

## **Pre-proposal for a Challenge Programme on “Climate change, agriculture and food security”**

*Partners in this pre-proposal (in alphabetical order):*

- Africa Rice Centre
- African Centre of Meteorological Application for Development, Niger
- Bangladesh Agricultural University, Bangladesh
- Bioversity International
- Caribbean Institute for Meteorology and Hydrology, Barbados
- Central Research Institute for Dryland Agriculture, India
- Centre Régional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (Agrhymet), Mali
- Centro Internacional de Investigacion del Fenomeno del Niño, Ecuador
- CIAT
- CIFOR
- CIMMYT
- CIP
- Consortium of French institutions: CIRAD, IRD, INRA, CEMAGREF
- CSIRO Sustainable Ecosystems, Australia
- Columbia University, International Research Institute for Climate and Society, USA
- DIVERSITAS
- El Colegio de la Frontera Sur, Mexico
- EMBRAPA, Brazil
- European Centre for Medium-Range Weather Forecasts
- Food and Agriculture Organisation of the United Nations (FAO), Department of Natural Resources Management and Environment
- Food, Agriculture and Natural Resources Policy Analysis Network, South Africa
- Global Change Impact Studies Centre, Pakistan
- ICARDA
- ICRISAT
- IFPRI
- IITA
- ILRI
- International Council for Science
- International Council for Science - Regional Office for Africa
- International Geosphere-Biosphere Programme
- International Human Dimensions Programme on Global Environmental Change
- IRRI

- IWMI
- Leibniz Centre for Agricultural Landscape Research (ZALF), Institute for Landscape Systems Analysis, Germany
- Max-Planck-Institute/Jena, Germany
- Monsoon Asia Integrated Regional Study Office, China
- National Agricultural Research Organisation, Uganda
- National Centre for Agricultural Economics and Policy, India
- Nepal Water Conservation Foundation, Nepal
- Natural Environment Research Council/QUEST, UK
- Potsdam Institute for Climate Impact Research, Germany
- Research Centre Karlsruhe, Institute for Meteorology and Climate Research, Germany
- Southern African Development Community, Food, Agriculture and Natural Resources Directorate
- University Corporation for Atmospheric Research/National Centre for Atmospheric Research, USA
- University of Aberdeen, Department of Geography and Environment, UK
- University of Botswana, Department of Environmental Science, Botswana
- University of Bristol, Department of Earth Sciences, UK
- University of California/Davis, Department of Land, Air and Water Resources, USA
- University of California/Santa Barbara, Department of Geography, USA
- University of Cape Town, Climate Systems Analysis Group, South Africa
- University of Copenhagen, Department of Geography and Geology, Denmark
- University of East Anglia, Tyndall Centre for Climate Change Research, UK
- University of Florida, Department of Agricultural and Biological Engineering, USA
- University of Montana, Department of Ecosystem Sciences, USA
- University of New Hampshire, Institute for the Study of Earth, Oceans and Space, USA
- University of Oslo, Department of Sociology and Human Geography, Norway
- University of Oxford, Environmental Change Institute, UK
- University of Oxford, Oxford University Centre for the Environment, UK
- University of Reading, Department of Agriculture, UK
- University of Reading, Department of Meteorology, UK
- University of the West Indies, Department of Agricultural Economics and Extension, Trinidad & Tobago
- Wageningen University and Research Centre, Crop and Weed Ecology Group, NL
- Wageningen University and Research Centre, Department of Environmental Sciences, Netherlands
- World Agroforestry Centre
- World Climate Research Programme
- WorldFish

## **Summary**

Climate change is a major threat to rural livelihoods and to food security in the developing world—i.e., to society. While the poor in general are the most vulnerable to climate change, the vulnerability of people and their agricultural systems is very complex due to interacting direct and indirect climate-related stresses. Year to year variability in climate already contributes to rural poverty where exposure is high and adaptive capacity is low. Climate change is already being felt in terms of gradual increases in temperature, increased variability in annual rainfall regimes and a greater prevalence of extreme events such as drought and floods. Rural communities must adapt to these changes if any development progress is to continue and if further impoverishment is to be avoided.

Fundamental changes in agricultural systems are needed for rural communities in less developed countries to adequately adapt to climate change. Climate change poses new and serious challenges for farmers and other resource users, for policy makers and those who invest in rural and agricultural development and poverty alleviation—and for science.

The changes in agricultural systems and their management that are needed to enable the rural poor, resource managers and policy-makers to adapt to these stresses and challenges will not come about in sufficient time unless the best of science based solutions are developed and the best of delivery mechanisms are put in place. The international agricultural research community (CGIAR and partners in the South and in the North) together with the worldwide global environmental change research community possess the combined strengths and capabilities required to meet such needs. The CGIAR Centres and their partners in agricultural research have experience in agricultural and social sciences in less developed areas; and have long worked in partnership with countries and national and regional institutions to define and operationalise research and results into impacts at the ground level. The global environmental change community and its partners bring to bear the latest and best of scientific understanding and methods regarding climate change, biodiversity, Earth system functioning and associated institutional and other socioeconomic issues.

## **Goal**

To provide science-based solutions which accelerate successful adaptation of agricultural systems to climate change for the rural poor and most vulnerable farmers in developing countries. These solutions (e.g., practices, technologies, policies) will enhance the capacity of farmers, other natural resource users and policymakers to better manage land, the environment and food security.

## **Overall Objectives**

1. To identify and prioritise areas and populations most at risk in the face of climate change.
2. To develop and implement agricultural adaptation and mitigation strategies in the face of climate change as an integral part of agricultural development, food security policy and donor investment strategies.
3. To improve our understanding of how agricultural adaptation and mitigation options at operational and policy levels affect ecosystems and the Earth system in order to address

both opportunities and trade-offs among poverty alleviation, food security and the maintenance and enhancement of global environmental goods.

4. To critically assess emerging science regarding climate, agriculture and policy—while considering the sometimes conflicting needs of all stakeholders—and to build the capacity of key stakeholders (farmers, policy-makers, scientists) to adjust their actions and agendas to address the challenges of climate change.

### **What are the major issues for agriculture, rural livelihoods and food security in the context of climate change?**

Agriculture is sensitive to changes in climatic conditions, with outcomes affecting food security, livelihoods and economic prosperity. Climate change is a threat that, in the shorter-term, will significantly affect the rural poor who are the most vulnerable given their limited resources and high exposure to risk. The poor in the tropics are of particular concern because some impacts of climate change—e.g., water availability, droughts, floods—are expected to be highly negative in the tropics and sub-tropics. Improved knowledge of such vulnerability is needed in order to design appropriate response and mitigation strategies. Although the international community has invested substantially in both climate-change impact studies and adaptation programs, less-developed countries have not yet been able to successfully incorporate adaptation into their development strategies.

Lacking are effective strategies to manage climate risk locally and on relatively immediate time scales. Strategies need to be devised from a holistic and integrated perspective so as to not further compromise the capacity of the Earth system to support approximately two billion more humans by mid-century. For example, poorly targeted and planned large irrigation schemes intended to respond to decreased rainfall in a given area could disrupt regional hydrological and biogeochemical cycles, leading to negative local and global repercussions. Also lacking are effective strategies to manage longer-term climate change, and which is driving much of the important and ongoing major policy developments worldwide (e.g., UNFCCC, G8-Glencree follow-up, international and national policy formulation on climate change and carbon trading schemes, GEF investments).

Climate change is occurring amidst global economic, demographic and social change, resulting at times in unexpectedly uneven outcomes on rural livelihoods. Minor changes in climate and climate variability may push some areas and households to food insecurity. People are and will be facing new threats beyond their experience or capacity to cope. In addition to local effects, agricultural losses in developing countries will translate into macro-economic impacts that will exacerbate problems of food access for the urban poor. Negative effects of climate change could push up food prices, seriously affecting all poor consumers. Even gradual negative changes in today's most intensive agricultural production areas in the developing world—such as the Indo-Gangetic Plains, the Brazilian savannahs and the Yellow River Basin—will play a pivotal role in both regional and global food security. Climate-induced problems will also be exacerbated by changes in consumption patterns (e.g., rising meat consumption and “supermarketization”), urbanisation and land use conversion. Against this background, several key needs related to climate risk management for agriculture can be identified:

- The need to enhance the resilience of vulnerable farming systems and livelihoods in the face of climate change.
- The need to protect livelihoods from adverse climatic extreme events through effective safety nets and pro-active coping responses.

- The need to continually adapt technology (e.g., agrobiodiversity, water use) and policy (e.g., land use planning, insurance schemes) to a changing environmental baseline.
- The need to anticipate and to positively exploit where favourable changes will take place.

The situation is urgent: Some 800 million people are currently food insecure; and two billion live in poverty. The poorest are the most vulnerable to negative events and trends, such that these figures are likely to worsen with climate change. Projections indicate significant impacts over the next 50 years. Local to regional changes in agriculture have global economic, environmental and social impacts. Without due caution, current and future policies in agriculture, natural resources and environment and international trade can contribute to the negative effects of climate change on the poor. Unfortunately, our understanding of the interactions among such factors is insufficient.

### **What major challenges does a new collaborative research programme need to address?**

The Millennium Ecosystem Assessment (2005) established that agricultural intensification has met the rising demand for food in most parts of the world, but that significant trade-offs have been associated with these increases. In particular, water and nutrient cycling, biodiversity and carbon stocks have been negatively affected; while emissions of greenhouse gases and habitat fragmentation have increased. In turn, environmental degradation exacerbates some of the drivers of climate change and further undermines the sustainability of agriculture.

The IPCC Climate Change Assessment (2007) stresses that most of the research on agriculture and climate change has focused on the impacts of climate change on crop production in different regions. The linkages between these analyses and the broader issues of sustainable development and food security in countries suffering from extreme poverty and malnutrition are, however, not sufficiently understood.

Despite the large body of work on which these assessments have drawn, and on which this CP will continue to build, several major challenges remain:

*Food insecurity and poverty is already a major issue in many parts of the developing world. For some regions there may be potential gains from climate change which should not be missed. But for most, the added complications that climate change will bring require renewed effort and new perspectives on agricultural development and poverty alleviation.*

*Agricultural adaptation and mitigation pathways need to be developed that are pro-poor and which minimise deleterious feedbacks to the Earth system. Key will be understanding the trade-offs involved in attempting to address poverty while protecting global environmental goods and taking advantage of opportunities posed by areas that stand to be positively affected by climate change.*

*Climate variability and climate change impacts and options for mitigation and adaptation are embedded in a highly dynamic policy environment. Climate change adaptation and mitigation strategies require supporting policy and institutional interventions at many different scales, ranging from crop and on-farm management to the community, national, regional, and global levels. Policy and institutional analysis must be part and parcel of support, reversing adverse and reinforcing positive impacts from climate change and climate mitigation and adaptation strategies. Specific analyses on policy and institutional aspects are therefore needed as an integral part of the impact and response research.*

*Agriculture needs to be conceived as an integral part of a complex whole system.* Needed is an understanding of the interactions and feedbacks of biophysical processes that determine food system viability and management practices that enhance the resilience of these systems to future shocks and stress. More than simple collaboration among the natural and social sciences will be needed--the complexity of the interactions to be addressed suggests a trans-disciplinary integration at the interfaces among disciplines.

*Mitigating further climate change must be based (in part) on improved natural resource management set within a stronger agricultural policy framework for climate change.*

Management options would be underpinned by improved understanding of the impact of the current agricultural policy framework on climate change; and by developing institutions and mechanisms to support sustainable, pro-poor response options to reduce climate change and adverse impacts of climate change. Such an approach will not only enhance or sustain agricultural production, but will also allow for opportunities such as participation in global markets for environmental services. While biofuel production offers novel opportunities for poverty alleviation and carbon offsets, the socioeconomic and environmental consequences of potentially large-scale implementation need careful analysis.

*Climate change has the potential to forestall or reverse the gains of the Green Revolution in some regions.* There is a risk that current gains will be reduced (e.g., due to reduced water availability for irrigation-dependent systems). New solutions will be required to increase resilience in high-potential regions, and to reduce vulnerability elsewhere where the green revolution has not had a significant impact (e.g., sub-Saharan Africa).

*Different solutions will be required across social, spatial and temporal scales.* Solutions will need to be responsive to low to high income, subsistence to commercial, domestic- to export-oriented, and illiterate to informed social groups. Although there may be common trends across agricultural systems, innovations need to be appropriate to the demands and opportunities of producers and consumers acting at regional rather than global levels.

In simplified terms, there are three levels of market integration—i.e., subsistence to local markets, regional to national markets, and international markets—each requiring different approaches:

A key aspect of this CP at the local level will be strengthening the capacities of marginal households to benefit from adaptation options, linked mostly to different crops and crop mixes, associated crop and resource management practices, land tenure rights, access to local markets and local institutions. Cultural values and gender issues probably play a greater role than at the other levels. Time scales are rather short.

At the regional to national market levels, national policies play a more prominent role; and the role of governance and institutions needs greater emphasis. Some forms of planned (versus autonomous) adaptation and small-scale mitigation could have an influence at reducing climate change impacts and adding income (e.g., reforestation projects). Time scales are short to long.

At the international scale, national and international policies (e.g., UNFCCC, WTO) need to be addressed. Mitigation is an important issue (e.g., the potential for biofuels, carbon trading and avoiding deforestation) as well as issues addressing international funding mechanisms for adaptation. Time scales are medium to long.

How therefore do we confront these challenges? We already know that:

1. Innovations such as plant breeding for drought tolerance and heat stress, pasture and livestock management, soil and water management, or forest management will be necessary but will not be sufficient on their own.
2. Integrated options, based on the use of appropriate combinations of different crops and management practices approached at a range of spatial levels are needed, accompanied by necessary policy and institutional support. Maintaining or enhancing diversity will be needed to engender flexibility in adaptation not only in technology and crops, but also in modes and scales of production.
3. Methods are needed to help policymakers and resource managers evaluate the tradeoffs between local benefits and global goods when addressing food, energy and water scarcity (among others).
4. Greater adaptive capacity has to be fostered, allowing communities to draw upon a range of options to support their livelihoods. This, in turns, implies a greater adaptive capacity on the part of policy-makers, decision-makers and scientists. Needed is an enabling institutional and policy environment. Improved links among research, the policy environment and the broader community in developing countries are required.

Facing these challenges requires trans-disciplinary partnerships among global, regional and local institutions working across scales and levels. Building on the considerable experience that already exists in the field of climate variability research and climate risk management, an innovative collaborative program of research is needed to help stakeholders to adapt to climate change and contribute to – and benefit from – mitigation opportunities. In the absence of such a large collaborative undertaking on the part of the agricultural research community and the global change community, including their partners, as proposed in this CP, food insecurity in the tropics and sub-tropics will increase, further delaying fulfilment of the Millennium Development Goal 1 (Eradicate extreme poverty and hunger). This CP will thus help towards meeting MDG1; and will substantially contribute towards MDG7 (Ensure environmental sustainability) and MDG8 (Develop a global partnership for development).

### **What are the main research areas?**

The CP will address four main issues related to the objectives above:

1. Targeting and priority-setting through identification and characterization of peoples, areas, agricultural systems and rural livelihoods that are most vulnerable to climate change.
2. Development and testing of technical, institutional and policy innovations needed to facilitate adaptation of the poor and vulnerable to climate change.
3. Assessment of impacts stemming from the interactions among potential adaptation and mitigation options, development and poverty reduction, and global environmental goods and feedback of the results into the development of innovations.
4. Design and testing of ways to more effectively engage and support stakeholders (from farmers to policy-makers to scientists) in the research and development process and in the strengthening of their capacities to change their actions and agendas to better react to climate change.

Each gives rise to more specific research areas linked to the above four *Objectives*:

**1. Targeting and priority-setting: Identify where climate change will highly and negatively affect the poor [Objectives 1, 3].**

Overall, targeting and priority-setting research (Appendix 1) will characterise peoples and areas where the CP can and should seek to achieve intended impacts, considering both food security and environmental goods and services in the face of climate change. Climate-related changes requiring human adaptation will be assessed. Such assessment will include tipping points for rapid change; interacting ecological, biogeochemical and climatic processes; future co-evolution of food and environmental security; where and how climate-related stresses may trigger collapse of particular agroecosystems; and key interactions among socioeconomic and biophysical components.

**Targeting and priority-setting will be achieved by:**

1. Spatially and temporally assessing the threats posed by climate change through analysis of current climate variability and of projected future conditions, including climate variability and probabilities of extreme events.
2. Determining to what degree international and national policies are exacerbating or reducing vulnerability to climate variability and change.
3. Identifying, locating and characterising vulnerable populations of the rural poor.
4. Integrating climate, economic and biophysical data from the farm household level to the community, national and regional levels.
5. Analysing climate data at scales relevant to agriculture and understanding why and where high vulnerability to climate arises.
6. Estimating how vulnerability might evolve over time by building integrated climate-land use models.
7. Determining what climate extremes may trigger the collapse of different agroecosystems as part of integrated scenarios exercises.
8. Identifying and prioritising for conservation wild species and landraces that are at risk.
9. Understanding the role of non-climate-related factors—e.g., economic globalization, urbanization, HIV/AIDS—in peoples' potentials to adapt to climate change.
10. Drawing lessons from these activities about effective capacity building mechanisms for scientists in the areas of data base integration, GIS, climate modelling and interdisciplinary approaches.

**2. Develop, test and implement adaptation and mitigation options for maintaining rural livelihoods, food security and environmental management in the face of climate change [Objectives 3, 4].**

The Program will design, test and implement innovative and holistic strategies that help the most vulnerable of the rural poor in the tropics and sub-tropics to adapt to threats imposed by climate change and to benefit from possible mitigation options. A range of new combinations of technical and policy adaptation and mitigation options relevant to diverse contexts will be included. The CP will seek “win-win” adaptation options that provide both livelihoods and certifiable ecosystem services. To this end, policy research at the sub-national level will collaborate directly with the mitigation and adaptation components, for integrated assessment of policy, institutional, and technological options, and to assess trade-offs across outcomes and strategies.

The Program will also seek to understand local knowledge, perceptions of climate risk and current adaptive strategies of rural communities, and how such knowledge and strategies are compatible with research-based recommendations; and conversely, understanding influences of local cultures and traditions on the uptake of new adaptation strategies. It will thereby help people cope better with *current* climate variability and shocks. This is an essential pre-requisite in building their livelihood resilience and hence their adaptive capacity for *future* climate change.

In the development and implementation of adaptation strategies, the Program will consider a range of relevant interacting factors, including market, institutional and policy constraints and opportunities; emergent considerations regarding food quality and preferences, carbon taxes, biofuels and “food miles labelling”; and impacts of policies and treaties (e.g., of the UNFCCC, the International Treaty on Plant Genetic Resources for Food and Agriculture).

***Innovative and needed adaptation and mitigation strategies will be developed by:***

1. Developing, testing and implementing adaptation and mitigation options based on innovative land and resource management practices integrated with new tools such as insurance mechanisms for agricultural systems at a range of spatial levels.
2. Improving the communication and use of weather information—including forecasting—to assist farmers and others to better cope with weather-related risk and uncertainty.
3. Assessing landscapes and land-use patterns that are more resilient to climate stress and that also provide ecosystem services.
4. Analysing potentials for deriving local benefits from payments for environmental services.
5. Identifying adaptation options in the context of value chain development.
6. Facilitating policy and institutional dialogues and change required to support climate change adaptation and mitigation strategies.
7. Examining commodity and carbon trade, and market policies and institutions, including certification, climate and energy policy, development and finance policies for mitigation and adaptation, and investment options.
8. Providing policymakers and stakeholders at various levels with tools to better understand, analyse, and inform policy decisions for adaptation to and mitigation of climate variability and change.
9. Drawing lessons from the above activities about effective mechanisms for capacity strengthening of farmers, decision-makers and scientists in the areas of innovative adaptation strategies, resilience assessment, policy dialogue and policy-making for climate change adaptation and mitigation.

***3. Determine the impacts of different adaptation and mitigation options on people and the environment [Objectives 2, 3].***

Determining the impacts of different adaptation and mitigation options on people and the environment will require understanding (including via modelling) of potential negative and positive feedbacks between individual adaptive actions and agricultural and ecosystem resilience to future environmental change. This will help to identify and promote sustainable adaptation to climate change; i.e. measures that reduce vulnerability to climate change and at the same time reduce poverty, increase food security and maintain ecosystem services, as outlined in the Millennium Development Goals. It will also entail assessing and internalising costs related to climatic change and environmental goods in economic models and relevant policies, and analysis of the impacts of climate change on trade policy, crop specialisation and commodity chain restructuring for national-level food security and sovereignty.

**Determining impacts will be achieved by:**

1. Understanding potential feedbacks of the technical, institutional and policy innovations developed by the Program on poverty, food security, the environment and the adaptive capacity of agricultural systems.
2. Analysing *ex ante* impacts—in terms of poverty, food security, and environmental goods and services—of Program innovations, including impacts of adaptive farming systems and resource use strategies, of GHG emission mitigation strategies, and of biofuel production. Using this information to further improve the innovations developed by the Program.
3. Developing and using cost-effective tools to measure *ex post* Program impacts in terms of poverty, food security and environmental goods and services. Analysis of the distributional consequences of Program impacts.
4. Establishing the impacts of alternative climate and trade policies, including the price of carbon and the greening of trade (certification, corporate standards, consumption), on local food and agroecosystems and food security.
5. Designing policy and institutional mechanisms that are effective at internalising, in an equitable manner, the costs of climate change adaptation and mitigation in national and international food policies.
6. Drawing lessons from the above activities for capacity strengthening of scientists and policy-makers in the areas of climate change impact assessments, including analysis of the distributional and equity consequences of policy options.

**4. Engage and benefit stakeholders more effectively throughout the research cycle [Objectives 1, 4].**

The Program will strive to employ participatory and community based approaches, will seek to determine effective ways to deliver needed climate and other information to help inform farmer decision making to policy development, will promote opportunities for social and community learning in the adaptation process, and will develop methods for translating research findings into effective adaptation by the poor to climate change while exploiting any opportunities provided by climate change. In the process, it will build the capacity of the stakeholders directly participating in the Program. Lessons and implications will be drawn from this experience to devise mechanisms for capacity strengthening that can be used and disseminated widely, outside of the Program itself.

**Effectively engaging stakeholders will be achieved by:**

1. Adopting a collaborative learning process approach among all stakeholders in setting agendas, conducting research, interpreting outcomes and implementing adaptation programs.
2. Strengthening regional partnerships with organisations that together represent distinct perspectives on food system development, and that are embedded in a diversity of regional social networks.
3. Integrating stakeholders' views on climate variability and climate change, impacts and responses by jointly undertaking scenario exercises to develop mutually-acceptable plausible futures.
4. Mapping the institutional and policy decision-making contexts from global to local, identifying populations typically excluded in the process and, overall, working to empower stakeholders.
5. Enabling stakeholders to effectively capture and apply weather and climate-related information.
6. drawing generic implications for how best to build the capacity of different categories of stakeholders, in a wider and sustainable manner.

## **CP partnerships: who will do this and why?**

The research program mapped out in this pre-proposal has been developed on the basis of a workshop held at the University of Oxford, attended by representatives from some 35 institutions and agencies. This was followed by intense and numerous interactions among the initial 35 proponents and an expanding set of institutions, some that were contacted, others that contacted the initial proponents and that indicated their interest in participating in the Program. A set of principles for participating in this collaborative undertaking was designed and implemented (Appendix 2).

This research program will require wide, innovative collaborative partnerships among national and regional partners in affected areas, the CGIAR community and the broader GEC research community. This is for a number of reasons:

First, independent research is often inefficient, missing the “big picture” and failing to bring the latest insights to bear from other groups and disciplines. Team work and partnerships will be required to solve these multi-dimensional problems and to achieve outcomes.

Second, there is a need to complement research capacities, whereby global institutions and partnerships down-scale their approaches for regional and local relevance; and for regional and local institutions to up-scale their orientations for global relevance. Down-scaling and up-scaling in the context of climate change is a major justification for the innovative collaboration model that is proposed in this CP.

Third, impacts arising from measures of adaptation to climate change may bring unanticipated negative impacts on local and regional environments and on the Earth system at large. Systems characterised by complex interactions among heterogeneous components frequently show non-linear responses, thresholds and tipping points that can lead to irreversible phase transitions.

Fourth, some actions may create emergent surprises at the global scale if not studied in an integrated way across regions (e.g., biofuel production may be locally reasonable but across many regions may reach thresholds threatening wider food security; or a break-down of regional food systems may lead to competition for food between developed and developing country populations, increasing vulnerability of the poor).

Finally, many of the models and data sets from the Earth system science community are at a sufficiently mature state to be of broad-scale value in the analysis of climate impacts and climate mitigation in agricultural systems. The notion of trade-offs and synergies must be articulated in this context. Food security is but one objective for a sustainable future. Any major new agricultural management policies must be vetted against other legitimate objectives—e.g., of maintaining biodiversity, energy security, carbon-neutral strategies, and reducing environmental pollution traced to agricultural production.

For the agricultural research community, work on adaptation of systems across scales from the plot, farm and landscape levels to the broader context of global biogeochemical and policy processes will increase CP impacts. For the GEC community, linking global studies to local and landscape level work will increase relevance, strengthen models, and further link the natural and social science global change communities. Integration across scales of biophysical and socioeconomic approaches will result in more robust policy and technical options.

The various institutions and agencies that have come together to produce this pre-proposal have either climate change programs or climate change-related activities that are on-going; they see this pre-proposal as a means of creating synergies that will achieve far more than

what they can achieve alone, and that will enable the Program to fulfil its very ambitious goal.

Due to the complexity of the subject and of the needed partnership arrangements, it will be crucial to have a governance model that enables the scientific and institutional management of the CP. Developing such arrangements—which will require negotiations with the diversity of scientific and donor communities—will be addressed in the full proposal, and once all partnerships, especially at the national and regional level, have been finalised. Lessons from existing Challenge Programs on what has worked, and what should be avoided will also be drawn.

Some coordination mechanisms that were developed independently of this collaborative Program will facilitate better coordination, internally within groups of institutions. The large numbers of GEC institutions and agencies that are involved in the Program have a coordination mechanism called the Earth System Science Partnership (ESSP). This formal partnership comprises the four international GEC research programmes: DIVERSITAS (specialising in biodiversity and agrobiodiversity); the International Geosphere Biosphere Programme, specialising in the physical, chemical and biological processes that define Earth system dynamics; the International Human Dimension Programme, specialising in institutional, socioeconomic and human security issues regarding GEC and the policies to address it; and the World Climate Research Programme, specialising in climate science. Many ESSP researchers play key roles in major international climate and environmental assessments and international fora (e.g., IPCC, MEA). There also exists a coordination mechanism among the fifteen CGIAR research centres: the Alliance of the CGIAR Centres. Finally, Agropolis provides an overall umbrella mechanism for the French agricultural research institutions involved in this Programme.

### **Timelines and deliverables**

The CP has a defined life span of 10 years. Research activities and outputs are designed to ensure the sustainability of interventions. The CP full proposal will set clear goals, milestones and review points to ensure measurable progress and integration between tasks and findings. Engagement, collaboration and partnership building will be the subject of focussed workshops and field activities; and will also be subjected to review relative to specific milestones. Suitable governance mechanisms will be determined to deliver appropriate monitoring, evaluation and synthesis.

Beyond developing new science, the CP partnerships will deliver relevant and targeted information and tools to farmers, natural resource managers and policymakers; it will strengthen the capacity of scientists to address the particular challenges of climate change in agricultural systems; it will enhance the capacity of key stakeholders to continue to adapt to the impacts of climate change:

#### *Short-term (3-5 years) outputs*

1. Improved targeting and priority setting to positively impact the poor and at risk, and the tools to achieve these for large multi- and cross-scale programs. Such output will imply new paradigms of what constitutes areas of high vulnerability in relation to food and environmental insecurity, adaptive capacity, resilience and poverty at a range of spatial and temporal scales.
2. Options for new varieties, different crops, rotations and other agricultural management practices—including market based interventions—to improve food security of the most vulnerable to climate change while maintaining ecosystem services.

3. Enhanced adaptation tools and strategies (including integrated bio-physical and socioeconomic approaches, advanced scenario analyses, probabilistic climate information, early warning of potential global surprises emerging from numerous unconnected regional interventions, modelling of the response of agricultural systems to current climate variability and climate extremes, analysis of plausible futures for proving context for policy discussion) for use by from farmers to policymakers.
4. Analysis of the reciprocal impacts of regional-scale food security/climate change adaptation interventions on the global environment and global economy.
5. Increased capacity within NARS and other partners through collaborative research and the joint exploration of adaptation and mitigation options.
6. Analysis of the policy and institutional context in which adaptation to climate change must be implemented.
7. Documentation and assessment of alternative options for policy reforms and institutions that affect climate change outcomes and those that support mitigation and adaptation strategies.

*Longer-term (5-10 years) outputs*

1. Identification of the appropriate knowledge, technology, resources, policy and institutional arrangements to enhance the adaptive capacity of vulnerable rural populations in face of climatic variability and change.
2. Enhanced use of climate and weather information based on improved understanding of information needs at different spatial and temporal levels.
3. Alternative options for policy reforms (e.g., regarding land use) and institutional change in support of climate change adaptation strategies. Options will be based on analysis of the impacts of different policies for adaptation on food security, poverty and ecosystems.
4. Decision Support Systems targeting different stakeholders and their needs.
5. Cost-effective monitoring and measuring systems for tropical lands for poverty and livelihoods and environmental services (including carbon, biodiversity), tied to market opportunities for carbon trading and payments for environmental services.
6. Recommendations regarding how to guarantee food production in the face of bioenergy production and regarding ways to protect biodiversity.
7. A durable forum for interactions among scientists, policymakers, managers and farmers based on enhanced researcher-policymaker partnerships to implement adaptation options and enhance adaptive capacity.
8. Vulnerable (targeted) farmers and communities better able to deal with the impacts of climate change in terms of livelihoods, resilience and maintenance of agroecosystems.
9. Enhanced capacity to respond to the impacts of climate change on agriculture by policy-makers and decision-makers.

## **Impact pathways: achievement of impact and generation of international public goods**

The four research themes of the CP are to be addressed in an integrated, mutually-reinforcing manner that will allow for the achievement of desired impacts and the generation of international public goods.

*Targeting and priority setting: Identify where climate change will highly and negatively affect the poor.* Targeting will be based, as described above, on outputs from use of a range of tools and data sets, themselves spanning from on-farm strategies in vulnerable areas to biogeochemical cycles to global characterisations and projections of climate change scenarios. As in other large regional to global programs, a key to achievement of impact is working with appropriate end users or stakeholders. Spatially locating and characterising potential targeted peoples and areas according to a broad array of key, interacting variables will allow the CP to set priorities (Appendix 1). Overall the CP will strive to work with large populations of the vulnerable rural poor. Targeted areas and peoples, however, will need to have the inherent potential to respond to CP innovations.

The international public goods generated by such targeting and priority setting are the applied tools, modelling, data bases and complex systems analyses in the face of climate change that will be developed by the Program. The magnitude of climate change as a problem to be faced by farmers, scientists, policy makers and the private sector implies new types of integrative problem identification and solving approaches. All these stakeholders stand to benefit from these international public goods and from the capacity building dimension of the Program. The fact that FAO is one of the partners in this Program ensures that large numbers of farmers and policy-makers will be able to benefit, while the collaborations through ESSP will help ensure wide dissemination of new findings across the international science community.

*Develop, test and implement adaptation and mitigation options for maintaining rural livelihoods, food security and environmental management in the face of climate change.* While this theme clearly falls within the mandate of the CGIAR, impacts will not be achieved through business as usual. Climate change will likely mean that many peoples and areas will have to make transitions from relatively poor but relatively stable systems to much more difficult agroecological conditions that to date have been largely by-passed by the Green Revolution. Maize farmers in Tanzania, for example, may have to produce a wider mix of crops and livestock to survive—i.e., they may have to rely on multiple crop and enterprise strategies in order to insure themselves against highly variable possible weather related outcomes. Similarly, water managers may have to modify practice due to better understanding of feed-backs to regional hydrology.

As expected, impact will be achieved in substantial part via development, testing and implementation of innovative whole systems of crop and resources management in the face of climate change. In the Tanzania scenario for instance, new crops might include small grains—e.g., millets, sorghums, new drought tolerant chickpeas, amaranths, biofuels—and smaller monogastric livestock in the place of cattle. In and of themselves, such changes in agricultural systems will be insufficient to fundamentally improve the livelihoods of the concerned farmers. The CP will therefore also strive to integrate work in the context of other global change forces (as described above); will work to facilitate adoption of systems that lead to payments for environmental services; will investigate mechanisms such as crop insurance; will expend efforts to develop value chains that benefit targeted end users; and will employ a wide range of tools and systems to manage information useful to stakeholders.

International public goods will stem from the emergent need to help people adapt to changing conditions—i.e., change their basic ways of life and their relationships to land, water and other resources. Research and development has previously addressed how

people can make the best out of what they have. For the most part (albeit not exclusively) this CP will address the challenge to help people make the best out of less. The capacity-strengthening aspect of the Program and the facilitation of the dissemination of these results by FAO and the international science community will ensure that farmers, scientists and policy-makers outside of the Program are aware of these results and have the capacity to use them.

*Determine the impacts of different adaptation and mitigation options on people and the environment.* Crucial to achievement of CP impacts will be clear, informed decision-making regarding the trade-offs (in the face of climate change) in terms of poverty alleviation or food security vs. the maintenance of global environmental goods and services. The partners involved in the CP are well equipped to make needed assessments and projections regarding outcomes—in the sense of being able to generate needed data and analyses. The challenge will be in transparent, informed (from the local to meta scales) decisions regarding trade-offs.

International public goods will stem from the novel, complex and all-encompassing analytical tools being developed and brought to bear on CP decision making regarding development/environmental trade-offs in the innovations it develops. In turn, these tools will largely benefit scientists and policy-makers outside of the Program. This will occur through the mainstreaming of these results throughout the various partner institutions, which are currently the main agricultural research and climate change research agencies, and, again, for policy-makers, through facilitation by FAO.

*Engage and benefit stakeholders more effectively throughout the research cycle.* A range of stakeholders will be actively engaged in the CP from initial targeting and priority setting to the development and implementation of innovations. “Innovations” include on-farm, community based, market driven, policy and institutional related new tools, practices, policy instruments, institutional arrangements, and also innovations related to international trade in ecosystem services or bioenergy production. Achievement of impact will critically depend on stakeholder engagement. While such involvement is often a part of proposal or project rhetoric, it can only be re-emphasized that adaptation to climate change poses the challenge of helping to get the poor out of poverty not in their current conditions, but in the face of substantially worsening conditions.

International public goods will stem not from “farmer participation” or ‘policy-makers’ participation *per se* but from the approaches developed by the CP to facilitate stakeholder participation in an integrated set of processes and engagements in dialogues, from on-farm to policy and institutional dialogue to new economic mechanisms. Here again, the emphasis on capacity building that runs through all the Program and the experience of FAO, ESSP and other partners and their ability to reach out to policy-makers globally and nationally will ensure that the outputs of the Program are very widely disseminated to stakeholders.

### **Links with CGIAR System Priorities**

This proposed Program cuts across all the System Priorities and will reinforce and strengthen on-going work on these priorities by providing a dynamic and forward-looking dimension. The relative emphasis on the different Systems Priorities may vary depending on the sites where the work will be implemented (see Annex 1).

Climate change will affect biodiversity. Research on agrobiodiversity conservation (**priority 1**) must consider the impacts of climate change on the plant, animal and aquatic genetic resources of relevance to agriculture and food production. The proposed CP will therefore increase the relevance of the work under priorities **1A, 1B, 1C and 1D**. At the same time,

conservation of agrobiodiversity is an effective option for decreasing the vulnerability of small-scale farmers in developing countries to climate change. Scientific breakthroughs, in particular from activities under research area 2, will contribute to the work under this priority.

Work on genetic improvement (**priority 2**) will provide more robust germplasm options for farmers and their capacity to adapt to climate change. In particular, breeding for reduced evapotranspiration (**priority 2A**) and tolerance to abiotic stresses such as drought and floods (**priority 2B**) will directly support--and benefit from--the proposed CP.

The CP will work to diversify farming systems as a way to increase their overall resilience and adaptation to climate change, and will thus contribute to **priority 3A** (diversification of farming systems) and **3D** (diversification of systems including trees and forests). Research on improving drought resilience through integration of fisheries and aquaculture into farming systems will also contribute to **priority 3C** (enhancing incomes through increased productivity of fisheries and aquaculture).

**Priority 4** is strongly connected to the proposed CP. Climate change directly impacts water quantity and quality, the state of forests, land and soil degradation. Changes in land uses (e.g., deforestation, afforestation, pastures) can lead to increased greenhouse gas emissions. The proposed CP will work on integrated land, water and forest management at the landscape scale (addressing **priority 4A** issues of governance of natural resources). **Priority 4B** dealing with the management of fisheries and aquatic ecosystems will be addressed by CP research on basin level impacts of climate change on fisheries and fishery dependent communities. CP research on predicted water stress and increased flooding is tied to improving water productivity (**priority 4C**). Research on agroecological intensification to overcome soil degradation (**priority 4D**) is particularly important in the context of Africa where soil degradation is predicted to increase.

Finally, policies for sustaining reduction of poverty and hunger (**priority 5**) will address—within the CP--the extreme vulnerability of small-scale farmers in developing countries to climate change. The CP will work on options to reduce this vulnerability (**priority 5D**). Research on carbon markets will directly bear on work on making international and domestic markets work for the poor (**priority 5B**).

The CP will work collaboratively with existing CPs (especially Water and Food and Sub-Saharan Africa). Dialogue will search for common ground where previous experiences, information exchange and synergies can accelerate the achievement of desired outcomes. Novel forms of collaboration will also allow for new funding opportunities from the respective donor communities more traditionally aligned with GEC research and from those more traditionally aligned with CGIAR research.

### **Donor interest**

DFID, Germany and Rockefeller-Gates have already volunteered their strong interest in supporting work under this CP. These would be new funds, rather than funds currently allocated to other activities in the CGIAR system. The opportunities for collaboration between the respective donors of the international agriculture and the GEC research communities are very substantial, and these opportunities are currently being pursued.

## Appendix I. Targeting and priority setting

Regions to be included are those where climate variability and climate change-related vulnerability is high, adaptive capacity is low, and where human and ecological systems are most at risk. The main climate-induced impacts relate to changes in climate variability and in climate mean values (especially temperature and rainfall). These changes lead to changes in water availability and sea-level. To maximize the research impact, an initial typology of systems can be based on sensitivities to the key climatic processes of drought, temperature, ground- and surface-water availability and sea-level rise.

Using this typology as a starting point, the CP will determine where research will be launched based on projections of significant climate change, vulnerability and poverty, potential environmental risk, likelihood of gains from adaptation and mitigation measures, and areas essential to global and/or regional food security. Further considerations are experience of partners, potentials for successful partnerships and expressed donor interest.

Focus region definition requires consultation and collaboration among agencies across scales. Three steps described below are needed. Steps 1 and 2 will be undertaken during full proposal preparation.

- 1) Determine which variables are needed in order to identify the key sites/regions for research investment based on a scientifically-robust approach.
  - a. What variables have recent vulnerability studies used?
  - b. What are the most appropriate spatial and temporal resolutions for defining climate change hotspots?
  - c. What goals are the collaborators and their national and regional partners targeting?
  - d. What datasets and methods already exist and how reliable are they?
- 2) Based on these agreed variables, establish a process for determining where research is likely to have most impact.
  - a. How, and to what extent, is climate variability and change expected to have an impact on vulnerability of agroecosystems hotspots and food insecurity?
  - b. Where are mitigation measures likely to have greatest impact in terms of poverty alleviation and mitigating further climate change?
  - c. What are the most appropriate ways of including probabilistic climate information in these hotspots?
  - d. How are the hotspots likely to evolve over forthcoming decades?
- 3) When the CP is launched decisions will be made on where research should be initially undertaken.
  - a. Where are the most vulnerable areas with respect to agriculture, food security and Earth system feedbacks?
  - b. Where is research investment likely to have most impact?
  - c. What commonalities exist between these areas?
  - d. What are the most likely successful partnerships, both in terms of generating sound scientific results and generating widespread impacts?

Step 3 will be addressed by the CP 'Steering Committee', based on inputs by all interested parties. Because this CP calls for new teams, partnerships and considerable capacity building it is proposed to pick a small number of initial pilot sites and projects where a firm foundation can be build upon existing knowledge and institutional relationships. These projects would have a broad partnership base and can thereby act as regional and national multipliers, so as to maximize impacts. This will be done using a competitive process that specifies criteria to be defined in the full proposal.

It is recognised that not all potential players will be involved in the initially-selected regions. Further research regions will therefore be established as research need and donor interest becomes apparent. The CP will undertake a systematic approach to identifying such further regions as part of the collaborative research endeavour. This will be based on a global analysis of vulnerability to climate change, based on a “starting point” approach to vulnerability that views vulnerability as a general characteristic generated by multiple factors, stresses and processes. This effort could involve the following steps:

1. Assessing climate change hazard, using trends already observed and improved GCM downscaling techniques as they become available, allied to estimates of changes in climate variability and the probabilities of extreme events such as droughts and floods with a focus on developing regions. (At the present time, while regionalised model projections may give widespread statements of change for particular periods, neither their quality nor quantity is adequate to support the specific and detailed information needed for adaptation purposes. In order to meet adaptation needs, the underlying climate science and models will need to be improved; uncertainties clearly communicated; regionalisation techniques evaluated and improved; and access skills will need to be strengthened, especially in vulnerable areas. Meanwhile valuable work can be done in relation to climate changes already underway.)
2. Using appropriate indicators that can be quantified with existing data resources to characterise biophysical vulnerability (the sensitivity of the natural environment to exposure to a hazard) and social and economic vulnerability (a function of exposure, sensitivity and coping or adaptive capacity) of agricultural systems and rural livelihoods in the developing world.
3. Integrating the areas of climate hazard and of current and future socioeconomic vulnerability to determine how current vulnerability can be identified, with at least qualitative assessment of how this vulnerability may change in the future.
4. Identifying a short-list of further CP sites and intervention entry points, characterised with respect to the goals and objectives of the proposed CP, the comparative advantage of the institutions involved, and CGIAR system priorities, from which more detailed science plans and appropriate partnerships can continue to be developed. These could compare both vulnerable and resilient regions to find out what factors can constrain and enhance adaptive capacity.

While most of the research will be based on focal points in the food security arena, this CP will also place these in a more global economic and environmental context, by assessing the reciprocal impacts of regional-scale food security interventions on the Earth system and global economy at large. This is a unique value-added to the proposed work and to existing knowledge never executed before.

## Appendix 2: Criteria for this collaborative research Program

The CP is built around fundamental criteria in that it:

1. Addresses key knowledge gaps related to sustainability and development, which are:
  - a. Major/global issues, and
  - b. A major impediment to progress
2. Maximises the chance for success in delivering solutions to climate change adaptation and mitigation for agriculture and food security that are based on innovative science outputs with clear:
  - a. Links across sectors
  - b. Inter-disciplinary approaches emphasising policy relevance
3. Is recognised as a priority research programme by both the agricultural research community and the GEC, and all other partners that have joined the Program and is of relevance to other stakeholders (farmers, resource managers, donors, policymakers, etc...), and which:
  - a. Focuses on coupled social/natural systems, with emphasis on rural poor livelihoods in developing countries
  - b. Targets hotspots which exhibit particular vulnerabilities
  - c. Crosses spatial and temporal scales
  - d. Addresses short term (seasonal and inter-annual) climate anomalies in the context of long-term climate change
  - e. Is scientifically exciting and stakeholder-relevant
4. Requires active, large-scale institutional collaboration between the agricultural and global environmental research communities to find unique intellectual space, and which:
  - a. Is highly-integrated and addresses complex systems and outcomes
  - b. Demonstrates the comparative advantage of joint effort
  - c. Can be implemented by a range of mechanisms (financial, administrative, ...)

The innovative feature is that the proposed work encompasses agendas that neither the agricultural nor the global environmental change community can address independently. Each community meanwhile has rich and varied ongoing and envisioned research agendas which are related to this CP but for which this collaboration is not necessary. This CP will however help promote such independent agendas and add value to their products by setting them in a broader context.