breeding initiatives, feeding into impact strategies related to adaptation funds.

Partner roles

This Objective will build on close collaboration with crop and livestock-based components of CRP3, and integrate closely with the ongoing Generation Challenge Program (GCP) molecular and breeding platform and the future GIB Service that do not currently address demands only evident after taking climate change into account. For each crop all major crop improvement programs will be incorporated into the research, including crop improvement programs at CGIAR centers, NARES, ARIs or indeed in the private sector.

Strategies will also be developed jointly with donors and national and regional research funding agencies to drive donor policy towards coherent crop improvement plans without duplicity of efforts.

Impact pathways for target environments

Crop breeding initiatives at the national, regional and global scale will be fully engaged to ensure that the best-bet plans are put in place, and global and regional donors will be fully briefed on the priorities for investments not only at the crop level but also at the food system level. In the first six months of the CRP a multi-stakeholder and cross-CGIAR high-level meeting will be conducted to build consensus among partners about the R&D and engagement process.

Theme 1 Objective 3: Targeted identification and enhanced deployment and conservation of species and genetic diversity for increased resilience and productivity under conditions resulting from climate change

Rationale and research questions

This Objective targets the genetic and cultural diversity that is threatened by climate change, but also seeks to exploit potential opportunities it provides. The diversity of traits and characteristics among existing varieties of agricultural biodiversity (both inter- and intra-specific) provide enormous potential for adaptation to progressive climate change. Biodiversity, and the cultures that interact with it, are at risk of being lost before they are even fully valued. Its potential is poorly understood, and under-exploited. Under this Objective, research will develop innovative methods and tools for the rapid identification of suitable materials both *in situ* (in the wild and on farm) and *ex situ* (in gene banks) for integration into production systems to facilitate adaptation to progressive climate change, and their enhanced use in breeding priorities identified in Objective 2. This will include the exploration of underutilized crops and species and their potential role in providing adaptation options as more conventional crops undergo losses. In addition to testing materials of interest, through collaboration with CRP1, under conditions including analogs for projected future climates, research will evaluate how to facilitate their integration into local production systems and adoption by farmers by analyzing enabling policies and seed systems and defining key interventions to enhance them. In addition to looking at specific varieties/species, the benefits of crop, fish and livestock diversity in production systems as a strategy for maintaining productivity despite climate change and variability and associated impacts (notably pests and diseases) will be assessed.

Research questions include:

- What priority gene pools for climate change adaptation are threatened, and how can they be conserved to ensure their continuing availability?
- How do cultural practices exploit this diversity and how can farmers' knowledge be used to help identify landraces and crop varieties suited for specific climatic conditions?
- How can access to crop diversity by local farmers be facilitated through enhanced seed systems or other mechanisms?
- How does on farm crop diversity in production systems contribute to maintaining productivity in the face of progressive climate change and increased variability in climate?

Activities

Activities will consist of developing tools and methodologies to rapidly identify materials *in situ* and *ex situ* with traits useful for climate change adaptation and to assure their conservation. Once candidate materials are identified, on-farm evaluation on a range of sites, in collaboration with CRP1, will be used to test their response in different climate conditions in the target regions. This participatory approach will not only

allow testing the material in a cost-effective way in a significant number of different agro-ecological conditions, it will also allow farmers' perceptions to be integrated into the evaluation, a key to future adoption. Additional strategies needed to facilitate the uptake will be formulated, focusing on both access to the material and its management. Finally, the contribution of crop, fish and livestock diversity in production systems as a strategy to climate variability and change will be evaluated and promoted.

Outputs/milestones

- *In situ* populations of priority genepools important to climate change adaptation identified, threats understood and conservation solutions proposed identified;
- Methods and tools developed to facilitate targeted identification of *ex situ* conserved germplasm with traits useful for climate change adaptation, including resistance to biotic and abiotic stresses;
- Strategies to improve existing policies, local management and seed systems, to facilitate the deployment of adapted germplasm;
- Assessment of the contribution of crop, fish and livestock diversity for climate change adaptation.

Partner roles

Collaborators on the *in situ* research will include NARES for crops, fish and livestock, ministries of forestry, fisheries and the environment and international and national conservation organizations for wild relatives, aquatic biodiversity and trees *in situ* in the wild. The *ex situ* activities will be carried out in collaboration with CGIAR centers that manage mandate collections as well as with national genebanks. The local evaluation and adaptation activities and the research on resilience of diverse production systems to progressive climate change will be carried out in close collaboration with NARES, development agencies, local farmer organizations and the global change community (including the Resilience Alliance and DIVERSITAS).

Impact pathways for target environments

Research will produce knowledge, information sources and guidelines as well as make available germplasm that has been selected, collected, conserved and tested to address targeted needs for climate change adaptation in areas likely to suffer most. Intermediate users of the information will include government agencies in target countries, genebank managers and conservation organizations that will participate and then continue to carry out the priority conservation actions defined by the research. Researchers and breeders in NARES and other institutions will use both the information about the germplasm (and the germplasm itself) to produce varieties better adapted to the conditions resulting from changed climates, including the changed dynamics, distribution and virulence of pests and diseases. Farmers will use and evaluate the selected germplasm and mixtures as well as varieties bred from it by the breeders. New knowledge about the benefits of crop diversity and about seed systems and the policies that affect deployment of germplasm will be used by crisis management agencies as well as NARES and international agricultural/rural development agencies to ensure that suitable and adapted germplasm reaches farmers.

Theme 2: Adaptation through Managing Climate Risk

Rationale

Managing the risk associated with climate variability is integral to a comprehensive strategy for adapting agriculture and food systems to a changing climate. Climate variability today and long-term climate change are two ends of a continuum of time scales at which the climate varies and impacts agriculture. The damage of climate shocks, such as droughts or floods, to health, productive assets and infrastructure can impact livelihoods long after the shock has passed. Climate variability and the conservative strategies that risk-averse decision makers employ contribute to the existence and persistence of poverty – sacrificing income-generating investment, intensification and adoption of innovation to protect against the threat of shocks. Apart from effective intervention, projected increases in climate variability can be expected to intensify the cycle of poverty, vulnerability and dependence on external assistance. This Theme enables promising innovations for managing climate-related agricultural risk at local and regional levels, and addresses gaps and supports improvements to climate-related information products and services that enable a range of agricultural risk management interventions. It targets the many short-term, climate-sensitive decisions that farmers, humanitarian response organizations and other private- and public-sector actors in the food system make routinely, which influence vulnerability to a changing climate in the longer term.

Objectives

The overall aim of Theme 2 is to bring promising innovations in climate risk management to bear on the challenge of protecting and enhancing food security and rural livelihoods in the face of a variable and changing climate. Its Objectives (Table 13) are to:

- Identify and test innovations in partnership with rural communities that enable them to better manage climate-related risk and build more resilient livelihoods;
- Identify and test tools and strategies to use advance information to better manage climate risk through food delivery, trade and crisis response;
- Support risk management through enhanced prediction of climate impacts on agriculture, and enhanced climate information and services.

Research approach to international public goods

Theme research targets strategic gaps in knowledge, methodology, climate products and services, evidence and capacity that currently impede development of climate-resilient rural livelihoods across regions. A combination of analytical research and participatory co-learning with rural communities and other key actors in the food system, across a range of agroecological and socioeconomic contexts, will produce international public goods including:

- Synthesized knowledge on innovative risk management strategies and actions that support climate-resilient rural livelihoods; and evidence of their feasibility, acceptability and livelihood impacts;
- An analytical framework and decision tools for targeting and evaluating the livelihood benefits of promising risk management innovations;
- Synthesized knowledge and evidence about differential impacts of a range of climate risk management interventions on different social groups, particularly women and men, and strategies for overcoming inequities;
- Synthesized knowledge of effective methods for using advance information to manage climate-related risk through food delivery, trade, crisis response and post-crisis recovery; and evidence of the impacts of climate-informed food system interventions on food security and rural livelihoods;

Table 13. Objectives, Outcomes and Outputs for Theme 2 for Phase 1 (Year 1-5) (the full list of milestones is given in Annex 1). Outputs to be achieved by Year 5, Outcomes by Year 10.

Theme 2. Adaptation through Managing Climate Risk		
OBJECTIVES	**OUTCOMES**	**OUTPUTS**
Objective 2.1 Identify and test innovations that enable rural communities to better manage climate-related risk and build more resilient livelihoods	Outcome 2.1 Systematic technical and policy support by development agencies for farm- to community-level agricultural risk management strategies and actions that buffer against climate shocks and enhance livelihood resilience in at least 20 countries	Output 2.1.1 Synthesized knowledge and evidence on innovative risk management strategies that foster resilient rural livelihoods and sustain a food secure environment
		Output 2.1.2 Analytical framework and tools to target and evaluate risk management innovations for resilient rural livelihoods and improved food security
		Output 2.1.3 Development; and demonstration of the feasibility, acceptability and impacts; of innovative risk management strategies and actions for rural communities
		Output 2.1.4 Tailor and disseminate research results for evidence-based policy and technical support for farm- to community-level risk management strategies
		Output 2.1.5 Identify and evaluate differential impact of agricultural risk management strategies on different social groups, particularly women and men, and communicate findings through technical and policy support activities
Objective 2.2 Identify and test tools and strategies to use advance information to better manage climate risk through food delivery, trade and crisis response	Outcome 2.2 Better climate-informed management by key international, regional and national agencies of food crisis response, post-crisis recovery, and food trade and delivery in at least 12 countries	Output 2.2.1 Enhanced knowledge of impacts of climate fluctuations on food security, and how to use advance information to best manage climate-related risk through food delivery, trade, crisis response and post-crisis recovery
		Output 2.2.2 Synthesized knowledge and evidence of the impacts of alternative risk management interventions within the food system on food security and rural livelihoods, to inform policy and practice
		Output 2.2.3 Platform and tools for sharing knowledge and fostering improved coordination among food crisis response, the market-based food delivery system, and agricultural research and development
		Output 2.2.4 Identify and evaluate differential impact of tools and strategies for climate risk management on different social groups, particularly women and men, and inject findings into support to agencies
Objective 2.3 Support risk management through enhanced prediction of climate impacts on agriculture, and enhanced climate information and services	Outcome 2.3 Enhanced uptake and use of improved climate information products and services, and of information about agricultural production and biological threats, by resource-poor farmers, particularly vulnerable groups and women, in at least 12 countries	Output 2.3.1 Improved climate information tools and products to support management of agricultural and food security risk
		Output 2.3.2 Synthesized knowledge and evidence on institutional arrangements and processes for enhancing climate services for agriculture and food security
		Output 2.3.3 Improved knowledge, tools, data sets and platforms for monitoring and predicting agricultural production and biological threats, and informing management, in response to climate fluctuations
		Output 2.3.4 Enhanced capacity of national and regional climate information providers, NARES and communication intermediaries to design and deliver climate information products and services for agriculture and food security management
		Output 2.3.5 Identify and evaluate differential impact of climate information services on different social groups, particularly women and men, and inject findings into support to farmers

- Mechanisms for sharing knowledge and improving coordination among food crisis response, the market-based food delivery system, and agricultural research and development;
- Synthesized knowledge, tools and evidence to tailor climate information for management of agricultural and food security risk;
- Improved knowledge, tools, data sets and platforms for monitoring and predicting agricultural production and biological threats, and informing management, in response to climate fluctuations; and
- Synthesized knowledge and evidence on institutional arrangements and processes that enhance the utility of climate services for agriculture and food security.

New content and innovation

Theme 2 targets emerging and integrated solutions for managing climate-related risk, which have not yet been fully exploited due to their newness, major knowledge gaps, climate information constraints, or dependence on effective coordination among actors. Combining analysis with participatory action research, it will develop integrated risk management solutions that combine rural communities' current knowledge and tactics; with innovations such as index-based risk transfer products, diversified farm and livelihood portfolio design, and adaptive management in response to seasonal forecast information; and evaluate them within a livelihood resilience framework. At the level of food systems, Theme 2 research will advance: the salience, accuracy and lead time of information about climate impacts; the timeliness and targeting of climate-informed food trade, delivery and crisis response decisions; and the coordination among actors within the food system. By bridging the climate, agriculture and food security communities, and overcoming bottlenecks to relevant climate services, Theme 2 will enable several innovative opportunities to manage agricultural risk better across scales.

Risks

Achieving outputs and outcomes will depend on the degree to which the Program can engage and influence the agendas of non-traditional CGIAR partners, particularly within the climate and the humanitarian response communities. Uptake of particular interventions may be constrained by farmers' resources and geographic context. Further, effective and equitable participation from rural communities and an open forum for dialog must be established with support of intermediaries for successful participatory research projects at benchmark locations. Several planned outputs depend on historic meteorological data; hence the need for good partnership with the meteorological services, regional climate centers and the WMO. For work on the delivery of climate services, institutional and technical capacity must be sufficient to support widespread delivery of climate services. The dependence on integration with the other CRPs mentioned below must be managed through appropriate governance structures that go beyond the Program. Silos among the Themes are also a risk; mechanisms to avoid these are discussed under the risks section for Theme 1.

Regional balance

Work on field- to community-level risk management (Objective 1) will span target regions, but is particularly relevant for rainfed agriculture in high-risk environments. Work on climate services (Objective 3) will also span target regions, and capitalize early on regional climate centers (i.e., ACMAD, ICPAC, AGRHYMET) and substantial investment in climate services (e.g., ClimDev-Africa) in sub-Saharan Africa. Objective 2 activities will be most prominent in sub-Saharan Africa, where the state of food insecurity and the scale of international humanitarian response are greatest. The work will be expanded to other regions as they are added, and in addition Objective 1 will include a global comparative element that cuts across all locations where the CGIAR operates.

Linkages to other CRPs

Work in this Theme is linked to CRPs 1, 2, 3, 5 and 6 (Table 14). Two-way interaction is expected with CRP1 on diversification of farming systems and its impact on risk and vulnerability. Theme 1 will interact with CRP2 in the areas of information delivery; risk management through off-farm livelihood diversification, insurance, collective action; and managing risk through the food delivery system. CRP3 will contribute to climate-resilient crop germplasm and seed systems, and will benefit from analyses of the risk implications of cultivar and crop mixes. Climate information can feed into CRP5 to provide information on soil and water management, while CRP5 will provide options for reducing climate risk through better water and land management. The Theme will draw on advice from other CRPs on agricultural enterprises that best work after extreme events (e.g. salt-tolerant varieties after salt intrusion from tsunami, short-cycle crops to rapidly increase agricultural outputs) or to mitigate extreme events (e.g. drought tolerant crops). Cofinancing CRP1, CRP3 and CRP5 is envisaged, whereby promising options developed in those CRPs are tested and further developed in the context of holistic adaptation-mitigation strategies in the CRP7 targeted regions.

Theme 2 Objective 1: Enable rural communities to manage risk and build resilient livelihoods

Rationale and research questions

The purpose of this Objective is to enable several promising innovations for managing climate-related agricultural risk, and understand their impact on the resilience of rural livelihoods. For example, within an enabling environment, seasonal climate prediction offers farmers and local market institutions opportunities to exploit favorable conditions and more effectively protect themselves from long-term consequences of adverse extremes. There is a rapid resurgence of interest in insurance as a pro-poor climate risk management tool, in part because of the innovations that base payouts on an Objective index (e.g., rainfall) that is correlated with losses, and thereby overcome long-standing obstacles associated with asymmetric information. Improving diversification – at the levels of cultivars, farm enterprises and rural livelihood portfolios – is a promising means of reducing risk. Some indigenous community risk management innovations are likely to be transferrable and scalable. These innovations face important knowledge gaps related to targeting, design, institutional arrangements needed, and the special needs of marginalized groups including women. There are numerous technical options for better managing seasonal risks, which need further development and testing. Research will build on and contribute to our understanding of determinants of vulnerability to climate, and identify promising pathways to reduce climate vulnerability and enhance resilience in the longer term.

Research questions include:

- How effectively do rural communities manage climate-related risk, and what strategies hold promise for transferring and upscaling?
- How can index-based financial risk transfer products be best targeted and implemented to reduce vulnerability to climate shocks and alleviate climate-related constraints to improving rural livelihoods?
- How and under what circumstances can seasonal climate prediction be successfully employed to take advantage of favorable seasons, and to improve coping responses in adverse seasons?
- What combination of livelihood diversification, intensification, innovation and risk transfer has the best prospect for building resilience and reducing the long-term climate vulnerability of rural communities?

Table 14. Interaction of CRP7 Theme 2 with other CRPs (Priority activities are indicated in bold).

CRP7 Objective # and Title	CRP1 – Integrated Systems	CRP2 - Policies, Institutions and Markets	CRP3 – Sustainable Production	CRP5 – Water, Land and Ecosystems	CRP6 – Forests and Trees
2.1 Enable rural communities to manage risk and build resilient livelihoods	*In CRP7:* Development and evaluation of improved risk management through diversification and sustainable intensification. *In CRP1:* Pilot and evaluate climate risk management. ***Cofinancing:*** **Coordinated set of trial sites in target regions for testing options.**	*In CRP7:* Evaluation and development of innovations in weather-index insurance mechanisms by small farmers under the value chain component. This could also include combination of insurance and access to credit to reduce the risks faced by farmers. *In CRP2:* Analyses of rural financial services and appropriate rural service provision for markets through information hubs and institutional innovations under the value chain component *Collaboration:* Rural institutions and delivery of weather-index insurance mechanisms	*In CRP7:* Development of improved risk management and climate-resilience through sustainable intensification. *In CRP3* Evaluation of improved germplasm under climate change conditions. ***Cofinancing:*** **Testing options for improved risk management of food system**	*In CRP7:* Provide climate info relevant to water and soil mgmt *In CRP5:* Provide technical/policy options for reducing risk through water mgmt ***Cofinancing:*** **Testing options for improved risk mgmt of food system**	
2.2 Managing climate risk through food delivery, trade and crisis response	*In CRP7:* Use of climate-related info to manage risk through food security safety nets, food reserves and trade *In CRP1:* Address needs for safety nets, food reserves and diversifying markets *Collaboration:* Joint priority setting for research on improved risk management of food system	*In CRP7:* Work with humanitarian community on crisis response and recovery *In CRP2:* Evaluation of social protection interventions for shocks *Collaboration:* Social protection, including humanitarian response, and its links to ag development.	*In MP7:* Improve use of climate-related information to manage risk *In MP3:* Address productivity increases and policy needs for safety nets, food reserves and diversifying markets *Collaboration:* Opportunity for collaborative research on evidence-based policy and practice		
2.3 Enhanced prediction of climate impacts, and enhanced climate services	*In CRP7:* Improved prediction of climate impacts and enhanced climate services *In CRP1:* Use of climate impact information in CRP1 research and development	*In CRP7:* Improvement and evaluation of climate information services and delivery mechanisms *In CRP2:* Improvement and evaluation of market information services and delivery mechanisms through ICTs *Collaboration:* Opportunity for synergies in developing rural information delivery mechanisms	*In CRP7:* Improved prediction of climate impacts and enhanced climate services *In CRP3:* Use of climate impact information in CRP3 research and development	*In CRP7:* Improved prediction of climate impacts and enhanced climate services *In CRP5:* Use of climate impact information in CRP5 research and development	*In CRP7:* Improved prediction of climate impacts and enhanced climate services *In CRP6:* Use of climate impact information in CRP6 agroforestry research and development

Activities

A network of participatory pilot demonstrations; which will engage rural communities and other local stakeholders at benchmark locations to identify, develop and evaluate suites of agricultural risk management strategies; will form the foundation of the Objective's research. Community-level surveys will assess the current use, unmet demand and bottlenecks to climate-related information for local-scale agricultural risk management in order to inform interventions to improve rural climate services (under Objective 3). Replicating the participatory pilot demonstrations across farming systems and environments will enhance the transferability of knowledge and evidence. The Objective will develop a robust framework and decision tools for designing and targeting risk management innovations, and evaluating their impact on livelihood resilience of rural households. Integrating bioeconomic modelling with participatory evaluation of risk management innovations will ensure that the analytical framework and tools are robust and useful to inform policy and practice, and provide a mechanism for transferring knowledge and scaling up successful interventions beyond benchmark locations. Knowledge of promising opportunities to improve management of climate-related risk – climate-resilient agronomic and natural resource management technologies, farm and livelihood diversification, climate-informed adaptive management, index-based risk transfer products, successful strategies that rural communities already employ – will be synthesized from critical reviews of literature and work across the CGIAR and its partners. Work under this Objective will pay particular attention to understanding and overcoming gender-based inequities in risk management interventions and the institutional services that support management of climate-related risk. Knowledge-sharing platforms will link knowledge and evidence produced under this Objective, with relevant policy and institutional stakeholders to foster support for improved agricultural risk management. The Objective will work closely with partners in governments, development agencies and the private sector to ensure that the research is demand-driven and provides practical, replicable outputs and outcomes.

Outputs/milestones

- Synthesized knowledge and evidence on risk management innovations that foster resilient rural livelihoods: climate-resilient production technology, diversification, climate-informed adaptive management, index-based insurance, and successful strategies that rural communities already employ.
- An analytical framework and tools to design, target and evaluate risk management innovations for resilient rural livelihoods.
- Methodology and tools for designing comprehensive risk management portfolios for particular farming systems and contexts; and evaluating their impact on livelihood resilience.
- Demonstrated feasibility, acceptability and impacts of innovative risk management strategies and actions with rural communities at benchmark locations.
- Knowledge-sharing platforms to link research results with evidence-based policy and technical support for farm- to community-level risk management (with Themes 1 and 3).
- Synthesized knowledge and evidence of differential impact of agricultural risk management interventions on different social groups, particularly women and men; and guidelines for ensuring equitable participation and distribution of benefits.

Partner roles

Rural communities, other local agricultural stakeholders, and research partners (NARES, CG, universities) will partner in identifying, designing and evaluating context-relevant opportunities to improve risk management; and in co-learning. Farmer associations and strong development NGOs (e.g., CARE, Oxfam) will help facilitate interactions with rural communities, and will ensure that research is responsive to the needs of women and other vulnerable groups and that it builds on existing knowledge. Work on index-

based financial risk transfer products will involve national financial institutions, and coordination with the international research and development community that is working on this area (e.g. BMGF, WB, I4, IRI, CARE, Oxfam). Work on the use of climate-related information will interface with Objective 3, and engage national and regional climate service providers; communication intermediaries such as agricultural extension, development NGOs, and organizations focused on communication through Information and communication technology (ICT) and the media; and a range of local private- and public-sector end users.

Impact pathways for target environments

Co-learning among researchers, institutional partners and rural communities will provide a foundation of knowledge and evidence to inform systematic technical and policy support for more effective farm- to community-level agriculture risk management. Concerted effort will be invested in capturing and sharing experiences with promising existing community-based risk management strategies. Participatory research with rural communities, with particular attention to the effective participation of women and socially marginalized groups, will provide evidence of the feasibility, acceptability and livelihood impact of current community-based risk management practices and new innovations. Key NARES and development NGOs will participate in the design, pilot implementation and evaluation of local risk management interventions. A range of communication channels will inform adaptation and development funders and organizations, the CGIAR, and NARES about the long-term impacts of alternative risk management actions, leading to better-targeted investment in agricultural development and adaptation, and ultimately to farming systems and rural livelihoods that are more secure in the face of a variable and changing climate. A combination of direct participation, aggressive outreach, and knowledge sharing platforms will foster widespread uptake of results by a range of public and non-governmental development agencies.

Theme 2 Objective 2: Managing climate risk through food delivery, trade and crisis response

Rationale and research questions

Decisions made within the food system influence constraints and opportunities that rural communities face, and influence food security in urban areas. There is substantial scope to use climate-related information to better manage grain storage, trade and distribution; and to better target timely assistance during food crises. Safety nets that provide well-targeted assistance in times of crisis can protect productive assets, encourage investment, and stimulate development of the value chain for agricultural products. Early response is essential to effective food crisis management, as delay can greatly increase the humanitarian and livelihood costs; and the availability of quality early warning information is a precondition. The use of advance information to manage regional trade and storage to stabilize prices is a promising component of food security management, as climate-related price fluctuations can lead to acute food insecurity for the relatively poor who spend the majority of their incomes on food, even if total food availability is sufficient to meet a region's needs. Improving the use of climate-related information is expected to improve targeting of safety net interventions, and improve the lead time of decisions within the food system. This Objective links closely with CRP2 in the areas of long-lead climate, market and early warning information and improved climate-informed management of safety nets and price volatility in the output value chain.

Research questions include:

- To what degree can advanced information about climate inform estimates of the determinants of food security (i.e., availability, accessibility and utilization)?
- What is the feasibility and best strategy to use advanced information to target and initiate safety net interventions and responses to climate-related market fluctuations and emerging food crises?
- How can agricultural development and humanitarian response activity and resourcing be coordinated most effectively?

- How can food delivery, crisis response and post-crisis recovery be best managed to reduce climate vulnerability and improve resilience of rural communities?

Activities

Work under this Objective will engage key international and national organizations involved in food delivery, trade and humanitarian crisis response in CCAFS focus regions; to improve management responses to climate fluctuations based on long-lead prediction; and to enhance coordination among actors within the food system. Informed by empirical analysis of impacts of climate fluctuations on the components of food security (food production, transport, prices, incomes, consumption, humanitarian assistance), participating stakeholders will work with climate service providers to design information products and decision tools to support innovative response strategies. Research will use longitudinal household survey data and economic modeling to understand the livelihood impacts and equitability (based on gender and social status) of current and alternative policies for managing climate-related safety net interventions and responding to food crises and price volatility. Direct engagement with key organizations within the food system and a web-based knowledge-sharing platform will foster co-learning, adoption of improved responses to improved information, and enhanced coordination.

Outputs/milestones

- Enhanced knowledge of the impacts of climate fluctuations on food security, and the use of advance information to best manage climate-related risk via food delivery, trade, crisis response and post-crisis recovery.
- Synthesized knowledge and evidence of the impacts of alternative risk management interventions within the food system, on food security and rural livelihoods, to inform policy and practice.
- Stakeholder engagement, platform and tools for sharing knowledge and fostering improved coordination among food crisis response, the market-based food delivery system, and agricultural research and development.
- Identification and evaluation of differential impact of interventions for dealing with climate fluctuations within the food system, on different social groups, particularly women and men, and injection of findings into food system policy and practice.

Partner roles

Key food security response (e.g., WFP, IFRC, World Vision, bilateral humanitarian assistance programs) and food trade organizations will engage in evaluation of promising improvements to response mechanisms. Work on improving the use of climate-related information will engage national and regional climate service providers, and crop forecasting and food security early warning organizations. IFPRI, other CG Centers working within CRP2 and appropriate ARIs will participate in analyses and development of response guidelines. A range of food trade organizations, food security early warning (e.g., FEWSNet, JRC) and humanitarian response organizations (e.g., WFP), information providers (e.g., the NMS and regional climate centers involved in the Regional Climate Outlook Forum process) and ministries of agriculture will participate in platforms to share knowledge and improve coordination.

Impact pathways for target environments

Critical actors in the food system will identify and evaluate promising strategies for using climate-related information to manage price volatility, respond to emerging food crises, and implement safety nets. Improved advance information about climate impacts on food production and food security will be designed with their participation, and disseminated through existing information providers and a range of forums. Dissemination through workshops, reports and policy briefs will complement the direct engagement of key food trade and humanitarian relief organizations in the development and evaluation of

improved response strategies. More timely and better targeted food crisis response will decrease long-term livelihood impacts of crises, reduce disincentives to agricultural producers and markets, and reduce cost of assistance. More timely and effective management of food trade, storage and delivery will reduce the adverse impacts of climate fluctuations on availability and accessibility of food, and on incentives to producers and market institutions.

Theme 2 Objective 3: Enhanced prediction of climate impacts, and enhanced climate services

Rationale and research questions

This Objective deals with the design and delivery of climate-related information products and services to support more effective management of agricultural and food security risk. Several opportunities to better manage climate-related risk depend on information about climate (historic, monitored, predictive) and its impacts on agriculture, but progress in implementing them at the scale of the development challenge is constrained in part by a substantial gap between current operational climate information services and the needs of development. If climate information services are to contribute fully to efforts to adapt agriculture to a variable and changing climate, several gaps need to be addressed in parallel, such as: data availability, design of salient information products and services, modeling frameworks to estimate impacts on agricultural and biological systems, delivery mechanisms, enabling policy, and capacity to respond. Understanding current use of climate information, any obstacles to accessing or responding to information, and underexploited opportunities to use information to manage risk, are prerequisites to developing more effective services. Partnering with emerging initiatives (such as the Global Framework for Climate Services that was endorsed by the World Climate Conference-3 and the ClimDev-Africa joint program of the AU, UN-ECA and AfDB) enhances the prospect of overcoming information bottlenecks that have limited opportunities to manage agricultural risk.

Research questions include:

- To what degree can available climate and environmental information be used to anticipate and manage variations in crop and forage production, biological threats, and food security outcomes?
- What combination of new products, services, delivery mechanisms and institutional arrangements offers the best opportunity to deliver useful, equitable, transferable and scalable rural climate services?

Activities

This Objective will engage climate information providers and key users – from farmers to food security humanitarian organizations – to design new or enhanced products and services for risk management applications (identified in Objectives 1 and 2); and overcome technical and institutional bottlenecks to the production and delivery of useful information products and services. Building on investment in seasonal prediction and reconstructing historic meteorological observations, and synthesis of existing prediction and early warning systems; research under this Objective will develop value-added information in the form of methodology, data sets, predictive and decision tools, and platforms for monitoring and predicting impacts of climate fluctuations on agricultural production and biological threats. Work on institutional arrangements and processes for enhancing climate services will be informed by critical reviews of strengths, gaps and opportunities of current climate services in each focus region; and by engagement with farmers and other local agricultural decision-makers at benchmark locations (Objective 1), and key actors within the food system (Objective 2). The work will pay particular attention to understanding and overcoming inequitable access and benefits from climate services, due to gender and social marginalization. This Objective aims to develop a consensus “roadmap” with critical actors in the climate and user communities, for improving the utility of climate services for agricultural and food security risk

management. Research and methodology development will be co-designed with national and regional climate information providers, NARES and communication intermediaries to deliver climate information products and services for agriculture and food security management.

Outputs/milestones

- Improved, tailored climate information products (reconstructed historic climatology, downscaled seasonal forecasts) and decision tools to support management of agricultural and food security risk;
- Improved knowledge, data sets, tools and platforms for monitoring and predicting impacts of climate variations on agricultural production, rangeland conditions and biological threats, for a range of early warning and risk management applications;
- Synthesized knowledge and evidence on institutional arrangements and communication processes for climate services; addressing relationships among climate and agricultural institutions, ICT-based and other innovative information delivery mechanisms, and protocols for communicating complex climate information effectively; leading to regional roadmaps for enhancing the utility of climate services for agriculture and food security;
- Enhanced capacity of national and regional climate information providers, NARES and communication intermediaries to design and deliver and support the use of climate information products and services for agriculture and food security management; including training and curriculum development for overcoming sparse historic observations, downscaling and tailoring seasonal forecasts for local agricultural decisions, and communicating climate information with farmers; and
- Synthesized knowledge and evidence on differential accessibility and benefits of climate information services among different social groups, particularly women and men, and approaches to overcoming inequities.

Partner roles

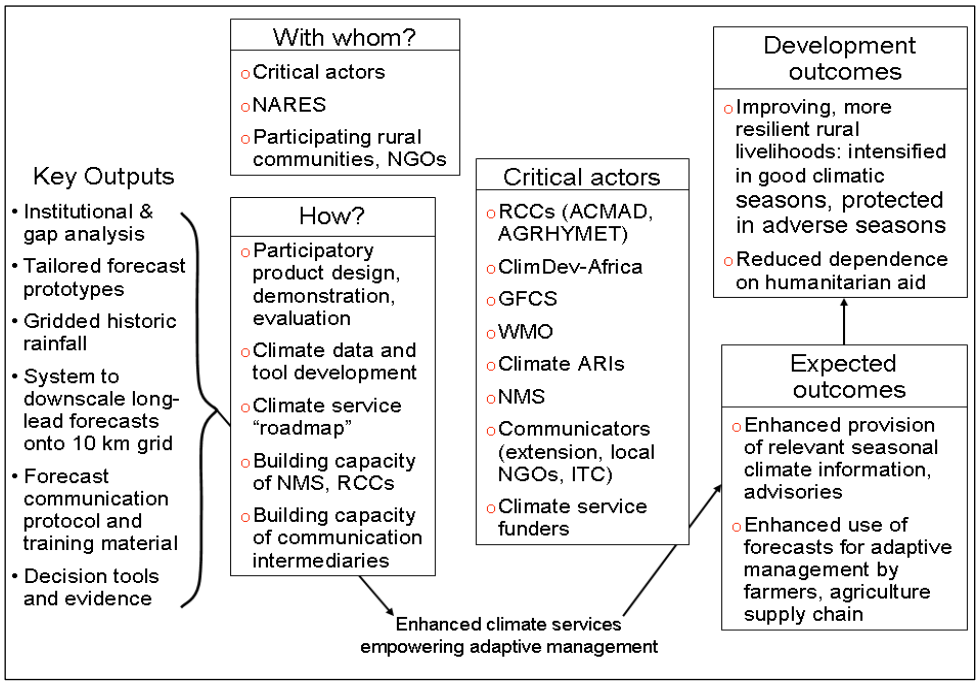
Key information providers (WMO, NMS and regional climate centers in Africa: ACMAD, ICPAC, AGRHYMET) and local- to regional-level users will participate in the evaluation and improvement of climate information products and services. Development of platforms to translate climate information into agricultural production and biological threat impacts will involve a range of partners such as FAO, NARES, CIRAD, JRC, FEWSNet and AGRHYMET. Scaling up the results will require coordination with international climate organizations and initiatives such as WMO, GFCS and ClimDev-Africa. Information intermediaries (NARES, development NGOs, media, firms and NGOs involved in rural ICT) will be involved in evaluating and developing strategy to improve and upscale information delivery mechanisms. Participation and feedback from representatives of agriculture (e.g., farmer associations, development NGOs, agribusiness), trade and food security response communities will be vital for guiding and evaluating improvements to climate services. Research will require partnership with the ESSP, in addition to CGIAR, NARES and agricultural ARIs.

Impact pathways for target environments

While the design and evaluation of climate information products and services will be led largely by rural communities at pilot locations (under Objective 1) and key actors in the food delivery system (Objective 2), NMS and international providers of climate services will participate in the process of developing and evaluating improvements to products and services. Results will be disseminated among the climate community through a range of forums including international programs (WMO, WCRP) and initiatives surrounding climate services (e.g., GFCS, ClimDev-Africa, regional climate outlook forums). The outreach process will include training and capacity enhancement for key information providers. Participating regional climate centers and NMS will improve information and services tailored to the needs of agriculture and food security. Partnering with initiatives such as ClimDev-Africa offers a mechanism to upscale improvements in climate information services. Improving climate information products and removing communication bottlenecks will enable improved management of agricultural risk at multiple levels, which

will contribute to more resilient farming systems, more secure rural livelihoods, and more effective and less costly safety net interventions (Figure 11).

Figure 11. Impact pathway for working with partners to enhance climate services for adaptive management – example from West Africa, using outputs from Theme 2, Objective 3.



Theme 3: Pro-Poor Climate Change Mitigation

Rationale

Agriculture contributes considerably to climate change by producing 10–12% of total global anthropogenic emissions of greenhouse gases (Smith et al., 2007). Agricultural practices can significantly reduce emissions by sequestering carbon in the soil or above ground biomass (for example in agroforestry or woodlots, or by reducing nitrous oxide or methane emissions), especially if large numbers of farmers take up these practices. However, many of the world's poorest also depend on agriculture and related natural resources to meet their basic needs. If the poor are to contribute to climate change mitigation, there is a need for mitigation options that have a positive impact on livelihoods, otherwise unacceptable trade-offs may occur. Carbon markets are unlikely to provide significant benefits to smallholder farmers in the near run and are highly uncertain, but livelihood options that produce mitigation co-benefits and carbon finance schemes that provide additional incentives should help farmers to meet both livelihood and environmental objectives.

The focus of this Theme is on how mitigation can benefit poor farmers and to understand trade-offs among different dimensions of poverty and different groups of the poor (including between men and women). Two windows of opportunity exist for pro-poor mitigation. The first is the design of low net emissions agricultural development pathways, i.e., options for securing food that minimize emissions of greenhouse gases and sequester additional carbon. These will need to be transformational alternatives that ensure future livelihoods and uses of land while simultaneously reducing people's impact on climate change. Past growth-based models of agricultural development have contributed to increased emissions and not always been environmentally or socially sustainable. Yet, food production will need to increase. As society gives

more emphasis to stability and resilience and compromises on economic growth as resource limits are reached, what options exist for agricultural development? What is the carbon footprint of these alternatives? How can we lower the carbon footprint of intensified agriculture? Countries will need such information to produce national mitigation strategies and manage larger food security, energy and biodiversity implications. For these to work, we need to understand how farmers may be able to combine mitigation and adaptation synergies and handle trade-offs. Agricultural development strategies should include how mitigation finance can be used to support adaptation. Strategies should also consider landscape-level impacts on conserved areas, such as forests and rangelands, which may have high mitigation impacts at low cost.

The second window of opportunity is the effective capacity of the poor to benefit from carbon financing, for example, the carbon market. Mitigation markets will commodify carbon and formalize rights to land, trees and carbon, both of which may marginalize the poor. Smallholders in developing countries are not currently competitive in these markets and carbon prices are inherently risky. Smallholders usually cannot afford the up-front costs of project development, data is often not available, and farmers manage diversified mixed crop-livestock systems. Furthermore, transparency and accountability are often poor among both government and private entities. Many farmers manage common-pool resources (rangelands, community forests, coastal zones) where boundaries, rights to benefits and collaborative management may be unclear, contested or complex. Benefits are often captured by elites or other actors in trading systems. Capacity for precise measurement of GHGs is often non-existent.

Yet, the largest potential for agricultural mitigation is among smallholders in developing countries. The combined value of markets for GHG emission reduction is more than US$100 billion, agriculture has been largely excluded from formal and informal carbon markets due to high uncertainty in the measurements of mitigation potential, the impermanence of agricultural practices and the transaction costs associated with smallholder agriculture. Similarly, the potential of aquatic system carbon sinks (‘blue carbon’, IUCN, 2009) has been little explored, and the possibilities for coastal resource users to act as ecosystem stewards for coastal and ocean carbon sinks have only been speculated upon.

Supportive future-looking institutional and incentive mechanisms will be necessary to encourage adoption of mitigation practices. Increasing the accuracy of estimates of carbon sequestration potential; designing low-cost measurable, reportable and verifiable monitoring, reporting and verification (MRV) standards; and investigating innovative methods to reduce other transaction costs and induce permanence are all necessary steps to enable smallholder farmers’ to earn performance –based payments. Understanding the impacts of carbon markets and other mitigation incentives and interventions on poverty and designing pro-poor institutional arrangements will be important to assure sustainable outcomes. Channeling benefits directly to farmers may be less effective for long-term development than investing proceeds in public infrastructure and educational or health. The feasibility of alternative approaches needs to be tested, and there is a need to learn lessons from schemes for payments for environmental services (PES), Reduced Emissions from Deforestation and Forest Degradation (REDD+), and the Clean Development Mechanism (CDM) to both reform these mechanisms to incorporate agriculture and to build new institutional arrangements.

Both the development of low net emissions pathways and participation of the poor in the carbon finance schemes require a sound technical understanding of the emissions associated with different land uses, farming practices, livelihoods and food system value chains to understand mitigation impacts. While much technical knowledge is available (much of which has been produced by the CGIAR), there is a need to link this knowledge to action on farms and landscapes. Information for developing country contexts is weak. There is a need for simple methodologies and protocols that are cost effective in developing country contexts. The allometric equations for different mitigation practices need to be refined and methods need to be integrated at landscape scales.

These three concerns—low net emissions agricultural development pathways, incentives and institutions for participation by the poor in mitigation markets, and on-farm mitigation—suggest the three research Objectives for this Theme (see below). For each research Objective, the Theme will seek to understand

synergies and trade-offs among poverty, food security and mitigation, while ensuring environmental sustainability to inform policy and decision-making. Synergies among these multiple outcomes are possible; for example, increasing soil organic matter in pastures or crop fields can sequester carbon while improving water retention and soil fertility. Practices that decrease methane production in livestock often result in better feed-use efficiency. Trees on farms can significantly raise biomass production and provide environmental benefits and income diversification. Conservation of coastal mangrove forests captures and stores carbon and also buffers against coastal erosion, storm-surges and impacts of sea-level rise, in addition to enhancing fisheries production and supporting diverse coastal livelihoods. For each Theme, an understanding of power dynamics and gender relations will be necessary to understand who wins and who loses in the food system and across the landscape.

Objectives

The aim of Theme 3 is to identify mitigation strategies that reduce poverty among the rural poor in developing countries. Special attention will be given to the trade-offs and synergies of mitigation, food security and poverty alleviation, while ensuring the health of water, land and ecosystems at different scales (e.g., farm, landscape, seascape, food value chain). The Objectives (Table 15) are to:

- Inform decision makers about the impacts of alternative agricultural development pathways
- Identify institutional arrangements and incentives that enable smallholder farmers and common-pool resource users to reduce GHG emissions and improve livelihoods
- Test and identify desirable on-farm practices and their landscape-level implications

Research approach to international public goods

The Theme will produce the following international public goods (IPGs):

- Analysis and identification of transformative agricultural development pathways that best support mitigation, poverty alleviation and food security
- Enhanced tools, data and analytic capacity in regional and national policy and research organizations to analyze the implications of different development scenarios and mitigation strategies
- Analysis of the gender and social differentiation implications of alternative agricultural pathways and findings built into communications and capacity building activities
- New pro-poor institutional arrangements and incentives that enable smallholder farmers and common-pool resource users to benefit from carbon finance and reduce GHG emissions
- Improved knowledge about the bundling of incentives for mitigation with payments for other environmental services such as water quality and biodiversity
- New methods and systems for GHG monitoring and accounting at farm, landscape and food supply chain levels
- Testing and demonstration, of the feasibility of agricultural mitigation that yields significant benefits for smallholders in developing countries
- Enhanced knowledge about the practice of reduced tillage, agroforestry, community forestry, low input aquaculture, managing aquatic ecosystems, residue management, nutrient management, improved feeding practices and other practices on GHG fluxes at the landscape level
- Scientific knowledge and validated simulation models about the trade-offs and synergies among GHG mitigation, food security, well-being and environmental health for alternative mitigation practices to inform policies and investments

- Platform for exchange and synthesis of information about innovations in agricultural mitigation, including participation of the poor, multi-level governance, landscape-based approaches to mitigation and MRV, low net emissions agricultural practices in different farms and agroecosystems, institutions and incentives for participation by the poor in carbon markets, carbon labeling, and mitigation financing for adaptation
- Analysis of impacts of on-farm and landscape level practices on women and poor farmers

Table 15. Objectives, Outcomes and Outputs for Theme 3 for Phase 1 (Year 1-5) (the full list of milestones is given in Annex 1). Outputs to be achieved by Year 5, Outcomes by Year 10.

Theme 3. Pro-Poor Climate Change Mitigation		
OBJECTIVES	**OUTCOMES**	**OUTPUTS**
Objective 3.1 Inform decision makers about the impacts of alternative agricultural development pathways	Outcome 3.1: Enhanced knowledge about agricultural development pathways that lead to better decisions for climate mitigation, poverty alleviation, food security and environmental health, used by national agencies in at least 20 countries	Output 3.1.1 Analysis of agricultural development pathways and the trade-offs among mitigation, poverty alleviation, food security and environmental health
		Output 3.1.2 Enhanced tools, data and analytic capacity in regional and national policy and research organizations to analyze the implications of different development scenarios and mitigation strategies
		Output 3.1.3 Analysis of the gender and social differentiation implications of alternative agricultural pathways and findings built into communications and capacity building activities
Objective 3.2 Identify institutional arrangements and incentives that enable smallholder farmers and common-pool resource users to reduce GHGs and improve livelihoods	Outcome 3.2: Improved knowledge about incentives and institutional arrangements for mitigation practices by resource-poor smallholders (including farmers' organizations), project developers and policy makers in at least 10 countries	Output 3.2.1 Evidence, analysis and trials to support institutional designs, policy and finance that will deliver benefits to poor farmers and women, and reduce GHG emissions
		Output 3.2.2 Improved capacity to increase the uptake and improve the design of incentives mechanisms and institutional arrangements to deliver benefits to poor farmers and women
Objective 3.3 Test and identify desirable on-farm practices and their landscape-level implications	Outcome 3.3: Key agencies dealing with climate mitigation in at least 10 countries promoting technically and economically feasible agricultural mitigation practices that have co-benefits for resource-poor farmers, particularly vulnerable groups and women	Output 3.3.1 Analysis of mitigation biophysical and socioeconomic feasibility for different agricultural practices and regions, and impacts on emissions, livelihoods and food security
		Output 3.3.2. Methods developed and validated for GHG monitoring and accounting at farm and landscape level to contribute to compliance and voluntary market standards
		Output 3.3.3 Synthesis of understanding about the direct and indirect economic and environmental costs and benefits from agricultural mitigation
		Output 3.3.4 Analysis of impacts of on-farm and landscape level practices on women and poor farmers

New content and innovation

Theme 3 innovates through synthesis linked to global processes and a clear, analytical focus on the trade-offs and synergies between mitigation and food security, poverty alleviation and environmental health (Outputs 3.1.1., 3.3.1). It will bring information on pro-poor mitigation into international and regional climate policy arenas and take carbon finance into new territories (Output 3.2.1). In addition, the three Objectives bring specific innovations to add value:

- Objective 1: Integration of CGIAR (regional- to local-scale data and partners, with social science, economic and applied technical capacities) with ESSP community (global and large-scale regional analyses, largely in the biophysical domain) to enhance research outcomes (e.g. enhance spatially-explicit modeling).
- Objective 2: Involving smallholder farmers and common-pool resource users in institutional design. Identifying incentives for local actors. Identifying multi-scale governance arrangements.
- Objective 3: GHG monitoring systems from ESSP linked to on-farm and landscape-level practices and outcomes. Linking emissions data and technologies to practical mitigation actions. Global comparative work across regions using benchmark sites (agree on common methods, plan for synthesis, trade-off analysis).

Risks

The major risk is that mitigation measures implemented by the rural poor are shown to be neither feasible nor cost-effective in contributing to reducing GHG levels or making a meaningful contribution to livelihoods. Operational and institutional risks include weak extension agencies, lack of viable carbon market, under-supported local capabilities, lack of incentives, complicated or expensive methods required to monitor, and unreliable governance. If policies and incentives do not exist for adopting agricultural mitigation, may be difficult to find partners to test innovations. There is a political risk of mobilization from politicians and civil society organizations against agricultural mitigation by smallholders on grounds of national needs for food security or global social justice. Internally, there are risks associated with management of the Theme across several continents with diverse agro-ecological, socio-economic and political conditions. Silos among the Themes are also a risk; mechanisms to avoid these are discussed under the risks section for Theme 1.

Linkages to other CRPs

The main impact of agricultural practice on carbon sequestration capacity in agricultural landscapes is likely to be via intensification of production that frees up land for restoration and carbon storage in biomass. Therefore a key strategic link will be with CRP6 (Forests and Trees), particularly in terms of work at the landscape level , given the close causal links between agricultural management and availability of land for forest cover, and trees on farms (Table 16). The Theme will also contribute to CRP1, situating mitigation within broader agricultural and other food production systems, CRP5 in its work on soil carbon, and CRP3, including methane reduction from rice systems and intensification of potato production to limit expansion into carbon-rich grasslands. CRP1, CRP3 and CRP5 will be the main CRPs where new mitigation technologies are developed and tested, and CRP7 aims to cofinance the testing of promising technologies in its target regions, where an integrated approach will be taken to adaptation and mitigation strategies, from farmers' field to policy levels. Within this Theme there is some focus on common property institutions for managing landscape emissions – this will link to the work on collective action in CRP2.

Table 16. Interaction of CRP7 Theme 3 with other CRPs (Priority activities are indicated in bold).

CRP7 Objective # and Title	CRP1 – Integrated Systems	CRP2 - Policies, Institutions and Markets	CRP3 – Sustainable Production	CRP4 – Nutrition and Health	CRP5 – Water, Land and Ecosystems	CRP6 – Forests and Trees
3.1 Inform decision makers about the impacts of alternative agricultural development pathways	*In CRP7:* Development of low-carbon ag. scenarios *In CRP1:* Development of farming systems that meet adaptation and intensification requirements *Collaboration:* Research on synergies between adaptation and intensification	*In CRP7:*Life cycle analysis of food supply chains *In CRP2:* Investigation of policy, investment and enabling environment for pro-poor growth *Collaboration:* Trade-offs among mitigation, food security and livelihoods of low emission food supply chain and ag. options.		*In CRP7:* Development of low-carbon ag. scenarios *In CRP4:* Reducing impacts of intensification on human and animal health *Collaboration:* Understanding implications of low-carbon scenarios for human/animal health	*In CRP7:* Assess trade-offs of low emission options on environ. services *In CRP5:* Test tradeoffs of biomass use for food/energy/ feed/soils *Collaboration:* Impacts of soil/water mgmt on mitigation	*In CRP7:* Identifying options for ag. intensification that reduce GHG emissions (e.g. agroforestry). *In CRP6:* Forest-based mitigation (e.g. REDD+). *Collaboration:* Reducing ag. expansion as a driver of deforestation
3.2 Identify institutional arrangements and incentives that enable smallholder farmers and common-pool resource users to reduce GHGs and improve livelihoods	*In CRP7:* Testing the feasibility of payments for mitigation by smallholders. *In CRP1:* Technical development of mitigation options in systems *Collaboration:* Linking incentives to new integrated technical options.	*In CRP7:* Identify institutions/tenure/ incentives that enable smallholders to benefit from C markets; role of collective action in aggregating small-holders into C markets *In CRP2:* Models/ tools to understand institutional, market and policy impacts; work on collective action. *Collaboration:* Inclusion of mitigation in modeling food security impacts	*In CRP7:* Testing the feasibility of payments for mitigation by smallholders on farms *Collaboration:* Linking incentives to new technical options		*In CRP7:* Testing bundling of C payments with other environ-mental service payments. *In CRP5:* Valuing and assessing environmental goods and services; *Collaboration:* Payments for C as incentives for mitigation	*In CRP7:* Identifying opportunities for pro-poor mitigation payment schemes *In CRP6:* Developing institutional arrangements for mitigation payments through agroforestry and forestry *Collaboration:* Testing institutional arrangements.
3.3 Test and identify desirable on-farm practices and their landscape-level implications	*In CRP7:* Testing the economic/ technical feasibility of mitigation options; aggregating at the landscape and farm levels *In CRP1:* Technical development of integrated mitigation options. ***Collaboration:*** **Verifying GHG budgets** ***Cofinancing:*** **Testing technologies**	*In CRP7:* Testing the economic and technical feasibility of mitigation options *In CRP2:* Understanding policy and market impacts on livelihoods *Collaboration:* Assessing role of policies and markets on the feasibility of mitigation options	*In CRP7:* Testing the economic and technical feasibility of mitigation options *In CRP3:* Integration of mitigation options into development of new technologies ***Collaboration:*** **Verifying GHG budgets** ***Cofinancing:*** **Developing technologies to enhance mitigation**		*In CRP7:* Testing potential for water mgmt and soil C-based mitigation options; *In CRP5:* Developing water and soil mgmt options. *Collaboration:* Developing protocols for C measurement. ***Cofinancing:*** **Developing technologies that enhance mitigation from land and**	*In CRP7:* Testing technical/ economic feasibility of mitigation options *In CRP6:* Methodological issues in managing and estimating carbon stocks associated with land use change National-level measurement and monitoring technical and institutional capacity Approaches for reducing

	that enhance mitigation.		**from specific commodities**		**water mgmt**	emissions from forests and peatlands ***Cofinancing:*** **Landscape-based approaches for mitigation and related MRV, including approaches that reduce forest degradation and deforestation**

Regional balance

The Theme will examine the research questions for a) areas where poverty is extreme and scenarios indicate populations to be most vulnerable to climate change (e.g., SSA and South Asia) and b) areas where the highest potential for mitigation and benefits to the rural poor exist (e.g., Southeast Asia, Amazon Basin). The aim is to understand to what extent people in the regions most vulnerable to climate change can contribute to benefits from mitigation, but also to know where investments in mitigation are likely to have the highest impacts. Emphasis will be placed on integrated approaches to mitigation and livelihood systems across landscapes.

Theme 3 Objective 1. Inform decision makers about the impacts of alternative agricultural development pathways

Rationale

The purpose of this Objective is to explore transformational agricultural development pathways that reduce net emissions and to compare their impacts. Increased needs for food production in an era of dwindling natural resources will require strategies for agricultural intensification, while also maintaining and enhancing the flow of ecosystem services from non-agricultural landscapes used by the rural poor (forests, grasslands, coasts and wetlands). The challenge will be how to do this sustainably with positive impacts on food, poverty and the environment. Intensification is associated with higher emissions at the farm level, but not necessarily at landscape level. We need to therefore look across the rural landscape at agriculture, forestry and degraded lands to understand drivers of land-use change. Higher energy costs and sources of energy will require strategies for energy conservation and efficiency that could lead to new configurations of the rural landscape, and new market opportunities. In addition, the push for biofuels could change farming landscapes and have negative impacts on food security. More variable temperatures and precipitation will require adaptation strategies to help farmers adjust to different growing conditions. Forest conservation and REDD+ will have implications for agricultural expansion. Better knowledge is needed about the mitigation implications of these policy choices. Understanding the REDD+ policy development process is likely to yield lessons that can help position agriculture in the global negotiations.

Research questions

- What are the implications of current mitigation policies and programs for poverty alleviation and resilience of the food system at different scales?
- What are alternative trajectories for low net emissions agricultural development and what are their likely impacts on FPE?
- To what extent can current food production be maintained under mitigation scenarios?

- How can agricultural production be intensified sustainably, while also contributing to climate change mitigation across agriculture-forest landscapes?
- What is the carbon footprint of different adaptation strategies?
- What are the synergies and trade-offs between climate change adaptation and mitigation in different regions?
- Where would investments in agriculture yield the greatest returns? (Output 3.1.2, and associated milestones)
- How do different pathways affect marginal and vulnerable populations, including women? (Output 3.1.3 and associated milestones)

Activities

- Develop alternative scenarios (including quantitative and qualitative techniques) and strategies for transformative agricultural mitigation with diverse stakeholders, including organizations advocating for women farmers' well-being. (Output 3.1.1)
- Analyze the potential emissions reductions from technical options compatible with maintaining food supply
- Compare the net emissions of a) agricultural intensification through high input agriculture (water, energy) with conservation agriculture; b) landscapes where intensified agriculture enables more land to be left as forest or degraded land to be restored with high levels of aboveground biomass; and c) non-agricultural landscapes that provide multiple ecosystems services, including food provision – e.g. wetlands, coastal zones, grasslands
- Analyze the mitigation implications of alternative adaptation strategies
- Produce synthesis report comparing results of different pathways
- Support science-policy dialogue on alternative agricultural development futures
- Provide tools, data and analytic capacity in regional and national policy and research organizations to analyze the implications of different development scenarios and mitigation strategies (Output 3.1.2)
- Strengthen capacity of 300 decision makers in use of appropriate tools and data in three initial regions
- Analyze the gender and social differentiation implications of alternative agricultural pathways and findings built into communications and capacity building activities (Output 3.1.3)
- Involve stakeholders and decision makers at multiple levels throughout this process, to share ideas about innovative agricultural development alternatives, scenarios, and consideration of their impacts

Outputs/milestones

Products will include a synthesis of: a) alternative transformative agricultural development pathways that are sustainable and analysis of their trade-offs for food security, poverty, and the environment; b) methods for the multi-stakeholder analysis of alternative agricultural development pathways; and c) products from science-policy dialogue identifying different stakeholder interests. Additional outputs will include capacity enhancement via a series of policy maker and researcher workshops. Results will be shared through websites, policy briefs and scientific articles. Given the need for detailed adaptation information in this Objective, work will be closely conducted with Themes 1 and 2, while some of the needed tools will be

derived from Theme 4.

Partner roles

This Objective will target partners involved in multiple levels of planning of and investment in agricultural development, including the World Bank, IFAD and other donors; agriculture, forestry and land use (AFOLU) ministries and planning agencies; local governments, women's organizations and NGOs; and the private sector, for instance the consortium members of the Sustainable Food Lab and SAI. This research will also work with partners, such as NARES, CARE and Oxfam, to develop practical strategies for farmers' livelihood options, with special attention to women's needs. In addition to the stakeholders participating in the formulation and implementation of this research, results will be shared with stakeholders concerned with agriculture, food security, and climate change, for example, the Subsidiary Body for Scientific and Technological Advice (SBSTA) Working Group and other high-level scientific and policy bodies. Alternative pathways will be integrated with Theme 4's modeling activities.

Impact pathways for target environments

Key users, such as national agencies, will be involved in research, design and implementation to identify plausible scenarios and evaluate desirable development pathways. Results should help decision makers to design well-targeted investments and incentives at nested levels of governance and development intervention. Results will be shared widely with development organizations to shape their strategies for intervention. Capacity will be built via workshops, a global platform and a set of carefully targeted policy communications to national and global policy makers on specific scenarios, trade-offs and options. To bring impacts on a greater scale, the focus will be on communications and interactions with key decision makers in global and regional public bodies and large-scale development NGOs, with outreach beyond the agriculture sector. Targeted information will also be delivered to intellectual leaders in the climate change arena (e.g. Potsdam Institute for Climate Impact Research or PIK, Tyndall, etc.) on specific topics.

Theme 3 Objective 2. Identify institutional arrangements and incentives that enable smallholder farmers and common-pool resource users to reduce GHGs and improve livelihoods

Rationale

A number of finance mechanisms and incentives exist or are likely to be developed to support agricultural mitigation. In addition, incentive systems developed for REDD+ may be able to drive behaviors in agriculture. To what extent can smallholder farmers in developing countries benefit from these incentive mechanisms, and to what extent will these incentives be effective and efficient in achieving mitigation? Carbon markets exist and offer real benefits, yet smallholders and those who depend on community-managed forests and other carbon-capturing ecosystems have not been able to participate effectively in Clean Development Mechanisms (CDMs) or voluntary markets to date, due to high transaction costs, a lack of information and a lack of interest among project developers. Consumers are increasingly interested in low net emissions food and may be willing to pay a premium, however the standards and benefits available to farmers remain unclear. The implications of financial returns for carbon per unit land, carbon per unit food product, and carbon per organizational unit responsible for the mitigation activity need to be tested for their impacts on incentives and subsequent impacts on food security, poverty reduction and the environment. Similarly, practice-based versus output-based monitoring need to be tested for their economic feasibility and trade-offs between cost and robustness in the measurement of GHGs. Experience with payments for environmental services suggests that trade-offs are likely between mitigation effectiveness and poverty alleviation. The distribution of projects and Certified Emission Reductions (CERs) has been geographically uneven, and weak collective action has allowed the wealthiest to accumulate the benefits. Resource tenure may also be a limiting factor. The most likely certain incentives will be to incorporate carbon benefits into existing promising livelihood options, making carbon a co-benefit.

This Objective will investigate which institutional arrangements and incentives are best suited to achieving positive impacts on food security, poverty and the environment. Important institutional arrangements and incentives to test will include how to: a) group farmers together so that viable quantities of carbon can be sold in the carbon market; b) ensure that benefits are accessible and shared fairly among the rural poor who supply environmental services; c) provide sufficient incentives to adopt sustainable agriculture, livestock, and land and coastal management; and d) create links across multiple levels of governance to ensure coordinated policy action and nested levels of incentives for livelihood and food resilience.

Research questions

- What incentives, institutions, market-based mechanisms and policies at project and national scales would enable smallholder farmers in developing countries to produce verifiable carbon credits and improve their livelihoods, including (i) carbon as co-benefit to more productive agricultural practices, (ii) carbon markets, (iii) corporate social responsibility technical assistance, (iv) carbon labeling
- What lessons can be learned from REDD+, CDM and PES? What lessons can be learned about benefit distribution from microfinance experiences?
- How can the poor, especially women, participate in the design of and gain better access to the benefits available from carbon finance?
- What are promising incentives and institutions for integrative practices such as conservation agriculture, sustainable land management and agroforestry?
- What underlying factors affect sustainable land management practices, as practices most likely to yield both food security and mitigation?

Activities

- Identify promising incentives, finance instruments, policies and institutional arrangements
- Organize expert consultation to identify the design and monitoring requirements of finance and institutional arrangements to better benefit poor farmers and women
- Pilot institutional arrangements, incentive mechanisms and MRV protocols for reduced emissions and carbon sequestration from agriculture, including both potential project developers and aggregators (including supermarket supply chains, producers of high-value export crops, NGOs and farmers' organizations) as aggregators and disseminators of management system changes. Test in areas where mitigation potential may be low, but local farmers are vulnerable and poor (e.g., semi-arid areas of Africa and India). Compare with areas where mitigation potentials are high (e.g., the Amazon Basin and Southeast Asia)
- Analyze underlying factors affecting mitigation for sustainable land management practices
- Assess barriers to entry and factors affecting benefits from carbon finance for different social groups, including women, and the range of emerging institutional arrangements and incentives for better inclusion and benefits
- Develop methods and build capacity to understand socioeconomic baseline conditions where farmers are participating in the carbon market, and assess the distribution of benefits over time

Outputs/milestones

Key products will be research outputs that identify finance, incentives, policies and institutional arrangements that can improve access of the poor to mitigation benefits, with empirical indications of the

impacts of these benefits on poverty alleviation and GHG emissions. Alongside research outputs will be targeted communications products for the strategic partners named above, and capacity enhancement events and workshops to increase the uptake and improve the design of incentive mechanisms and institutional arrangements. Results will be shared through websites, policy briefs and scientific articles.

Partner roles

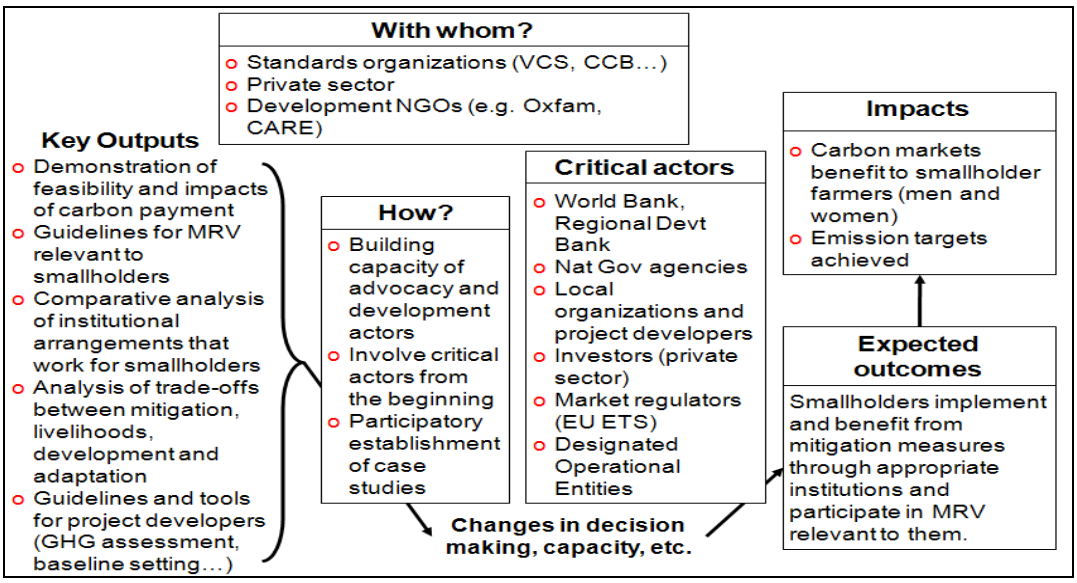
This Objective will work closely with project developers, the World Bank, regional development banks, local and project investors, farmers' organizations, and intermediaries such as the Nature Conservation Research Center (Ghana), BRAC (Bangladesh and Uganda) and Pradan (India), to develop and test innovative institutional arrangements and incentive mechanisms. Partners for research and policy impact will include international and national policy research organisations such as EcoAgriculture and Instituto de Pesquisa Ambiental da Amazônia (IPAM). Capacity enhancement will focus on development of understanding of carbon markets, and negotiation and advocacy skills for farmers' interests, including advocacy for women's interests. We will work with the private sector to identify consumer demand, standards for carbon labeling, and lifecycle analyses of food products. The intended users of this research include the World Bank Biocarbon Fund, the Voluntary Carbon Standard, the Climate, Community and Biodiversity Alliance and the Sustainable Food Lab. Some aspects of this work will be conducted through case studies where a range of partners will be engaged for different roles. For example, a case study from Kenya includes: Care International, Care Kenya, VI Agroforestry, AATF, EAFF, CAMCO (carbon financing consulting firm), Equity Bank.

Impact pathways for target environments

This Objective will increase carbon market opportunities for small-scale producers and reduce transaction costs by working with three sets of participants in the carbon value chain: 1) aggregator organizations (producer groups, farmers' organizations, natural resource management associations, etc.); 2) intermediary organizations; and 3) private sector players in the voluntary carbon market. Impacts will be enhanced by use of carbon market list serves and forums and regional policy forums, as well as regional farmer associations to reach broader research and practitioner audiences. Targeting specific groups, particularly women farmers and farmers in specific geographic localities, will enable more effective outcomes for poverty alleviation.

An example impact pathway for the global level is shown in Figure 12. Working with farmers' organizations, government agencies, intermediaries and the private sector to market the 'bundles of environment services' that are delivered by poor rural households will increase the reach of these products among the rural poor.

Figure 12. Impact pathway for influencing how carbon markets serve smallholder farmers. The key outputs listed would be derived largely from Theme 3, Objective 3, but also from other Objectives.



Theme 3 Objective 3: Test and identify desirable on-farm practices and their landscape-level implications

Rationale

This Objective investigates the potential for mitigation accruing from agricultural practices and tests the feasibility of using specific mitigation practices on farms and landscapes from the farmers' perspective. The IPCC's AR4 is ambivalent on the potential of agricultural sequestration, largely because different practices vary in outcome. For example, some studies show that reduced or no-till agriculture does not always result in soil carbon gains in locations that already have high soil carbon content, and that the net effects of reduced or no-till practices on N_2O are inconsistent, depending more on soil and climatic conditions. Furthermore, there may be either synergies or trade-offs for local livelihoods, landscape-level environmental sustainability, and wider-scale knock-on effects. Thus more research is needed to establish the actual impacts of what appeared to be technically desirable on-farm practices. Secondly, it is important to assess the full economic costs and benefits of agricultural mitigation. Many sustainable land management (SLM) practices are beneficial for both agricultural adaptation and mitigation. Furthermore, the mitigation value of agricultural practices may be less in terms of direct impacts on GHG emissions and much more in terms of indirect impacts at the landscape level, for example agricultural intensification that frees up land for forest conservation or grasslands. Thus, costs and benefits need to be assessed at the local, national, and global levels. Even where data exist, effort will be needed to link this data to mitigation actions through stakeholder involvement.

Standards for monitoring and accounting of GHGs in smallholder systems and across agriculture-forest landscapes in developing countries also need to be developed. These will need to be effective and efficient. Capacity building will be coordinated with forest-related efforts to develop integrated Agriculture, Forestry and Land Use Change (AFOLU) approaches.

Research questions

- What is the technical and economic feasibility of agriculturally based mitigation among smallholders in developing countries?
- What are the impacts of agriculturally based mitigation on smallholder poverty, food security and on greenhouse gas emissions?

- What is the GHG abatement potential (full net–net GHG accounting) of promising carbon sequestration and non-CO_2 GHG emissions reduction technologies and management practices?
- What technologies and management systems can deliver GHG sequestration and emissions reduction cost-effectively with maximum benefits to poverty alleviation, food security and environmental health at the landscape level?
- How do different technologies and management practices affect men and women, or the poor and larger farmers differently? (Output 3.3.4)
- What accounting methods would provide a robust and cost-effective standard for monitoring, reporting and verification of GHGs in rural landscapes?
- What kind of stakeholder involvement and communication is necessary to link emissions knowledge to mitigation actions? (Linked to Output 4.1.3)

Activities

- Test and identify the carbon sequestration and GHG abatement potential of a variety of natural resource management approaches in 9 benchmark sites
- . Target practices where CRP7 can contribute to possible win–win outcomes through new partnerships and novel analytical techniques. These practices may include livestock management, agroforestry, fertilizer management and reduced tillage, among others
- Measure GHG fluxes, working with partners in the Global Environment Change (GEC) community, and assess impacts on poverty alleviation, food security and environmental health at multiple scales
- Develop and test accounting methods that provide a robust and cost-effective standard for monitoring, reporting and verification of GHGs in rural landscapes and are appropriate for small holders and integrated farming systems (agricultural systems and agricultural-forest landscapes for terrestrial carbon). (Output 3.3.2 and associated milestones)
- Assess technical and institutional capacity for national-level measurement and monitoring
- Analyze issues in estimating and managing carbon stocks in rural landscapes through participatory, community-based monitoring
- Develop training material and online tutorials on estimating and managing carbon stock
- Develop project design and monitoring guidelines for smallholder agriculture in developing countries produced and contributing to global standards
- Organize workshop with standard-setting bodies (VCS, ACR, etc) to share proposed methods standards for smallholder agriculture in developing countries
- Use field results and simulation models to identify the technologies and management systems that best deliver bundles of benefits at the household and landscape levels for both men and women. Analytical approaches may include a range of technology assessment methods, including economic surplus analyses that simulate different market conditions, technology adoption processes, research spillovers, and trade policy scenarios within a global partial equilibrium model.
- Organize science workshop and synthesis report on impact of different approaches and potential for synergies to identify strategies for implementation
- Analyze findings from field trials on social differentiation impacts of mitigation options initiated in 9 CCAFS benchmark sites
- Organize workshop for national agencies to review mitigation options and their impact

- Work with field-based partners to develop user-friendly ways of communicating data that farmers and decision makers can use to change their land-use practices and create a global communication platform for exchange and synthesis of information about innovations in agricultural mitigation.

Outputs/milestones

This Objective will deliver an evaluation of potential direct and indirect economic and environmental costs and benefits from agricultural and rural landscape mitigation, and identification of technologies and management systems that can deliver agricultural mitigation and rural landscape options. A wide range of options will be tested, ranging from those that increase soil carbon to water management tools for reduction of GHG emissions from wetlands and tropical reservoirs. A PhD student network will be formed to support this work and facilitate capacity enhancement. In addition, this Objective has three methodological outputs: a) developing the data and methods to for GHG monitoring and accounting at farm and landscape level to contribute to the development of global GHG standards; b) validating simulation models that can be used to identify the mitigation potential of different options; and c) methods for assessing social impacts and trade-offs. Results will be shared through websites, policy briefs and scientific articles.

Partner roles

The CGIAR and FAO with local partners will establish a complementary set of agricultural mitigation sites in representative agroecosystems. Common methods will be employed to enable comparability. The research will integrate and add value to CG expertise in different agricultural sectors (e.g., livestock, rice, irrigation and water, aquaculture, fruit crops, staple cereals, agroforestry, forestry). The research will link local-level emissions data and land use change emissions to the Land Use Change research planned by the Global Carbon Project. On-farm testing, in collaboration with CRP1, will take place with local level partners connected to international entities that can scale-up impacts, such as EcoAgriculture and CARE. National planning and AFOLU agencies will be primary advisors and direct beneficiaries of the research, as will international development agencies.

Impact pathways for target environments

The expected impact is that agricultural development will occur in a sustainable fashion that addresses food needs, reduces poverty and results in climate change mitigation. Research results will be shared by involving research users in generating information about likely and alternative agricultural development options, as well as through annual workshops and the final workshop for policy makers. The final workshop will be targeted for wide participation and media coverage, materials will be available on the project website (and that of partners), and policy briefs and briefing notes will be designed to communicate ideas in the most efficient way. The longer technical reports, workshop proceedings and research reports will be targeted to appropriate journals, conferences and general meetings of agricultural scientists, agricultural mitigation fora, and policymakers, for maximum exposure.

Theme 4: Integration for Decision Making

Rationale

The goal of achieving sustainable food security is already under unprecedented pressure from population and income growth. Climate change will exacerbate the challenge, with the potential for highly heterogeneous impacts across space and time. At the same time, interactions between climate change and other drivers of change in agricultural systems (and development generally) remain largely unknown. While

broad trends may be discernible, more location-specific detail is required about the impacts of climate change (positive and negative) on food security and the preservation of ecosystem services needed for the long-term sustainability of global agriculture, effects on livelihoods, and options that increase the well-being of people dependent on natural resources.

The research undertaken in this Theme provides an analytical and diagnostic framework for the whole of CRP7 that is grounded in the policy environment, incorporates biophysical effects, quantifies uncertainty where possible, and ensures effective engagement of rural communities and institutional and policy stakeholders. It will address the need for methods, models, databases and system metrics aimed at two broad challenges: a) enhanced assessment of the likely impacts of climate change on agricultural systems, particularly in the context of other social and economic changes; and b) improved methodologies to assess the likely impacts of different policy and program interventions to foster adaptation and mitigation in terms of poverty alleviation, food security and environmental health. To address specific climate challenges with best-bet options, policy makers need quantified assessments of impacts and the consequences of policy changes. While much is known about some components, there are gaps and uncertainties in the knowledge, processes, model capacity and databases needed for these analyses. The work proposed here is designed to address these gaps, many of which can be filled uniquely by CGIAR researchers and the ESSP. The integrated framework will also form the basis for a monitoring and evaluation system to allow *ex post* impact assessment of research to be carried out in relation to a baseline set of key indicators at study sites.

This Theme also provides an integrative function for CRP7 stakeholder engagement from local to global levels, both in terms of setting research agendas and providing forums for discussing emerging results and options for action. In addition, Theme 4 will pull together the information at multiple scales that is needed to address the research questions of Themes 1 to 3 of CRP7. Climate and socio-economic outputs from global models will need to be downscaled to the local level to allow appropriate analysis of options to be carried out. At the same time, research results from study sites will need to be upscaled to broader, regional and cross-regional domains, so that research impacts can be appropriately magnified. The work in this Theme will be both demand and supply-driven; demand-driven through the needs identified by the place-based Themes and other CRPs, and supply driven by the early recognition of challenges that comes with sophisticated forward looking analyses that are supported by novel data collection and fusion.

Objectives

Theme 4 provides a critical integrative function for CRP7. In response to demand from policy makers in countries in the regions and at global level, it will generate standardized global datasets with location-specific elements through a multi-site data collection effort, collate and disseminate existing and new global datasets and undertake scenario research to provide plausible futures and guide the development of new technologies and policies in the other Themes of CRP7. It will also create mechanisms to integrate work conducted by Themes 1–3 at regional and global levels and act as a major conduit for two-way information flow between CGIAR institutions, the ESSP and other international research organizations. Finally, it will provide methods to involve stakeholders more in agenda setting for Themes 1–3 and communicate their individual and integrated outputs. Its research Objectives (Table 17) are to:

- Explore and jointly apply approaches and methods that enhance knowledge to action linkages with a wide range of partners at local, regional and global levels
- Assemble data and tools for analysis and planning;
- Refine frameworks for policy analysis.

Table 17. Objectives, Outcomes and Outputs for Theme 4 for Phase 1 (Year 1-5) (the full list of milestones is given in Annex 1). Outputs to be achieved by Year 5, Outcomes by Year 10.

Theme 4. Integration for Decision Making		
OBJECTIVES	**OUTCOMES**	**OUTPUTS**
Objective 4.1 Explore and jointly apply approaches and methods that enhance knowledge to action linkages with a wide range of partners at local, regional and global levels	Outcome 4.1 Appropriate adaptation and mitigation strategies mainstreamed into national policies in at least 20 countries, in the development plans of at least five economic areas (e.g. ECOWAS, EAC, South Asia) covering each of the target regions, and in the key global processes related to food security and climate change	Output 4.1.1 For each region, coherent and plausible futures scenarios to 2030 and looking out to 2050 that examine potential development outcomes under a changing climate and assumptions of differing pathways of economic development; developed for the first time in a participative manner with a diverse team of regional stakeholders
		Output 4.1.2 Global and regional maps, tables and associated syntheses, showing current vulnerable agricultural and fishing populations in relation to food security to 2030 and 2050
		Output 4.1.3 Evidence on, testing and communication of, successful strategies, approaches, policies, and investments contributing to improved science-informed CC-ag development-food security policies and decision making
		Output 4.1.4 Analyses providing evidence of the benefits of, strategies for, and enhanced regional capacity in, gender and pro-poor climate change research approaches that will increase the likelihood that CCAFS-related research will benefit women and other vulnerable as well as socially differentiated groups
		Output 4.1.5 Mainstreaming adaptation strategies into national policies, agricultural development plans, and key regional and global processes related to agriculture and rural development, food security and climate change
		Output 4.1.6 Building of capacities to engage in global policy making processes and adopt risk management strategies
Objective 4.2 Assemble data and tools for analysis and planning	Outcome 4.2 Improved frameworks, databases and methods for planning responses to climate change used by national agencies in at least 20 countries and by at least 10 key international and regional agencies	Output 4.2.1 Integrated assessment framework, toolkits and databases to assess climate change impacts on agricultural systems and their supporting natural resources
		Output 4.2.2. Socially-differentiated decision aids and information developed and communicated for different stakeholders
Objective 4.3 Refine frameworks for policy analysis	Outcome 4.3 New knowledge on how alternative policy and program options impact agriculture and food security under climate change incorporated into strategy development by national agencies in at least 20 countries and by at least 10 key international and regional agencies	Output 4.3.1 Tools developed and climate change impacts assessed at global and regional levels on agricultural systems (producers, consumers, natural resources), national/regional economies, and international transactions
		Output 4.3.2 Likely effects of specific adaptation and mitigation options, national policies (natural resource, trade, macroeconomic, international agreements) analyzed
		Output 4.3.3 Differential impact on social groups (gender, livelihood category etc) of climate change adaptation and mitigation options identified, evaluated and communicated
		Output 4.3.4 Likely effects of specific adaptation and mitigation options and national policies (including for socially differential groups) communicated to key local, national and regional agencies and stakeholders

Research approach to international public goods

The Theme will produce the following IPGs:

- An enhanced analytical framework, drawing upon research and products available at CG centers such as IFPRI and ILRI and from selected ESSP researchers, that provides a suite of tools and infrastructure that enable stakeholders to understand, diagnose and communicate vulnerability as well as target and assess the likely impacts of adaptation, mitigation and policy interventions on socially-differentiated groups. Particular focuses will be on the development of *ex ante* impact assessment tools at different levels, and on the development and use of decision aids and information for different groups of stakeholders. A "farm vulnerability" index will be devised to complement the UN's Human Development Index, so as to focus attention on the farming sector.
- Globally consistent, multi-site and publicly accessible data sets on climate change, current agricultural practices, performance characteristics of existing plant and animal germplasm and management practices, and related variables needed for assessing climate change impacts and opportunities for cost-effective adaptation and mitigation, including vulnerable populations and probabilistic projections of climate impacts under a set of different development scenarios.
- Evidence of feasibility, acceptability and impacts (related to food security, livelihoods and the environment) of comprehensive climate change adaptation strategies and mitigation opportunities locally and regionally.

New content and innovation

The work proposed in this Theme has several innovative features:

- It will provide a broad food-security perspective on vulnerability to climate change and other drivers; something that almost all global assessments and scenario development exercises conducted to date have not addressed fully (Wood et al., 2010). The food system perspective will also foster the transition within the CGIAR from a commodity focus to a more integrated approach.
- The work will mainstream a dynamic approach to vulnerability within the CGIAR through the use of scenario development at global and regional levels and modeling to project possible future vulnerability in relation to plausible storylines of changes in multiple drivers, including feedback loops from proposed interventions.
- It will contribute to an integrated, landscape approach to mitigation across agriculture and forestry
- The work will build a much stronger partnership between the CGIAR and the global change communities worldwide, providing them with common research goals.

Risks

The success of capacity enhancement and uptake of the research will depend on continued global political attention to the impacts of climate change on agriculture and food security. The research proposed in the Theme is highly integrative – across the other Themes of the CRP, across the CRPs as a whole, across disciplines and across research communities – and as such will require strong relationships, particularly in the formulation of mutually agreeable research agendas, as well as good access to data, tools and methods. Silos among the Themes are also a risk; mechanisms to avoid these are discussed under the risks section for Theme 1.

Regional balance

Several aspects of the research in the Theme are of a generic nature, and will draw on data and skills worldwide. One of the early outputs is to identify 'hotspots' of vulnerability beyond the initial three target

regions, where development, demonstration and evaluation of adaptation and mitigation pathways will be addressed in particular agro-ecological and socio-economic contexts. The baseline indicator data collection will occur in the target regions, and the scenarios work will also be focused in the target regions.

Linkages to other CRPs

This Theme contributes large-scale research on climate change vulnerability and the modeling of impacts, which will set the framework for work in all the other CRPs (Table 18). The Objective on linking knowledge with action provides platforms for other CRPs to interface with the ESSP and the wider climate change community. The focus of Theme 4 on vulnerability and downscaled assessments of the impacts of climate change will create and necessitate strong links with CRP1 (Integrated agricultural systems for the poor and vulnerable). Modelling and decision-support tools developed within this Theme will be tested and validated within CRP1, CRP3, CRP5 and CRP6. This Theme and CRP2 (Policies, institutions, and markets for enabling agricultural incomes for the poor) will share *ex ante* assessment of policies and programs (with this Theme particularly focused on such assessments in the context of climate change). The scenarios of intensification and disease futures for CRP4 will be informed by the climate and development scenarios evaluated in this Theme.

Table 18. Interaction of CRP7 Theme 4 with other CRPs (Priority activities are indicated in bold).

CRP7 Objective # and Title	CRP1 – Integrated Systems	CRP2 - Policies, Institutions and Markets	CRP3 – Sustainable Production	CRP4 – Nutrition and Health	CRP5 – Water, Land and Ecosystems	CRP6 – Forests and Trees
4.1 Linking Knowledge with Action	*In CRP7:* Vulnerability assessments for targeting; Mainstreaming CC strategies into key regional and global food security processes; **Access to key stakeholders in the climate community**	*In CRP7:* Identify institutional arrangements that benefit smallholders and women; **Access to key stakeholders in the climate community.** *In CRP2:* Identify innovative governance arrangements to strengthen property rights, assets, rural services *Collaboration:* Institutional, collective action and boundary spanning approaches to science into action	*In CRP7:* Developing plausible future food security scenarios under climate change; **Access to key stakeholders in the climate community; Regional scenarios teams working with policymakers.** *In MP3:* Development of plausible scenarios of crop production in target regions derived from biophysical and socio-economic settings *Collaboration:* Sharing of data and results relevant to future scenarios.	*In CRP7:* Enhanced regional capacity in gender and climate change research; **Access to key stakeholders in the climate community.** *In CRP4:* Mitigating impacts of intensification on human/ animal health *Collaboration:* Scenarios of intensification and disease futures	*In CRP7:* Developing plausible future food security scenarios under climate change; **Access to key stakeholders in the climate community.** *Collaboration:* Boundary spanning approaches that enhance uptake of improved NRM	*In CRP7*: Vulnerability assessments for targeting; Mainstreaming CC strategies into key regional and global food security processes

4.2 Assembling data and tools for analysis and planning	*In CRP7:* **Setting the climate change context.** Vulnerability analyses; **down-scaled climate change info;** tools for ex-ante analysis. *In CRP1:* Methods and tools for analysis / improvement of agricultural systems in target regions *Collaboration:* Data assembly, scoping studies on, and testing, tools and methods	*In CRP7:* **Setting the climate change context.** Develop tools for ex-ante impact assessment, at multiple levels *In CRP2:* Strengthen capacity in ex-ante impact assessment, priority setting, and targeting *Collaboration:* Sharing approaches and datasets	*In CRP7:* **Setting the climate change context.** Large scale research on climate change vulnerability and priority setting; **downscaled climate change info** *In CRP3:* Data on status and trends of crops etc.; crop simulation models and scenarios on crop technology development *Collaboration:* Developing tools and data sharing; Training on data and modelling approaches to crop, livestock and fish performance	*In CRP7:* **Setting the climate change context.** Quantification of sustainable development pathways *In CRP4:* Global assessment of agriculture-associated disease *Collaboration:* Evaluation of agriculture-associated disease under different development pathways	*In CRP7:* **Setting the climate change context. Downscaled climate change info.** Tools for ex-ante assessment of adaptation options. *In CRP5:* Development of soil/water/eco-system info systems *Collaboration:* Water basin hydrology and ag. water utilization modelling	*In CRP7*: **Down-scaled climate change info**. Tools for ex-ante assess-ment of adaptation options. In *CRP6:* Develop-ment of landscape models
4.3 Refining frameworks for policy analysis		*In CRP7:* Climate change as an additional challenge to designing pro-poor technologies. *In CRP2:* Research to assess most effective policy and program interventions. *Collaboration:* Better incorporation of climate change impacts on productivity into models.	*In CRP7:* Assessing the policy and program environment of potential crop and farming system innovations to climate change *In CRP3:* Development of new technologies *Collaboration:* Potential new crop, livestock and aquaculture fish characteristics and evaluation of policies to develop and disseminate		*In CRP7:* Assess policy reforms to enhance land/ Water mgmt under climate change *In CRP5:* Technologies and data on sustainable land/ water mgmt *Collaboration:* Policy options for improving soil mgmt under climate change; Co-design of water-access policies to address water stresses	

Theme 4 Objective 1: Linking knowledge with action

Rationale and research questions

Food security in the coming decades will be threatened by a number of factors whose future trends are uncertain. These uncertainties pose major challenges to research, to policy formulation and to resource management related to food security. Agricultural production and resource management under climate change demand new ways of thinking about risk, about vulnerability and about resilience. It requires us to question what is needed in terms of policies, institutions and governance to support these changes, rather

than to maintain the status quo. A powerful approach to help decision makers start addressing these transformational challenges is to run **participatory scenarios exercises**. These help to enhance decision making under uncertainty through the development of a structured range of plausible futures within which analyses of policy and technical interventions can be undertaken. They also provide an effective mechanism for involving a range of both public and private sector stakeholders and for facilitating debate and communication among them. The whole process of stakeholder engagement and debate about plausible futures will contribute to CRP7's foresight analysis and feed into priority setting (see "Foresight, priority setting and impact assessment"). This Objective will be conducted at local, regional and global levels. At the regional level, qualitative scenarios or 'storylines' will be developed by regional teams trained in this approach, that was developed and before now used only at the global level. These teams will then be given access to e initial quantitative global scenarios developed by CG researchers and others to enrich them further through empowering the regional storyline teams, and linking them to ongoing global scenarios model results and processes in an iterative process, by Year 3 the result will be more relevant qualitative scenarios where internal plausibility is maintained with quantitative modeling, and the global modeling will, for the first time, more appropriately deal with strategic regional food security, agricultural development and climate-related issues as defined by key regional players.

Tools for linking knowledge with action are increasingly tested and applied by interdisciplinary, multi-organizational research-for-development teams (Kristjanson et al., 2009). Examples include participative mapping of impact pathways (Douthwaite et al., 2007, Reid et al., 2009), negotiation tools informed by research (van Noordwijk et al., 2001), social network analysis, innovation histories, cross-country analyses and game-theory modeling (Spielman et al., 2009). But there is much yet to discover about means to improve the links between knowledge and action, and, critically for climate change approaches, about the interactive linkages between science and policy. We know that strategic and participatory engagement, communication and capacity building efforts, particularly those aimed at 'spanning boundaries' between the diverse actors and institutions key to farming household risk management, adaptation and mitigation measures, are critical (Clark et al., 2010). Efforts aimed at increasing the knowledge and capacities of farmers' organizations to innovate, along with strengthening of networks and alliances to support, document and share lessons on farmer-led innovation are also needed. Research as to the effectiveness of different ways of communicating uncertainty around climate predictions to different audiences, and testing of new (e.g. cell phone-based) communication methods for communicating improved weather information to smallholders, will help ensure CRP7 science translates into action. Other needs include innovative engagement and communication strategies to ensure that scientific results inform international policy processes (e.g. UNFCCC), regional (e.g. adaptation funds) and national processes (e.g. NAPAs and NAMAs) – these different audiences will likely require different strategies to elicit effective responses.

This Objective will provide an integrating forum for the intersection of all the work in CRP7, from regional research priority setting to bringing key outputs from CRP7 into the stakeholder processes. The means of engagement, and not just the development of tools, will be key to nurturing an on-going and evolving dialogue with a range of stakeholders. Interfacing closely with policy processes and identifying policy 'windows of opportunity' at global and regional levels and in the countries selected for detailed work will be key impact strategies. In so doing this Objective will work closely with Objective 3.

Research questions include:

- What are the plausible futures encompassing interactions between changes in climate and other key drivers of agricultural systems and food security?
- What are the key factors causing vulnerability to climate change and climate variability among agricultural and food systems and the people who depend on them, and how may this vulnerability change in the future?
- What boundary-spanning objects and actions (e.g. partnership-building and policy engagement processes, communications and capacity-building approaches) can improve the likelihood that CCAFS-generated knowledge will result in actions that contribute to sustainable poverty reduction?

- What are the main options to deal with climate change impacts, where are the key policy opportunities, and who are the key decision makers?

Activities

A major activity under this Objective will be the development of a structured range of plausible futures within which analyses of policy and technical interventions can be undertaken. Similar work will be conducted at more local levels (e.g. within the benchmark sites or at national levels as part of national processes). Here the emphasis will be on understanding the key issues faced by farmers in relation to climate change and understanding what options are feasible in specific national contexts. Capacity enhancement and empowerment of local and regional scenarios teams is key, as CRP7 will facilitate their engagement in key global processes (e.g. those driven by the UNFCCC, IPCC and G8).

Another activity will be to carry out multi-scale vulnerability assessments, building on what has already been done and identifying who is vulnerable and why, what are existing practices, and how vulnerability and food security may change in the future in relation to multiple stressors, including climate change. These will be valuable for improved targeting of research for all the CRP's, and considerable efforts will go into widely communicating these vulnerability maps and analyses and engaging with policymakers at different levels (local, regional, national and international) so that they are both useful to, and used in, national and regional agricultural development strategies (e.g. EAC, ECOWAS, COMESA, CAADP).

Outputs/milestones

- A plausible set of scenarios to 2030 and 2050 for each target region and globally, which examines potential development under a changing climate and differing pathways of economic development;
- Enhanced regional capacity to engage with key policy makers and use CCAFS research outputs to inform national adaptation and mitigation plans, regional agricultural development and food security strategies, as well as to engage with, and inform, global climate and food security processes as to critical regional interests/concerns. Regional capacity enhanced and gender-responsive research on regionally-identified climate adaptation and mitigation priorities undertaken in 3 regions.
- Maps, reports and policy briefs about vulnerability that can be used to inform the targeting of research activities in the other Themes of CRP7 and in other CRPs;
- Major events at global level linked to products that are targeted to ongoing international processes (Agriculture and Rural Development Day at COP16 and COP17; targeted side events to help develop the UNFCCC workplan for agriculture).

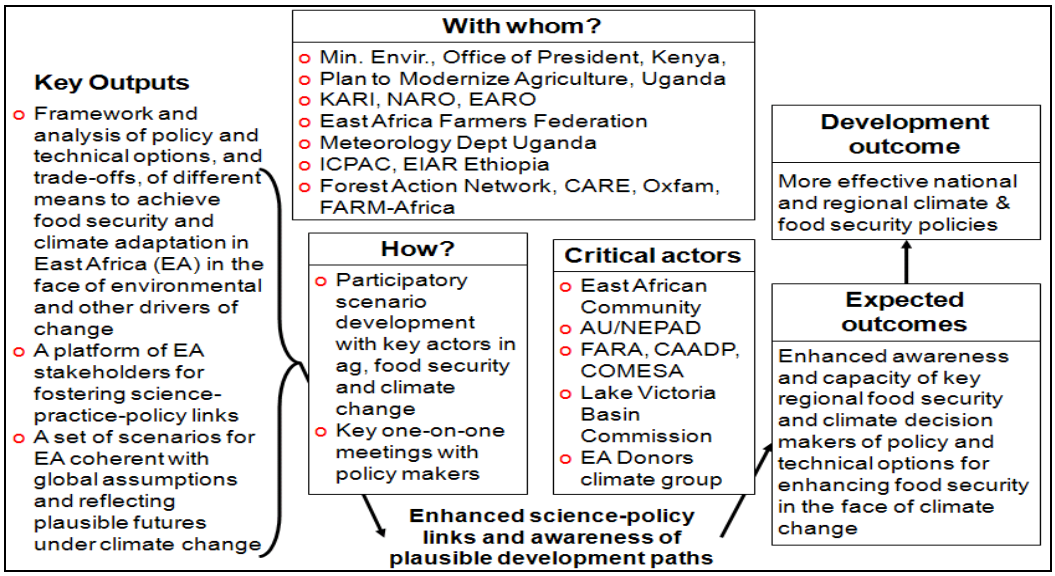
Partner roles

The scenario and vulnerability mapping activities will be conducted working closely with the ESSP and numerous regional and national stakeholders in each of the target regions. These will form an important aspect of communications and capacity enhancement and will help build regional science–policy teams who can take CRP7 outputs forward. At the global level, key partners initially are the Canadian International Development Agency (CIDA), IDRC, the UK's Department for International Development (DFID), the European Union (EU), FAO, IFAD, the Global Forum on Agricultural Research (GFAR), the Global Donor Platform for Rural Development, the International Federation of Agricultural Producers (IFAP) and the World Bank.

Impact pathways for target environments

By creating accessible yet scientifically robust storylines, the scenarios will create a platform for CRP7 to engage with policy-makers, development agencies and business strategists in the regions (Figure 13). The scenarios will form the basis for vulnerability and trade-off analyses throughout CRP7 and will guide the targeting and development of appropriate adaptation and mitigation strategies in the target regions. As such it will use the tools developed under Objective 2, including the *ex ante* assessment tools. The work on vulnerability will be conducted with the key actors that drive adaptation investments, so that the approach achieves widespread acceptance among such actors. The results will be displayed using innovative communication tools linked to Google Maps. It is expected that the results will help drive future investments in terms of their focusing on climate change "hotspots".

Figure 13. Impact pathway for enhancing awareness and capacity about regional options for agriculture under climate change, through participatory scenario development: An example for the East Africa region. The key outputs listed would be derived largely from Theme 4, Objective 1, but would rely on Outputs from all other Objectives



Theme 4 Objective 2: Assembling data and tools for analysis and planning

Rationale and research questions

No comprehensive framework currently exists to analyze the implications, both positive and negative, of human responses to the climate challenge in terms of regional food security and the preservation of important ecosystem services, upon which the long-term sustainability of global agriculture must be based. There are key gaps and uncertainties in knowledge concerning some processes, in model capacity, and in appropriate high-resolution databases. Just two examples of many are the large uncertainties that surround CO_2 effects on crop growth in developing countries, and the impacts of a changing climate on rangelands and livestock productivity. The work under this Objective will address some of these gaps and will be focused particularly on data and tools for genuinely integrative ex ante assessment, thereby combining adaptation and mitigation agendas, and exploring synergies and trade-offs among outcome targets. These assessments will be done at different scales. For example, the IMPACT model, initially developed at IFPRI and now being enhanced with work at several other centers, will be applied at the global and regional levels to assess the impacts of different human interventions to address the climate change challenge. Different sets of tools will be developed and applied to evaluate impacts at household and landscape levels, to assess viability and performance of different adaptation and mitigation options, which can subsequently be tested in farmers' fields. Key research questions for this sub-theme are as follows: what are the critical knowledge and data gaps and how can these gaps be filled effectively? Should

existing models such as IMPACT be further expanded, and if so, how? Does a complementary approach to developing different tools make most effective use of scarce resources?

Activities

A first step is to collect information on the existing situation in the CGIAR, ESSP and elsewhere about datasets, tools, methods and infrastructure that can be used for vulnerability assessment. A series of scoping studies will identify critical gaps. Some of these can already be anticipated; for example, downscaling climate model outputs to temporal and spatial scales that are appropriate for biophysical and socio-economic modeling, making improvements in crop modeling and coordinating site-specific data collection approaches using standard data protocols and reporting mechanisms.

Another important initial step will be to critically review what knowledge the ESSP community has to offer the agricultural research for development and food security community and vice versa. For example, the Global Carbon Project, Global Environmental Change and Food Systems project, agroBIODIVERSITY project and Global Land Project each have very obvious areas of mutual interest, and the Earth System Governance Project and the International Human Dimensions Programme are areas where information exchange and joint future project development (e.g. in regions where ESSP has not been active) could very significantly inform and add value to CRP7.

One group of activities will be focused on climate science, including the identification of climate trends and variability in the target regions, and assessment of methods for downscaling climate change information for agriculture and natural resources management. There are also crucial information gaps concerning near-term climate prediction, for which there is great user demand for information.

Another group of activities relates to database development and collation. An early activity in CRP7 at the regional sites will be site characterization and baseline data collation, building as far as possible on existing sites, databases and information. These baselines will also form the basis for *ex-post* evaluation of research activities in later years.

A third group of activities relates to making improvements to biophysical and socio-economic models and the interactions among them. CRP7 will work on enhancing the geographic precision of agricultural impact models for more targeted analysis, so that policymakers, researchers and farmers can make decisions with a greater understanding of the interactions between local conditions, national policies and programs, and international developments, in the face of multiple drivers of change. Work during the first year will involve several scoping studies on agricultural impact model gaps and needs, bringing together the key global players to decide on how these gaps and needs can be addressed most effectively. Integration of models and databases to generate the information needed will be achieved not through tight coupling but through loose aggregation. In this way, different tools and models with different strengths and sensitivities can be used in parallel to address the major questions and ensure that the impacts of multiple stressors (of which climate change is but one) on livelihood systems and natural resources can be appropriately taken into account.

Outputs/milestones

This work will result in a framework and set of modeling tools and databases to analyze the implications, both positive and negative, of human responses to the climate challenge in terms of regional food security and the preservation of important ecosystem services, upon which the long-term sustainability of global agriculture must be based. Products will include cutting-edge and innovative climate model outputs that can be utilized in the other Themes and by others, decision aids and information packs that can be used to help build capacity of key users and socially-differentiated groups, considerably enhanced agricultural impact and global economic models, downscaled models that allow much higher resolution predictions of climate and agricultural impacts within regions, and new high-quality databases that are accessible to inputs and utilization by national agencies. The *ex ante* impact assessment tools produced in this Objective will help in priority setting in future years, as well as being available to other agencies needing *ex ante* assessments.

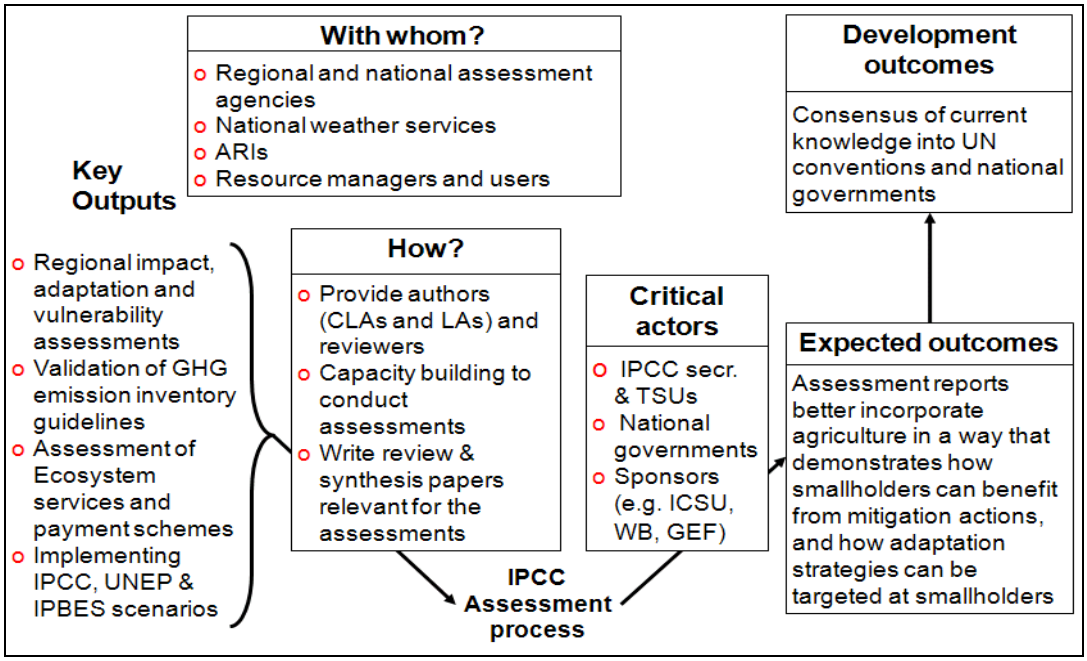
Partner roles

These activities will be conducted through an extensive array of partners. The international climate science community will be engaged to bring cutting-edge climate science to CRP7. The ESSP, the CGIAR (through the Consortium for Spatial Information (CSI), the IMPACT modeling environment of IFPRI and other initiatives), and regional and national stakeholders in each of the target regions, will contribute to database collation, building on the considerable amount of information that already exists. Work will build on earlier International Geosphere-Biosphere Programme (IGBP) (Ingram, 1996) and other climate change crop modeling efforts and directly involve the international agricultural impacts modeling community through ARIs (e.g. IIASA, the Netherlands Environmental Assessment Agency) and key players such as the International Consortium for Agricultural Systems Applications (ICASA) and the recently launched Agricultural Model Intercomparison and Improvement Project (AgMIP). NARES researchers will be partners in improved model development and will also be supported for capacity development as needed.

Impact pathways for target environments

The key intended users of the tools and datasets will be the numerous agencies involved in planning for and researching climate change impacts on agriculture, food security and natural resource management, NGOs and the private sector. The program will target these users by engaging the dozen or so key agencies that drive the agenda on climate change information provision and by making available the tools and datasets in appropriate formats. Arming the next generation of agricultural researchers and the public with state-of-the-art agronomic, environmental and policy-related information sets will result in important spin-off benefits in areas of the world where these may be the only practicable sources of quantitative information that can be used to help make decisions. This Objective will target the IPCC, among others (Figure 14).

Figure 14. Impact pathway for bringing CRP7 data and analysis into the IPCC process. The key outputs listed would be derived from Theme 4 and Theme 3 activities.



Theme 4 Objective 3: Refining frameworks for policy analysis

Rationale and research questions

There is a wide range of policy and program options for dealing with climate change effects; however there has been little analysis of the trade-offs and synergies possible among the environmental, livelihood and food security aspects. Furthermore, a wide range of technology and policy options relating to risk management, adaptation and mitigation are being pursued or considered in different regions. Systematic analyses of these interactions and strategic engagement with partners along with investments in communication efforts to share the results will lead to better policy and program choices.

Research questions include:

- What are the consequences of international, national and local policy and program options for improving environmental benefits, enhancing livelihoods and boosting food security in the face of a changing climate?
- Given the plausible futures in specific regions, what are the promising policy and program options to support adaptation and mitigation?
- Who are the key policy-makers in the climate-agriculture-food system nexus, what kinds of information do they require and use (or not) to make decisions, and how would they like to have this information communicated to them?

Activities

The principal set of activities in this Objective is to carry out *ex-ante* assessment of a wide range of technology and policy options related to risk management, adaptation and mitigation, and to evaluate the trade-offs and synergies among the environmental, livelihood and food security aspects. These analyses, carried out over a range of time and spatial scales, will include quantification of the uncertainties associated with the methods used, and will reflect the information needs of different stakeholders. Of equal importance is providing the tools to do this type of assessment to a wide range of stakeholders.

Working with coherent sets of scenarios that describe global and regional development pathways and estimates of vulnerability impacts into the future (Objective 1) and the quantitative modeling tools developed in Objective 2, one key activity to address this Objective is integrated assessment modeling at different scales, using a suite of tools and datasets to permit more precise understanding of the consequences of technology, policy and program choices made by national governments and international institutions, with a focus on the potential for CGIAR research. They will be based upon unprecedented integration between biophysical and socioeconomic modeling of global agriculture and natural resource systems. Research will deepen our understanding of the complex linkages between socioeconomic and environmental change and the functioning of agricultural systems and human well-being.

The product will be a comprehensive modeling environment integrating socioeconomic, biophysical and technological responses to global, regional and local consequences of policy choices, from agricultural technology investments to property rights, trade and macroeconomic policies. It will provide an improved platform to assist international agricultural research centers, development agencies and national governments in strategic planning and in making investment decisions as they confront the coming challenges of climate change. Both analytic and communication effort will be put in to make sure that the quantitative models are accessible, transparent and readily usable by policy communities.

Early on in CRP7 implementation, integrated assessment will be focused on *ex-ante* analysis to help set in place systems for monitoring and evaluating CRP7 research activities. In later years, the framework and data collected will be used for *ex-post* assessment of the research outputs and outcomes, in relation to a baseline set of key indicators measured at the start of the work in the target regions and case-study sites.

Another set of activities to address this Objective is analysis of policy-maker information needs and the most effective ways to foster two-way communication and ensure that final CRP7 outputs are appropriate

and useful. There is considerable need to enhance the two-way flow of information between end-users and scientists. To start this process, workshops with policy makers in government and other sectors will be held early on in target regions, applying 'Linking Knowledge with Action' tools that will help to build effective information networks and to set the agenda for CRP7 work in the regions, bringing together policy and science priorities. These will build on the regional teams involved in the scenarios activities, and outputs from scenario analyses and integrated assessment will be fed into stakeholder dialogues via these networks in subsequent years.

Outputs/milestones

The activities undertaken as part of this Objective will result in global and regional assessments of climate change impacts on agricultural systems and food security, and ultimately will result in a set of detailed information products on promising adaptation and mitigation policy options, including assessments of the potential returns to investments in various breeding and management activities, and extension activities. It will also highlight the needed complementary investments such as rural roads, irrigation systems and market infrastructure.

Partner roles

These activities will be conducted with an extensive array of partners, including the CGIAR, the international ESSP research community and regional bodies and climate change-related programs and networks (e.g. ASARECA, WECARD, CORAF, Clim-Dev, AfricaAdapt) and national stakeholders (NARES, NGOs, farmer organizations, etc.) and the private sector in each of the target regions.

Impact pathways for target environments

This work will provide information on alternative strategies and scenarios that can be used by agencies to implement adaptation and mitigation strategies. It will engage key actors to ensure that climate variability and climate change issues are mainstreamed appropriately into national, regional and international agricultural development strategies and institutional agendas. Policy outputs will be delivered through coalitions of policy partners and decision makers, researchers, regional information networks, pro-poor civil society organizations and development agencies that have been engaged through efficient private-public partnership processes. Outputs will inform the ongoing negotiations of the UNFCCC and the assessment processes of the IPCC by conducting comprehensive integrated assessments that quantify vulnerability reduction, food security enhancement and environmental health in target regions.

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