

**Cycle 2 Challenge Programs Concept Notes
Recommended by Science Council**

Challenge Program: High Value Crops - Fruits and Vegetables

Plugging the income and nutrition gap in food security development

Introduction

The CGIAR System Priority 3A was identified on the premise that high value crops (in particular fruits and vegetables), provide poor farmers the opportunity to derive additional income and increase enterprise stability through crop diversification. A Challenge Program on this topic could support poor communities to reduce their reliance on basic staple pulses, cereals and starch crops and, through diversification of their cropping systems into high value commodities, to make the transition from subsistence to market-oriented agriculture, with the concomitant improvement in human health¹.

High value crops generally refer to non-staple agricultural crops such as vegetables, fruits, flowers, ornamentals, condiments and spices^{2, 3}. Most high value agricultural crops are those known to have a higher net return per hectare of land than staples or other widely grown crops. They therefore generally have a monetary value higher than staple crops in emerging and expanding local, national, regional and global markets. High value crops and products present an ideal opportunity for the poor in many developing countries to increase their income by participation in commodity value chains, provided there is effective vertical coordination to ensure that supply is in relative balance with demand.

A number of CGIAR Centers work on various high value crop species, including aromatic plants, spices, nuts, oil, medicinal and cosmetic species. There is also some emerging emphasis on research relating to high-value differentiation in certain commodity and basic staple crops. In this proposed Challenge Program, however, the scope would be generally limited, in the first instance, to research on fruits and vegetables, to ensure focus and impact, and to take advantage of their nutritional value for food security. The Challenge Program will also include investigation on some key process research challenges, involving links between high value commodities, value chains and poverty alleviation. This is aimed at producing some results (of generic nature) that could be adopted and applied to other high value commodities and products. It needs to be emphasized also, that this Challenge Program will have a strong pro-poor orientation in its research mandate.

Why the focus on Fruits and Vegetables? Fruits, in the context of the CGIAR mission and areas of focus, comprise tropical and temperate fruits, including tree crops, which are pertinent to developing countries. Vegetables comprise both exotic and indigenous vegetables, many of which are a multi-purpose food source. The high value of fruits and vegetables not only include their monetary, social and cultural, aesthetic and environmental value, but also, their significant strategic role in improving the diets of people around the world. The World Health Organization⁴ estimates that low fruit and vegetable intake contributes to approximately 2.7 million deaths a year from chronic diseases and causes about 31 percent of ischemic heart diseases and 11 percent of strokes worldwide. It ranks low fruit and vegetable intake as the 6th main risk factor for mortality in the world.

The main rationale for focusing on fruits and vegetables can be summarized as follows:

¹ Weinberger, K. and Lumpkin, T.A. 2005 Horticulture for poverty alleviation - the unfunded revolution. Shanhua, Taiwan: AVRDC - The World Vegetable Center, AVRDC Publication No. 05-613, Working Paper No 15, 20pp

² Temu, A.E. & A.A. Temu 2005. High Value Agricultural Products for Smallholder Markets in Sub-Saharan Africa: Trends, Opportunities and Research Priorities. *International Workshop on How can the poor benefit from the growing markets for high value agricultural products?* 3-5 October 2005 International Center for Tropical Agriculture, Cali, Colombia

³ CGIAR 2005. CGIAR System Research Priorities 2005-2015. CGIAR Science Council Secretariat 96pp

⁴ World Health Organization 2002. The World Health Report 2002: Reducing Risks, Promoting Healthy Life. WHO, Geneva, Switzerland. 230pp.

- the production of fruits and vegetables tends to require more labor input compared to other crops, so the horticulture sector can contribute to poverty reduction by providing employment and wages to laborers;
- fruits and vegetables generate high economic returns per unit of land, thus the production of fruits and vegetables has a comparative advantage under conditions where arable land is scarce;
- low fruit and vegetable intake is a main contributor to micronutrient deficiencies in the developing world, and it is increasingly recognized as one of the key risk factors for cardiovascular diseases and some forms of cancers, the two leading causes of death in the world today^{1,2};
- fruits and vegetables are generally perishable so they experience serious marketing problems which can be addressed with appropriate public investments in research, infrastructure, and institution building; and
- the growth in demand for fruits and vegetables in developing countries combined with growing export demand creates new opportunities for poor farmers in the developing world, but developing countries need assistance in adapting policies, institutions, and infrastructure to take advantage of these trends.

Harmonized investment - higher rates of return

In the context of increasing income through fruits and vegetables in developing countries (CGIAR Priority Area 3A), there are many opportunities for impact through the production of international public goods by both the CGIAR, AVRDC - The World Vegetable Center and other partners. The CGIAR works on different aspects of production, enhancing water use efficiency, value addition, human nutrition and environmental concerns related to high value crops and products, either as individual centers (usually in partnership) or within one of the four current Challenge Programs. There is some coherence and synergy between the centers, but scope for substantive increases in activities exists thus requiring a new, more effective, coordination and funding mechanism. Also, the field of high value crops – fruits and vegetables - is one in which a lot of expertise exists in other non-CG institutions (AVRDC, CIRAD, CABI, EMBRAPA, etc.), that could be coupled with the CG experience and capacity with great effect. A coordinated approach, through a Challenge Program, with a broad range of partners is essential to ensure impact on this topic.

There are many opportunities for poverty alleviation in developing and emerging countries, through high value crops, including added value brought by application of advanced technology tools in biology and communication, market opportunities brought by global trade and changing demand, and value addition possible through supermarkets, fair trade and exports. Other, more immediate, opportunities include the diversification of cropping systems, which can make better and more secure use of available land, water, labor and other resources, thus reducing risk for income generation. In addition, this diversification can provide, through high value crops, opportunities to diversify diets through local consumption, as well as increasing local income while diversifying, and perhaps improving, diets globally. Although fruits and vegetables have received insufficient research and development attention from the international community, commodity chains and competitive organizations have developed because of the high demand and high value of the products. Tremendous improvement can still be made for each of the commodities at each marketing step, and any improvements must build on previous successes.

To maximize the output and impact of the proposed Challenge Program, it is imperative that interaction between partners is established and optimized, that effective synergies are developed and that resources are disbursed efficiently and equitably. Effective mechanisms to monitor the delivery and application of the resulting local, regional and international public goods will be prerequisite to ensure that impact is appropriately documented. However, this is

also the ideal juncture for a Challenge Program to provide leadership and coordination of the CGIAR's activities with its partners in high value crops.

A Challenge Program on High Value Crops - Fruits and Vegetables

This Challenge Program must deliver regional and global international public goods, both to increase the income of poor rural and urban families, as well as contribute to improving their livelihoods (including nutrition) through sustainable and efficient use of natural resources. Both are vital topics, and the CGIAR and its partners are ideally placed to contribute, through research and development, to the alleviation of poverty and reducing malnutrition in developing countries and countries in transition, while building on the environmental benefits which accrue through crop diversification and good natural resource management

The Challenge Program must address the need to promote added value, and fairly share that added value, in the value chain, as well as how to sustain added value in a competitive context. It must include the following elements, taking into account that added value is stimulated by the 'fresh market', by export, by quality standards, by processing, by information systems and by stakeholders' organization which leads to technological and organizational innovations fitting market demands:

- Strategic positioning and priority setting in research and development on high value crops for impact;
- Research to improve economic and environmentally sustainable production; including optimum use of genetic resources, species diversification, seed systems, suitable multiplication techniques and strategies, crop protection and good practices in using inputs and natural resources (including soil and water);
- Research to understand the diverse interests and risk management strategies at the household and landscape level which will affect the uptake, and to reduce any vulnerability, of the advocated technologies and products. This will include gender dimensions and the specific opportunities for women empowerment.
- Research in markets, institutions and policies required for moving selected commodities, products and systems into high value outputs, and to sustain this added value in the context of complex and dynamic relationships between the components;
- Postharvest management and small-scale processing in the early stages of the value chain;
- Market-chain development, involving various forms and levels of linkages (e.g. rural-urban linkages, private-public sector linkages, formal-informal markets);
- Identification of nutrition and health opportunities of selected high value crops and how to exploit those opportunities most effectively;
- Identification of policy measures and other mechanisms to facilitate increased income generation from fruit and vegetable production and increased consumption of fruits and vegetables, particularly among women and young children
- Determination of policy implications and support mechanisms including Sanitary and Phytosanitary (SPS) measures, food safety issues, and regional or global standards.
- Key elements of cropping system information, processes and tools that that provides insights on whether business models actually reduce poverty. Results of such research are likely to be of generic nature that permits adaptation to other products.
- Strengthening capacity within the CGIAR, AVRDC and other partners in research and value chain development related to fruits and vegetables.

Capacity-building will have a vital role in this Challenge Program. High value crops are particularly knowledge and technology intensive, and it is important that the information and technologies reach the end-users as quickly and effectively as possible. Capacity building at many different levels will be critical to ensure the success and sustainability of proposed research and development activities.

Impact / monitoring

This Challenge Program must quickly demonstrate quantifiable impacts. It will be managed in order to provide clear impact of the Challenge Program as a whole, as well as for the individual research activities, or of single interventions. Ex-ante studies will be required to give detailed baseline information, followed by assessments during the research activities and then surveys to quantify impact of the research activities on the target populations and environment. Whenever appropriate, the Challenge Program will link data from natural scientists with that of social scientists in assessing the impact of its interventions.

Partnership and Coordination

A Challenge Program on High Value Crops - Fruits and Vegetables will require effective partnerships. The Program must be carefully managed to ensure integration of all the partners to address geo-political as well as programmatic issues. Partners will be not only the CGIAR centers and AVRDC, but also other international centers, national agricultural research and extension services (NARES), advanced research institutions, the private sector, regional and sub-regional organizations, non-governmental organizations and other stakeholders. The private sector has traditionally played an important role in high value crops, but their role has not always benefited the poor in developing countries where the sharing of the added value has not been equitable.

There must be transparent and participatory mechanisms to ensure all stakeholders provide input into the process of setting priorities, whether these are geographical, commodity or systems priorities. This prioritization will ensure that the available funding is targeted to articulated pro-poor needs to meet the goals of this Challenge Program. Funding will be available for the research and development activities in the participating CGIAR Centers and AVRDC, the other partnering international centers, and the national agricultural research and extension systems (NARES) while also facilitating a support network with advanced research institutions. Such funds will support staffing as well as operation expenses. The best scientific competencies from both within and outside the CGIAR will be mobilized to address the research, development and capacity-building objectives of the Challenge Program.

Collaboration and linkages with relevant programmes and platforms such as the Global Horticulture Initiative (GHI), the Global Facilitation Unit on Underutilized Species (GFU) and the International Centre on Underutilized Crops (ICUC) will be explored and facilitated. Coordination of the Challenge Program must result in clear timelines for outputs and associated monitoring. Timelines and verifiable outputs will facilitate the coordination, allow weak links to be identified and supported to ensure the overall success of the goals of the program. It is expected that a light bureaucratic and governance mechanism can be employed in response to lessons learned from earlier established Challenge Programs.

Conclusion

This Challenge Program is an ideal mechanism, with effective and streamlined coordination, and visionary leadership, to ensure that international public goods of the CGIAR and AVRDC, and the research, capacity building and development activities of other international centers, are coordinated with those of the NARES and the private sector, and other global interventions, to meet the needs of the poor in developing countries.

This Challenge Program is just one part of a larger vision to improve the livelihoods of the poor. It must coordinate its activities with other programs within the CGIAR, and with other global interventions. The greatest impact of this Challenge Program will result from interaction with other research and development programs around the world, creating synergies and ensuring maximum impact toward the Millennium Development Goals which are the globally agreed highest priorities of research and development for the next 10 years.

Initial Concept Note for a Challenge Programme on Climate Change, Agriculture and Food Security

The 15 Centres supported by the CGIAR have recently decided, through their Alliance Executive, to develop a large-scale collaborative research programme on climate change, agriculture and food security with the global environmental change (GEC) community. The Chairs and Directors of the four international GEC programmes and their joint projects¹ have likewise formally approved the preparation of a collaborative research programme with the Alliance Centres.

Both the Alliance Executive and the GEC Chairs and Directors decided that the preparation of such a collaborative programme includes, as a first step, a scientific workshop. The main purpose of this workshop is to identify the research priorities, themes and research activities that need to be undertaken collaboratively and that will constitute the scientific backbone of this proposed challenge programme (CP)². The dates for the workshop (February 21-23) were agreed upon before the timeline for submitting concept notes was known. Given the number of institutions concerned it proved impossible to change the dates of this workshop at short notice.

In order not to preclude the outcomes of the workshop whilst nevertheless answering the request for a concept note, the Alliance and the ESSP are submitting the following text. A short addendum to this concept note will be submitted just after the conclusion of the scientific workshop, to relay the main research priorities which the workshop will identify.

1. Significance and urgency of the problem

More than 800 million people in tropical and sub-tropical countries are currently food insecure. Their situation is expected to worsen, and the number of food insecure people is likely to increase, as changes in extreme weather events, inter-annual variability and mean climate parameters will negatively affect crop and animal yields and agro ecosystem resilience. Sea level rise and ocean changes will also threaten food production and livelihoods in coastal areas. Climate predictions and analyses of past and current trends indicate that small-scale farming households in tropical and sub-tropical areas will be exposed to increased climate risks and will become more and more vulnerable to these risks, unless drastic measures are implemented to increase their capacity to adapt to climate change. In the absence of measures at the local, regional, national and international levels to better adapt agriculture to the effects of climate

¹ These are: DIVERSITAS, the programme specializing in biodiversity and agrobiodiversity, the IGBP (International Geosphere Biosphere Programme), specializing in biogeochemical cycles, the WCRP (World Climate Research Programme), specializing in climate science and the IHDP (International Human Dimension programme), specialising in institutional, socio economic and policy issues regarding global change. These four GEC programmes have come together under the banner of the Earth System Science Partnership ([ESSP](#)) to promote international and interdisciplinary research, including in cross-cutting areas (carbon, food, water and health).

² The main objectives of the workshop are: (i) To identify those research questions concerning climate change and agriculture (FAO definition) that are priority research areas for the CGIAR and GEC communities, that fill key knowledge gaps and that can only be addressed by the two communities working together (result in new synergies), (ii) To identify the type of partnerships needed for implementing such research and propose ways of implementing these partnerships 'on the ground' through joint research programmes and (iii) To identify possible sources of funding for such programmes.

change, and where appropriate to mitigate climate change with different agricultural practices, food insecurity in tropical and sub-tropical areas will increase and the fulfilment of the Millennium Development Goals will be further delayed

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, the water cycle, nutrient cycling, biodiversity and carbon sequestration have been negatively affected, whilst the emission of greenhouse gas and habitat fragmentation have increased. In turn, this environmental degradation exacerbates some of the drivers of climate change and further undermines the sustainability of agriculture.

The IPCC Climate Change 2001 Assessment stresses that most of the research on agriculture and climate change has focussed on the impacts of climate change on crop yields. This has provided an excellent foundation for assessing how climate change may affect crop productivity 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. These include the linkages between the impacts of climate change on agricultural productivity, natural resources and ecosystem and agro ecosystem resilience in tropical and sub-tropical countries.

- Climate change and increased climate variability is inevitable, is occurring and will likely accelerate over the next 50 years. Its impact will be felt worldwide, but those impacts will be most severe in the developing world where impoverished and vulnerable communities are already struggling to deal with current climatic hazards.
- Adaptation to climate change is therefore no longer a secondary and long-term response option only to be considered as a last resort. It is now prevalent, and for those rural communities in the developing world already vulnerable to the impacts of present day climate hazards, an urgent imperative.
- Within the framework of the Millennium Development Goals, policies and innovations to enhance adaptation to climate change cannot be viewed in isolation from current development priorities: indeed many key stakeholders recognize the need to focus on 'climate resilient' policies and innovations that address both current development priorities as well providing greater livelihood resilience in the face of future climate change.
- National and international policy makers have often stated that they lack the knowledge necessary to confront the issues climate change will raise.

2. Major knowledge gaps

These challenges require a new type of research strategy and approach. The proposed Challenge Programme will address this requirement by focusing on major knowledge gaps.

Key knowledge gaps include the linkages between impacts of climate change and adaptation and mitigation options, and in particular the scaling issues linking information at the plot, farming system, landscape/watershed, regional and global scales. Research has shown that there are important ecological processes and geochemical processes which interact at these different scales (e.g., carbon cycle, water cycle,). Furthermore previous research has demonstrated that the lack of effectiveness of the international policy regime regarding climate change is attributable, in part at least, to the fact that this regime clashes with many local, regional and national policy mechanisms. This range of geochemical and ecological processes, along with economic, policy and institutional processes need to be understood and managed across relevant spatial and

temporal scales in order for adaptation and mitigation options to be effective for tropical and sub-tropical small-scale farmers.

A further acknowledged gap in climate change and agriculture research concerns the insufficient cross-fertilisation and integration of approaches between the natural and the social sciences (e.g., valuation of ecosystem services affected by climate change). Research is needed on how to translate research findings into policies that are effective in minimising the human and economic costs of climate change for small-scale farming households in the tropics and sub-tropics. Approaches focusing on the relationship between rural livelihoods and ecosystem services, including risk management and enhancing adaptive capacity for adaptation to climate change are required. This will also need to include an international perspective, as local, regional and national measures will have to be linked to international mechanisms. Some of the current challenges include understanding how carbon markets can function effectively, including ways in which they link tropical developing regions to the climate regime through the Clean Development Mechanism; the implications of rapid climate change (rather than a gradual warming) for managed and unmanaged ecosystems; the scientific and policy challenges of valuation and payments for ecosystem services; the new proposals for an international adaptation regime; and the emerging debates about the carbon and water embodied in traded food and materials.

3. Some potential priority areas, themes and research activities

The scientific workshop will identify, within these two areas of knowledge gaps, those priority research questions that are of relevance to both the CGIAR and ESSP. It is envisaged that not more than **4 or 5 priority areas will be identified for joint research focus**. The workshop will specify the scope of the priority areas in the CP, as well as the themes within priority areas, the set of common research objectives and complementary contributions of the CGIAR and the GEC communities within each theme and agreed upon geographical location of sites for field and modelling work

At this stage we can only provide examples of possible priority areas, as an illustration, viz.:

- Improving use of climate information and agroecosystem modelling to forecast changes in crop/livestock/fish/forest productivity and agro ecosystem resilience at a range of spatial and temporal resolutions –from global to local. This will help to determine potential impacts on human welfare and vulnerability and regional food security.
- Assessing changes in carbon, nitrogen and water dynamics in tropical forests and agroecosystems driven by emerging rural livelihood opportunities based on increasing production of ecosystem-based renewable energies (biofuels).
- Development of water-saving technologies and natural resources management systems that contribute to high water-use efficiency in agriculture and the energy sector and which minimise disruption to the global biogeochemical cycles.
- Climate change may render parts of the world less / more suitable for agriculture and shifts in major production areas may occur. Implications of these shifts for investments in water infrastructure and agricultural water management need to be investigated.
- Linking genetic improvement to management strategies to enhance the capacity to adapt to climate change for small-scale farmers in developing countries .
- Developing tools, with stakeholders at various levels , to better understand analyse and inform policy decisions for adaptation to climate change, including options for streamlining adaptation and mitigation strategies in national development policies and sectoral economic planning. Emphasis could be on assessing the net impacts of climate

change on rural livelihoods in developing countries and developing adaptation scenarios and likely outcomes for vulnerable countries. This would result in the development of generic principles for adaptation policies and strategies and wide dissemination for global and regional levels, as well as detailed policy reform options for countries and regions, to address the current clash between these different policy levels.

Potential themes and research activities: Initial internal discussions among Alliance centres led to expressions of interest from some centres in more specific themes and research activities. These, as well as the above priority areas, will be discussed by the scientific workshop. They are provided here as indications of potential research activities.

Theme 1 - Impact Assessment: Determine impacts of climate change on agricultural livelihoods and assess adaptation options

Climate change is a global phenomenon with locally variable impacts. This variation breeds uncertainty about the nature of change, preventing people at all levels from making the critical decisions that are necessary to adapt. If future impacts are better anticipated, they are also more manageable. Initial estimates of how climate change will affect agricultural systems will set the research challenges, identifying the scale and nature of the problem that global change represents to rural communities. This would include obtaining more reliable estimates of the impact of climate change on water resources, crops and livestock at global, regional, national, and local levels. Research activities would couple the latest global circulation models with socio-economic and biophysical models of crop productivity and farming systems.

Theme 2 - Crop Adaptation: Develop crop cultivars and management strategies resilient to climate change impacts

Future cropping systems will have to be more resilient to a variety of abiotic stresses to cope with the direct and indirect consequences of climate change. Higher temperatures will cause heat stress in some regions and seasons, will alter precipitation patterns and will lead to rising sea levels. More significant over the short to medium term is the projected increase in the frequency and magnitude of extreme climatic events such as heat waves, droughts and floods. Plant breeding can significantly enhance heat, drought, submergence and salinity tolerance, while crop management can be adjusted to minimize losses or take advantage of rising CO₂ levels and -- in some regions -- eventual improvements in climatic conditions. The existing knowledge on damage mechanisms of abiotic stresses can be used to develop screening tools for the identification of improved germplasm on a large scale. Recent advances in functional genomics can accelerate development of improved germplasm through marker-aided breeding system and candidate gene isolation. Crop management can be improved using advanced decision support tools to optimize yields and resource use efficiency under climate change scenarios. Breeding efforts as well as natural resource management research will benefit from synergies with the Challenge Programs Generation, Harvest+ and Water and Food.

Theme 3- Crop adaptation within the context of ecosystems, including water, land and forests

Mitigation and adaptation strategies for increasing food security in the face of climate change encompass specific resource management options that focus on water and terrestrial carbon pools. To deal with the increasing frequency and magnitude of water-related disasters and their impacts on food security, for instance, aquatic ecosystem management and conservation and water allocation mechanisms may in many areas restore lost food and ecosystem capacity (e.g. environmental flows and wetland restoration could provide a base for adaptation). Likewise, reducing emissions and managing terrestrial carbon pools may in a number of areas be achieved through specific forest management options. Integrated approaches are needed to bridge the trade-offs between improved livelihoods and stopping deforestation, resulting in reduced impacts of land-use change and the greenhouse gas emissions it causes. Work under this theme would include the development of standardized, widely accepted and scientifically sound methodologies for compensating reduced emissions from deforestation and other land-use change.

Theme 4: Strategies and Policies to Adapt to Climate Change

Responses to climate change need to encompass several levels, including crop and farm-level adaptations, national-level agricultural and supporting policies and investments, and regional and global policies and investments. Analysis of adaptation strategies for increased food security under climate change must take into account the relevant hydrologic, agronomic, economic, social, and environmental processes at the global and regional, national, basin, and local levels. Emphasis would be on developing adaptation scenarios and likely outcomes for rural livelihoods in developing countries based on the assessed net impacts of climate change. Research activities would include implementation of socioeconomic farm-household production and vulnerability surveys to estimate crop production and farm-level adaptation strategies; modelling of response options and adaptation strategies at the basin and national level based on alternative adaptation and agriculture and complementary sector investment strategies; and assessment of regional and global trade and economy-wide policies and adaptation strategies to climate change. For each type and level of adaptation strategies, distributional impacts would be estimated, to identify pro-poor adaptation options.

4. How does this proposed CP address the SC criteria?

This proposed CP brings together two international scientific communities, each with a solid track record, that have not worked very closely together before. This is expected to generate more significant outputs and impacts through synergies and complementarities. As shown above, the issue addressed by this CP is recognised internationally as being of overwhelming significance at the global, regional and sub-regional levels. The results will be, de facto, international public goods.

The centres of the CGIAR have un-matched expertise and experience in tropical agricultural research, in particular in genetics, breeding, natural resource management and food policy research; they also hold the largest germplasm collection of food crops. With food security at the core of the CGIAR mandate, it is urgent that the centres address the challenges of the emerging threats brought about by climate change. At the same time, a comprehensive research agenda on Climate Change, Agriculture and Food Security will ultimately rely on expertise beyond the genuine research domain of the CGIAR.

CGIAR-ESSP programme collaboration on the cross-cutting issues of climate change, agriculture and food security will enable each community to add value to its current research agenda. For the CGIAR agenda, relating work on adaptation of systems at the crop, farm and landscape level to the broader context of global biogeochemical and policy processes will increase the effectiveness of the options devised. This should, in turn, lead to greater impact on the ground. For the GEC community, linking global level and regional level studies to local and landscape level work, will increase relevance and strengthen models, as well as better frame the GEC agenda within the context of sustainable development in the tropics and sub-tropics. Finally, for both communities, better integration of biophysical and socio-economic approaches, especially when undertaken across relevant spatial scales, will result in policy and technical options that are more robust, flexible, self-correcting and based upon social learning processes that enhance adaptive capacities of stakeholders.

This proposed CP 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. Depending upon the specific priority areas identified by the workshop, the relative emphasis on the different Systems Priorities may vary of course.

Climate change alters the state of biodiversity (e.g., changes in ecosystem boundaries, changes in genetic make-up). Research on agrobiodiversity conservation (**priority 1**) must take into consideration the impacts of climate change on the conservation of 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.

Work on genetic improvements (**priority 2**), in particular on breeding for reduced evapotranspiration (**priority 2A**) and tolerance to abiotic stresses such as droughts and floods (**priority 2B**) can directly support, and at the same time benefit from the proposed CP, resulting in more robust germplasm options for farmers and crop management strategies that enhance farmers' capacity to adapt to climate change.

The proposed CP will address the issue of the diversification of farming systems, as a strategy to increase their overall resilience and adaptation to climate change, and will thus contribute to research under **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).

Work under **priority 4** has strong connections to the proposed CP. Climate change directly impacts water quantity and quality, the state of forests, land and soil degradation and changes in land uses (e.g., deforestation, afforestation, pastures) can lead to increased greenhouse gas emissions. The proposed CP will draw upon, and feed into research on integrated land, water and forest management at the landscape scale (**priority 4A**, including by addressing issues of governance of natural resources). Research on the management of fisheries and aquatic ecosystems (**priority 4B**) will include research on the impacts of basin level processes, including climate change, on the productivity and value of these resources and on adaptation and reduction of vulnerability in fishery dependent communities. Research on improving water productivity (**priority 4C**) is essential under predicted water stress for most of the tropics and sub-tropics, as well as under conditions of increased flooding. 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**) need to explicitly account for the extreme vulnerability of small-scale farmers in developing countries to climate change. Work on options to reduce this vulnerability (**priority 5D**) will be directly concerned by the proposed CP. Research on carbon markets would have a direct bearing on work on making international and domestic markets work for the poor (**priority 5B**).

Proposal for CGIAR Challenge Program 2nd Call (Phase 1: Idea Generation)
Mycotoxins, other Contaminants and Food Safety

Summary

The CGIAR Science Council recognizes that the work of the Harvest Plus Challenge Program on micronutrient enhancement is central to research on system priority 2C (*Enhancing nutritional quality and safety*) but that it is not yet adequately linked to the other CGIAR research targeted at other aspects of nutritional quality and safety, such as microbial toxin reduction or resistance¹. Indeed, many millions of people (both adults and children) suffer from food-borne toxins, especially in the developing world. In the tropics, staple crops (e.g. maize and groundnuts or rice), can be the source of mycotoxins, which are highly toxic metabolites produced by a number of fungi especially in drought-prone environments, unseasonably rainy environments, or high moisture during and after harvest. Human exposure to levels of aflatoxins from nanograms to micrograms per day occurs through consumption of maize and groundnuts (dietary staples in several tropical countries). The chronic incidence of aflatoxin in diets is evident from the presence of aflatoxin in human breast milk in West Africa, Sudan, Thailand, and the United Arab Emirates, and in umbilical cord blood samples in sub-Saharan Africa. Children exposed to aflatoxin may become stunted, underweight, and more susceptible to infectious diseases in childhood and later life. Frequent consumption of low levels of aflatoxin has been associated with chronic diseases like cancer. Furthermore, if small farm-landholders are to participate in global markets and take advantage of growing demand for food in the developed world, where food safety concerns are high, they will need greater capacity to implement food safety protection standards mandated by sanitary and phytosanitary regulations. At the Third United Nations Conference on the Least Developed Countries in Brussels on 14th May 2001, Secretary-General Kofi Annan stated that the World Bank estimated that if the EU reduced the regulatory level for aflatoxin (from 15 ppb to 4 ppb), the decision would significantly reduce income from sub-Saharan Africa exports. In addition, largely due to contamination of irrigation water, there is growing concern for the levels of arsenic and of cadmium in food crops, and especially in rice. For each 1000 people exposed to arsenic in drinking water above 0.05 ppm, there are 0.78 arsenicosis patients and there is a positive correlation between arsenic exposure level and arsenicosis prevalence. The most serious occurrences identified globally are in Bangladesh and West Bengal (India), e.g. in Bangladesh alone, 28 to 35 million people are exposed to arsenic concentrations in drinking water above 0.05 mg/L (the Bangladesh standard for acceptable limit of As), and 46 to 57 million people expose to more than 0.01 mg/L (WHO threshold). The CGIAR addresses issues of mycotoxin and other contaminants in its mandate crops and seeks options that ensure the health and income of the resource poor who struggle with this food safety concern and potential trade barrier. Through research-for-development undertakings, CGIAR centers focus on the major mycotoxins such as aflatoxins, *Fusarium* toxins, and ochratoxin, and on the major contaminants. For example, genetic enhancement, biological control, habitat management, crop management (including insect management), risk assessment, institutional capacity development, and public awareness are among the tools already employed to combat mycotoxins worldwide. A holistic approach involving non-CGIAR partners should be pursued to continue this fight against mycotoxins and other food contaminants. It should focus on, integrated crop management (including genetic enhancement), low-cost detection technology, and a participatory process for assessment. A research-for-development program network, facilitated by this CGIAR-led Challenge Program, may be therefore required to deal with mycotoxins and contaminants in food safety and trade. Such a Challenge Program on Food Safety must develop and implement a large scale research-for-development program together with the international human health research community with the aim of improving human health through agricultural innovations.

The Mycotoxin Issue: A Global Challenge affecting Food Safety and Trade

Food is a necessary part of our daily lives, and the quality and safety of this food is a concern for many people, including those at the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO), who have created the *Codex Alimentarius*, a food standard guideline. Mycotoxins are toxins produced by fungi that can contaminate staple foods, thus deteriorating food quality. Particularly this can happen in the developing world at all stages

¹ http://www.cgiar.org/exco/exco11/exco11_sc_strategy_implementation_priorities.pdf

of crop production: pre-harvest, harvest, and storage. The most well known mycotoxin is aflatoxin (Fig. 1), which is produced by a few species of the fungus *Aspergillus*, and commonly occurs in maize, groundnut, sorghum, and some root and tuber crops. Species of the fungus *Fusarium* also produce mycotoxins such as fumonisins, zearalenone, and deoxynivalenol in cereals such as barley, maize and wheat. While not as well highlighted in some other crops, mycotoxins can be severe also on rice and has been linked strongly to high moisture content and to poorly dried and poorly stored grain. Mycotoxin contamination is most acute in brown rice. Brown rice is a more nutritious food and the brown rice industry and the campaigns for consumption advocacy, such as that of the Asia Rice Foundation, would benefit from mycotoxin control. Because they are hazardous to health, mycotoxins are regulated through international markets and are considered non-tariff trade barriers.

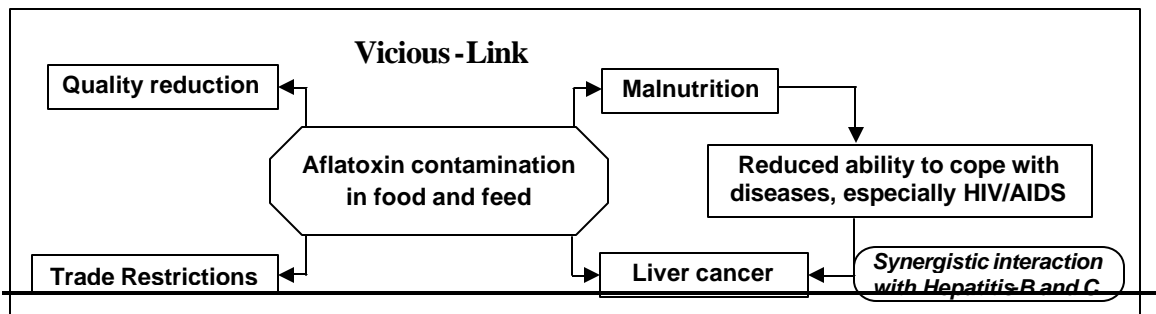


Fig. 1. Aflatoxin affects human health and trade

In the developed world, regulatory standards prevent exposure of humans and animals to dietary mycotoxins. These safety regulations reduce risks of morbidity and mortality that are associated with the consumption of contaminated food. In the developing world, particularly in Africa, monitoring and enforcement of standards are rare. If a fumonisin standard of 0.5 mg kg^{-1} were adopted worldwide [3-fold higher than US standard of 2 mg kg^{-1}], total export maize losses may exceed US\$ 300 million annually. Likewise, export losses from aflatoxins in peanuts may exceed US\$ 450 million under the current EU regulatory standard of $4 \text{ } \mu\text{g kg}^{-1}$: [almost 5-fold higher than US standard of $20 \text{ } \mu\text{g kg}^{-1}$]. The costs of food safety regulation include expenses in compliance and administration, as well as the deadweight loss associated with these costs. In countries with widespread aflatoxin occurrence, best quality foods are exported and poor quality foods are consumed locally, harming the health of local people. In addition to their carcinogenic and tumorigenic properties, many mycotoxins are anti-nutritional, causing poor growth and immune suppression in children and young animals. Hence, mycotoxins deteriorate food quality, are barriers to trade, pose serious risk to health, and have caused several deaths in Africa and Asia. Drought recurrence, further induced by climate change, might accentuate the mycotoxin problem.

Other Contaminants in the Food Chain

Arsenic On an average a Bangladeshi adult drinks about 4 L of water a day and consumes about 450 g of rice. Assuming water and rice has 0.05 ppm and 0.5 ppm arsenic (As) respectively the dietary intake from water and rice would be 380 μg (200 μg from water and 180 μg from rice). This is about double the FAO/WHO limit of dietary intake of arsenic. This does not take into account the As intake from other sources (especially leafy vegetables and meat). Apparently, rice contributes significantly to intake of As in Bangladesh and this could be true in other parts of the world especially where arsenic levels in drinking water are on the higher side and rice consumption is high. Therefore, it is important to explore mitigation options through breeding rice cultivars that do not accumulate As when grown in As-contaminated water and soil. The different amount of As in cultivated rice suggests it is possible to breed suitable rice cultivars.

Cadmium Excess exposure to cadmium (Cd) is detrimental to human health. Cd is a known carcinogen and can accumulate in human kidney for up to 30 years, resulting into kidney dysfunctions. At high doses it can induce severe respiratory problems and bone diseases. Ingestion of Cd in food is the principal pathway of Cd exposure for non-smokers. The average daily intakes from food in non-contaminated areas is at lower end of the 10 to 25 µg range of which approximately 0.5 to 1 µg is actually retained in the body (Cd uptakes more than double for smokers). Several studies also show that iron deficiency leads to increased Cd absorption, especially amongst pregnant women. Cd content of agricultural products is derived basically from contaminated soil and atmospheric deposition of Cd to exposed plant parts. Soil contamination results from excessive phosphate fertilization and use of sewage sludge for irrigation. Considerable Cd contamination, ranging from 65 to 125 ng g⁻¹, was reported in the rice fields in Japan, where considerable Cd finds its way to average person's diet. Significant Cd levels were also detected in unpolished rice grown in contaminated farms in Indonesia and China. Increase in phosphate fertilization in these countries, due to intensification of rice farming, may have increased Cd in the soil.

The Role of the CGIAR on Mycotoxins, other Contaminants and Food Safety Research

The Alliance of the CGIAR Centers recognizes that mycotoxins and other food contaminants are an important constraint to the goal of improving human health and well-being through agriculture. The CGIAR pursues various strategies for the management of mycotoxins and food contaminants from the field to the fork. For example, aflatoxin management practices in farmers' fields and storages were developed by CGIAR centers and being implemented through national partners. Work continues on dissemination of management practices, biological control through competitive exclusion strategies, and resistance breeding. Also, the prevalence of fumonisin contamination in field and stored maize has been surveyed, and management processes that influence their prevalence have been identified. Fungal-insect relationships both for *Aspergillus* spp. and *Fusarium* spp. have been investigated in the field and in storage, but still several aspects of research-for-development need further attention. These aspects include food basket surveys, strategies to reduce the impact of mycotoxins on trade, bio-ecological aspects of mycotoxin production, biological control, use of genomics to understand the hosts, the toxigenic fungi and their interactions, resistance breeding, impact of management options, and nutritional improvement on children's growth and health in high-risk zones.

Why a CGIAR-facilitated Challenge Program on Mycotoxins and other Food Contaminants

The CGIAR Science Council recognizes that the work of the Harvest Plus Challenge Program on micronutrient enhancement is central to research on system priority *X* (***Enhancing nutritional quality and safety***) but that it is not yet adequately linked to the other CGIAR research targeted at other aspects of nutritional quality and safety, such as microbial toxin reduction or resistance¹. An inclusive Food Safety Challenge Program involving CGIAR centers and partners worldwide with clear outputs and roles is expected to refine impact-oriented CGIAR research in this area. Furthermore, synergies between regional research efforts on mycotoxins and other food contaminants in the developing world need coordination for information exchange, transfer, and eventual implementation of tested mycotoxin and food contaminant management strategies by various regions. A research-for-development program network, facilitated by this CGIAR-led Challenge Program, may be required to deal with mycotoxins and other contaminants, food safety, and trade. Such a Challenge Program on Food Safety must develop and implement a large scale research-for-development program together with the international human health research community with the aim of improving human health through agricultural innovations and innovations in the management of the natural resource base of agriculture.

A mission-driven “Mycotoxins, other Contaminants and Food Safety” Challenge Program

The major mycotoxins that are researched in the CGIAR institutes are aflatoxins in maize, groundnut, sorghum, cassava, pistachio, almonds, and chili peppers, *Fusarium* toxins in maize, wheat and sorghum, and ochratoxin in cocoa and cashew². Likewise, research on As and Cd included in intensive rice cropping systems. Genetic enhancement (both through plant breeding and biotechnology), biological control, habitat management, risk assessment, institutional capacity development and public awareness are among the tools in the “CGIAR research-for-development kit” to fight mycotoxins worldwide. They ensued from strategic, applied and adaptive research by scientists of the international agricultural research centers in partnership with their counterparts in the national agricultural research systems and advanced research institutes. Decades of research-for-development by the CGIAR centers suggest that a holistic approach should be pursued to deal with mycotoxins and other food contaminants. The outputs of a Food Safety Challenge Program should therefore include:

- ▶ Integrated crop management and food processing packages;
- ▶ Low-cost detection technology for rapid analysis to facilitate trade;
- ▶ Improved understanding and models of host pathogen systems to guide mycotoxin management;; and
- ▶ High-level panel with scientists, NGOs, farmers, traders, consumers, health officers and policy makers to monitor intervention strategies and to organize awareness campaigns.

In this way, the CGIAR also addresses the Millennium Development Goals because mycotoxin- and other contaminant-free food is key for better health, especially to improve the health of post-weaning children (particularly in sub-Saharan Africa and South Asia), and to cope with malnutrition and HIV/AIDS.

Potential Impacts

This Challenge Program will provide both the framework and technologies to reduce the impact of mycotoxins and other food contaminants on trade and health (primarily women and children). This Challenge Program will span the market chain and direct benefits will impact small-scale producers, input suppliers, processors, retailers and consumers in all targeted countries and beyond. The benefits would include millions of healthy and productive people gaining from increased farm profits through enhanced market access to safe food. Policy makers and people at large will be informed of the risk of exposure to mycotoxins and other food contaminants.

Partners of a CGIAR-facilitated “Mycotoxins, other Contaminants and Food Safety” Challenge Program

Alliance of CGIAR Centers, Health and Nutrition Sector:[e.g., Univ. of Leeds/Centre for Epidemiology and Biostatistics, Medical Research Council (South Africa) and others in international human health research community], **NARS** [e.g. Bangladesh (BARC), Benin Rep, China (CAAS), Brazil (EMBRAPA), Ghana, India (ICAR), Kenya (KARI), Malawi (DART), Mozambique (INIA), Nigeria, South Africa (ARC), Togo, Uruguay (INIA)], **ARI** [e.g. ICIPE (Kenya), USDA/ARS, EU institutions researching on mycotoxins such as. Univ. of Bonn, Univ. of Wageningen, ISPA-forthcoming EU 7th Framework project, US Land Grant Univs. such as those in Peanut-CRSP, INTSORMIL, or Cereal Scab Initiative, Univ. of Arizona, Cornell Univ.), JIRCAS (Japan)], **CSO** [Rotary International, Catholic Relief Services, Oxfam, Plan International, World Vision], **Private Sector** [e.g. SME in developing world involved both in local and export trade, as well as in diagnostics] and **UN** [FAO, WHO]

² Ortiz, R., T. Ban, R. Bandyopadhyay, M. Banziger, D. Bergvinson, K. Hell, B. James, D. Jeffers, P. Lava Kumar, A. Menkir, J. Murakami, S.N. Nigam, H.D. Upadhyaya & F. Waliyar. 2006. CGIAR research-for-development program on mycotoxins. In Leslie, J.F., R. Bandyopadhyay & A. Visconti (ed.) *Mycotoxins: Detection Methods, Management, Public Health and Agricultural Trade* CABI Publishing, UK



A Concept Note for a CGIAR Challenge Programme to Combat Desertification (Dryland Degradation)

Why desertification?

One-third of humanity lives in the drylands, including the poorest nations on earth. The poorest peoples within these areas are agriculturalists (including herders). They struggle valiantly and with great ingenuity to eke out a living from lands that are especially vulnerable to degradation.

These regions urgently need help. The world agreed when 191 nations signed the United Nations Convention to Combat Desertification in the mid-1990s, following the Rio Earth Summit. The call to action was echoed in the World Summit on Sustainable Development, the New Partnership for Africa's Development, the Millennium Development Goals, and the Millennium Ecosystem Assessment.

Why the CGIAR is needed

The UNCCD has been less science-driven than the Climate Change Convention — a weakness that has hindered its progress. CGIAR Centers, meanwhile are making significant research investments in sustainable dryland development, but these efforts are fragmented among the different Centers and submerged within other thematic programs and initiatives, so their contribution to the global fight against desertification is insufficiently coordinated and under-recognized by the world at large.

The CGIAR has been urging Centers to 'elevate their game' by aligning their collective work more visibly with such major global and System imperatives, and broadening their partnerships to solve major, difficult research problems. The CGIAR is seeking Challenge Programmes (CPs) that contribute strongly to the new CGIAR Priority framework in ways that could not be effectively served by Centers working in isolation of each other and of external partners, or apart from global sustainable development priorities and frameworks.

Investing in CGIAR Priority 4

Land degradation, through the poverty and hunger that it induces, is a major concern of the CGIAR, as reflected in CGIAR Priority 4 ("Poverty alleviation and sustainable management of water, land and forest resources"). This dovetails with the interest of the UNCCD, which in Article 1 defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climate variation and human activities."

The drivers of desertification are especially operative at the landscape scale, yet most past focus has been on the field and plot scale, and on narrow sectoral or disciplinary areas. Oasis intends to especially target CGIAR Priority Area 4A ("Integrated land, water and forest management at landscape level"), but also 4C and 4D. As might be expected from an integrated NRM approach, it will also deliver outputs that contribute to Priority 5 (e.g. improving policies and markets, options to reduce the riskiness of dryland agriculture, and community-led models to increase impact); diversifying cropping systems and agrobiodiversity (Priority Area 3 and 1B), and making use of stress-tolerant germplasm generated by Priorities 2B, 2C, and 2D.

Crucial, but difficult research questions

Intractable research questions have lingered, constraining progress against desertification because of the absence of a coordinated global scientific effort to tackle them. Oasis will

bring together the right mix of inter-disciplinary advanced science with on-the-ground partnerships to make major gains in these areas. Oasis' wide consultations have indicated that the following high-level questions deserve priority attention:

1) How can we effectively assess and quantify dryland degradation at the landscape scale, a problem that includes subtle, long-term changes in natural resource capital and ecosystems function, involving not only biophysical measurements but valuations of ecosystems goods and services relative to the needs of both poor land users and national, regional and global societies that depend on these services?

This need was recently and strongly reiterated by the Millennium Ecosystem Assessment, which concluded in its Desertification Synthesis (p. 19) that “*without a scientifically robust and consistent baseline of desertification, identifying priorities and monitoring the consequences of actions are seriously constrained*” and “*understanding the impacts of desertification on human well-being requires that we improve our knowledge of the interactions between socioeconomic factors and ecosystem conditions.*” The CGIAR holds unique strength in leading-edge land assessment technology, including the interfacing of remote sensing and GIS with agricultural systems models; socio-economic assessment techniques; and ground-truthing through partnerships and participatory analyses at benchmark sites across the drylands of the developing world. By joining with external partners these strengths can be built upon to develop new capabilities. Examples include the development of effective, practical, accurate techniques and verifiable indicators to measure degradation and rehabilitation at landscape scales; methodologies for analyzing the interdependencies between agricultural and natural ecosystems; and methods for the valuation of ecosystem goods and services.

2) How can we quantify the landscape-scale dynamics that lead to losses of precious soil, water, nutrients, and biodiversity, and devise practical approaches to reduce those losses? Dynamic systems modeling, including interactions with climatic variability that interfaces between land degradation and climate change research (an area of study called for by both Conventions) are major research needs. Most past research has been at the field and plot level, while many of these dynamics are driven at the landscape level. Landscape-level analyses have been rare because they are difficult and require an integrated, inter-disciplinary approach. They must address complex and interacting hydrological, nutrient, topographical, and human land-management dynamics. The CGIAR must partner with advanced research institutions to advance in this direction, and the CP mechanism would provide the platform to make this happen.

Research has shown that even in the resource-constrained drylands, there is enormous waste of scarce natural resources. Much of the water that falls on these areas runs off or drains through without being used by crops or livestock, and nutrient flushes are leached into the groundwater because crop roots are too malnourished to capture them. Over-use of rangelands degrades their productivity and biodiversity, losses that could be prevented through community-based land management based on a better scientific understanding and in synch with appropriate policies.

Opportunities to enhance water and nutrient supplies through tighter resource cycling, landscape management (e.g. integrated tree-crop-livestock systems) to buffer variability in natural resource flows and balances (also easing the impacts of climate variability), and the supplementation of resources through water harvesting, smallholder-appropriate irrigation, and judicious fertilizer use, are just a few avenues of opportunity to be addressed.

3) How can policy, market and institutional dynamics that aggravate land degradation be overcome?

Inappropriate policies, market failures, and institutional deficiencies are major bottlenecks to sustainable dryland development, and prime causal factors behind desertification. Yet these

policies continue, because of a dearth of understanding, solutions, and means for enacting change within the policy-making institutions and frameworks of dryland countries. Land tenure insecurity, insufficient infrastructure (from roads to information to research investment), insufficiently-developed human capacities, lack of access by the poor to financial credit and other inputs, public neglect of the drylands, unfair subsidized competition, weak market structures, and other dysfunctions are just a few of many factors creating disincentives to sustainable dryland management.

The political commitments made by nations through the UNCCD process (National Action Plans) create a new entry point for attacking these issues. The UNCCD is working with nations to ‘mainstream’ these plans into national development agendas. However, major policy and institutional changes usually invoke tradeoffs that create both benefits and costs. Oasis will contribute policy analysis and advice to provide a stronger understanding of these tradeoffs, so that policymakers can become confident that they are making the right choices leading to more sustainable dryland management. Oasis’ unique combination of land-use science with world-leading agricultural policy analysis expertise creates a unique and much-needed resource, because policy on land degradation must meld both areas of expertise.

4) What motivates land-degrading vs. land-rehabilitating choices made by dryland users, and how can they be motivated to choose development pathways and livelihood options that lead to more sustainable, diverse, remunerative, and resilient dryland management?

Past attempts to counter land degradation largely overlooked the motivations of land users that ultimately cause, or correct land damage. These poor land users are more than just a means to an end, though; their welfare is the CGIAR’s direct concern. Yet the CGIAR, like others has often examined land-use from the limited perspective of only certain activities (e.g. crops or livestock or forests) rather than from the holistic, integrated lens through which land-users themselves perceive their environment. The challenge is to understand and ensure that the choices available to reduce land degradation are also attractive to land users, both individually and collectively, reconciling tradeoffs while rewarding more sustainable land care with increased, reliable income and other livelihood benefits that they value (employment, security, cultural values, etc).

To address the risk of location-specificity of such investigations, generating international public goods and lead to wide impact, a conceptual framework for understanding dryland development pathways is needed. To meet this challenge, Oasis will analyze the external and exogenous conditioning factors, land-user motives, and livelihood dynamics that influence livelihood change in the direction of more sustainable, less degrading land management. Additionally, the analysis of prior successes and failures will reveal lessons that are likely to be influential in similar target domains elsewhere. This development pathways framework will account for diverse options such as choices between diversification/specialization, intensification/extensification, subsistence/commercialization, rural/urban dynamics, on/off-farm activities, agricultural/environmental services, and others. The framework will help guide investments that provide land-users with choices that generate greater rewards from better land care.

5) How can knowledge-rich land management interventions be successfully shared with disadvantaged, isolated rural communities in ways that can be effectively up-scaled for wide impact?

Natural resource management interventions are often criticized as being inherently location-specific, requiring large investments to benefit small areas. Past approaches, however tended to overlook a large and potent resource for magnifying impact — namely, the knowledge and knowledge-sharing capacities of land-users themselves. Impressive examples of land-user innovation and large-scale impact in natural resource management have been described in all dryland regions, but rarely have scientific institutions analyzed or leveraged such mechanisms to extend their impact. Recognizing the potential in the drylands, the UNCCD within its

Articles repeatedly exhorts all parties to gather and make use of local knowledge through participatory approaches.

Much needs to be learned about ways to maximize effective co-learning between a global scientific team like Oasis and widely-dispersed, poor rural dryland communities faced with limited communications or extension infrastructure. What kinds of relationships and communications channels can be devised not merely to “get the word out”, but to enable and foster rich dialogue? How can good ideas found in one location be shared and understood at the level of principles, methods and tools that can be locally customized by another community to meet their special needs and priorities? How can co-learning bridges be built between policy-makers, scientists and land users that build consensus resulting in agreement on steps to improve land care? How can such intensive co-learning be up-scaled so that substantial impacts can be achieved across regions, including the harnessing of the new possibilities of information technology? How can impacts of such diverse and widespread innovations be assessed so that evidence of gains goes beyond the merely anecdotal to the scientifically-verifiable? Answers to these questions are vital not only for Oasis; they will have broad utility across the CGIAR agenda.

Outputs, impacts and exit strategy

To conform to the Challenge Programme intent, Oasis has been careful to focus on activities that are likely to lead to large-scale impacts within eight years. The paths to impact for the five over-arching research questions are suggested in the discussions above, but to add clarity we list here a few of the main categories of impact expected by year 8:

- Proof-of-concept of much more effective land degradation assessment techniques across strategic landscapes in sub-Saharan Africa, including a standardized methodology and set of indicators; these tools will be in use by a large number of development partners and developing countries, and in ecosystem goods and services valuation studies.
- Practical techniques devised and proven for improving the efficiency of use of, and increasing the recycling of nutrients and water in farming systems and for preserving dryland agro-biodiversity, and for the efficient supplementation of nutrients and biodiversity through external inputs; these techniques in wide testing and utilized on an additional million farms in target and spillover countries in Africa and Asia.
- Policy guidance on key strategic policy interventions and demonstrably influencing policy changes towards better dryland care and investment in target and spillover developing countries.
- Development pathways framework defined and being used by partners to develop livelihood options in target and spillover countries, including income generators such as higher-value market systems..
- New livelihood options for diversified tree-crop-livestock systems, dryland-advantaged high-value crop and livestock products, land care systems and other more sustainable livelihood options developed and being widely tested and implemented by partners on-farm.
- New models for co-learning partnerships between the global Oasis scientific network and the constellation of local, national, regional stakeholders devised and under implementation; models for scaling-up NRM impact through improved knowledge-sharing techniques under test and in pilot scale implementation in target and spillover countries.

Oasis' exit strategy is to ensure that development partner's capacities are built to carry the outputs forward to achieve impact continuing long after the eight-year Challenge Programme period is completed. This requires involving those partners from the beginning of the

Programme so that the outputs are conceived in ways that are relevant and readily adoptable. It also involves deployment of the outputs in pilot test studies led by the development partners, with Oasis backstopping, during the CP period to get the development momentum going. In the five research question discussions we explained how these partner capacities will be built: policymaker engagement, learn-by-doing joint research, stakeholder co-learning, and processes that facilitate the customization of basic principles through land-user participation.

Partnerships

Eleven CGIAR Centers that conduct dryland research are engaged in Oasis so far: CIAT, CIFOR, CIMMYT, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, BIOVERSITY, ILRI, and WARDA, with ICARDA and ICRISAT co-convening. These Centers bring a broad, multidisciplinary range of CGIAR capacity, expertise, partnerships, and geographic experience to bear on dryland degradation. They form a nucleus that will attract leading global players and investors to join Oasis.

Oasis Centers have participated in the UNCCD process since its inception in the early 1990s. Oasis has established strong partnerships with all the major actors in the field of combating desertification, such as UNCCD, TerrAfrica, UNEP, UNDP/DDC, UNESCO, OSS, regional NARS bodies, investors (GEF, IFAD, GM, USAID, others), NGOs, and many more.

Parties have been urging the UN Desertification, Climate Change and Biodiversity Conventions to increase their coordination, because many issues intersect all three of them. Oasis will also foster interaction with sister initiatives on climate change and biodiversity in the CGIAR as these develop, and will build linkages and benefit from the knowledge gained by sister Challenge Programmes and other initiatives, for example the lessons in integrated NRM compiled by the CGIAR's INRM Task Force.

Oasis benefits from large regional partnerships already engaged by Centers such as the Desert Margins Program (sub-Saharan Africa), the Mashreq and Maghreb Project (North Africa-West Asia), and the CACILM Project (Central Asia and the Caucasus). Oasis will also benefit from ICRISAT's strong relationships in India, the locus of dryland poverty in South Asia; and relationships being built by ICARDA and ICRISAT in dryland China.

Stimulating Market-led Agricultural and Rural Transformation

Making Markets and Institutions Work for the Rural Poor

Idea Note

Why stimulate market-led agricultural transformation for the rural poor?

Policymakers, development agencies, and national and international research organizations, including the Consultative Group on International Agricultural Research (CGIAR), face a major challenge in stimulating sustainable productivity and income growth for the rural poor while simultaneously ensuring growth in food supplies essential to feed a growing population. More inclusive and competitive markets and market-related institutions that improve the rates of return on the sparse assets the poor own and encourage uptake of more efficient production and post-harvest processing technologies are essential for opening up pathways out of rural poverty and kindling agricultural and rural transformation in low-income regions. To make markets work for the rural poor, we need to understand the reasons why the poor—or certain segments of the society—are systematically excluded from such processes, or why market-driven development may have an uneven impact on them. Greater participation in more remunerative marketing channels has spurred significant improvements in rural livelihoods and resulted in an inclusive agricultural transformation in many parts of the developing world, especially where good agricultural potential and access to complementary infrastructure exist. In such places, improved agricultural productivity and attractive off-farm livelihood opportunities through rural non-farm markets have helped small farmers and landless rural households participate in broad-based economic growth while simultaneously reducing real food prices, thereby benefiting the poor. However, this encouraging trend is noticeably absent in highly marginalized regions of Africa, Asia and Latin America, where less favorable agro-ecological conditions and weak institutional and physical infrastructure have hampered the development of markets and institutions that propel sustained improvement in livelihoods of the poor.

Strategic research issues

1. Understanding what ignites pro-poor market-oriented transformation

Despite the well-known empirical regularity of rural transformation – increased productivity and commercialization in agriculture, feeding diversification of the rural economy and still-more-rapid economic growth overall so that agriculture’s share of employment and output in a growing economy shrinks, even within rural regions – we are handicapped by a limited understanding of what ignites market-oriented transformation that benefits poor people. Hence the need to design and evaluate interventions that combine biophysical and social technologies to benefit the poor. However, the world continues to lack an integrated approach to the research challenges of pro-poor crop and value chain development. This critical knowledge gap hampers policymakers and development practitioners’ capacity to squarely address the Millennium Development Goals and other food security and poverty reduction objectives.

2. Identifying best practices in engaging the poor and small farmers in markets

The *System Priorities for CGIAR Research 2005-2015* clearly recognizes in priorities 5B, 5C and 5D, the urgent need to identify how best rural producers can be engaged in remunerative markets and producer organizations so as to increase productivity, incomes, and well-being. Markets are changing rapidly throughout the world as progressively more globalized finance, management models, and communications and transport facilities lead to dramatic and unprecedented transformations in agri-food market channels, as is perhaps most starkly reflected in the supermarket revolution. If the CGIAR and its partners fail to identify how (i) producers can organize and more fully reap sustainable gains from evolving market patterns, (ii) policymakers can induce more inclusive growth and commercialization, and (iii) businesses can more completely engage the rural poor, and (iv) technology development using CGIAR gene-based research outputs can fuel (or harm) market-development of crops important to the poor, they will miss a critical opportunity to help shape the path of agricultural and rural transformation that significantly enhances the upward socioeconomic mobility of the rural poor.

3. Developing knowledge support systems for evidence-based decision making

Effective policymaking and technology design for sustainable hunger and poverty reduction depend fundamentally on plausible evidence establishing the constraints to smallholder innovation, market entry and effective producer organization, and opportunities and incentives that enable the poor to overcome them.

However, knowledge on stimulating markets, developing technologies that give poor people a comparative advantage in meeting growing and changing demand, and institutional arrangements to promote upward socioeconomic mobility and inclusive agricultural and rural transformation is severely constrained by the lack of high quality panel data at different levels and over a wide range of cultures, agro-ecologies, and policy regimes.

Knowledge support systems also support evidence-based decision making by providing information that enables monitoring and evaluation. Critical features in understanding the changes brought about by market oriented development are prices; structure, conduct and performance of markets; and information flows through markets. Overlaying these data with information on other local, regional and national characteristics using GIS techniques provides policy makers with information on where and how markets are developing. In order for such systems to be effective and sustainable, they need to be embedded within country institutions. Thus, engagement with national governments (eg statistics agencies, ministries of finance and agriculture) and civil society actors (eg traders' organizations) will be critical as will efforts to enhance the capacity of such groups to collect and use these data.

4. Establishing a research-to-policy platform

One of the key challenges that constrains adoption and implementation of robust research results and innovations in poor regions is the lack of a platform linking actors along the research-development-policy continuum. A comparative advantage of the CGIAR in pro-poor, market-oriented R&D is its unique capacity to catalyze interaction between socio-economic research and biological science – both within and outside the CGIAR System – and to bridge the gap between development action and basic research. This is needed to stimulate pro-poor agricultural and rural transformation. The final pillar of this CP aims to address this need by establishing mechanisms for capacity building, institutional learning, policy dialogue, and advocacy at different levels (global, regional, national, and local) to influence research agendas, policy and institutional reforms favoring the rural poor. Resting on the edifice of evidence-based analyses of contextualized development opportunities and strategies, this component will identify alternative mechanisms for establishing viable research-to-policy platforms that bring together private and public sector participants. This will ensure that the required strategies and mechanisms to inform public and private sector policies based on validated and tested innovations, development pathways, and good practices for accelerating socioeconomic transformation in rural areas, are in place.

The issues mentioned above must not be analyzed only at the domestic local, sub-national and national levels isolated from the international (bilateral, regional and multilateral) levels. This challenge program shall incorporate also the international dimension of poor access to markets (through the economic effects and political-economy determinants of the subsidy and border-protection policies and barriers of entry, including new food safety and quality standards).

Research strategy and approach

We envision a coordinated, goal-oriented, and demand-driven program of research on Stimulating Market-led Agricultural and Rural Transformation (SMART) in authentic partnership with multiple CGIAR Centers, national agricultural research systems (NARS), advanced research institutes (ARIs), think tanks, universities, non-governmental organizations (NGOs) and private sector entities in both developed and developing regions. The CGIAR's uniqueness in bringing to fruition this Challenge Program lies in its ability to draw together diverse partners and the strong synergy between its biological scientists (breeders, agronomists, etc.) and social scientists (economists, sociologists, anthropologists, nutritionists, and psychologists), thus offering a rare and unrivalled capability to ignite high-impact research on making markets work for the poor. This strong multi-disciplinary base within the CGIAR and in its partnerships also provides a natural conduit by which the CP results can inform other areas of research on the resource systems that supply and are impacted by markets (for instance on crops, livestock, fisheries, forestry), to strengthen the impact of the proposed research.

This CP will mount an across-the-board research and capacity building effort that will ultimately benefit and empower the poor farmers in the often harsh and marginalized conditions of rural Africa, Asia, and Latin America. Specifically, SMART will accomplish the following:

- **Research** to create a platform within which CGIAR Centers and NARS can study (natural or managed) experimentation to conduct credible impact analysis that can inform technology design, improved

policy, projects, and decision-making by governments, donors, communities, and businesses at all scales. Research will assemble rich micro-level longitudinal data sets within which one can embed natural or managed experiments with policy reforms and institutional projects to credibly identify the effects of such reforms or projects on behavior and outcomes.

- **Train and build capacity.** Stimulating market-led agriculture and rural transformation is a multi-layered challenge. It requires the development of new generations of agricultural and social scientists within the NARS and CGIAR, trained in new approaches including mixed evaluation methods (participatory, randomized, survey-based), innovation systems, and the collection, maintenance and analysis of high quality longitudinal social science data. Since the capacity for analyses of markets, market institutions, agro-enterprise opportunities, and development strategies is inadequately developed and constrained by funds within current initiatives, there will be an extensive need to re-build and strengthen such skills at different levels within the NARS, the private sector, and the CGIAR. This would play a crucial role in unlocking the potential of markets and institutions for the benefit of the poor.
- **Policy dialogue and communication.** Translating research results into local development impacts requires effective policy dialogues and communication. Platforms to facilitate a two-way interaction between research, development, and policy formulation will be established as well as channels for more effective dialogue and collaboration with the private sector, whose role in market-led development is pivotal. Promising policy and institutional and technology innovation strategies for strengthening market participation and commercialization of agriculture will be tested, validated, and promoted.
- **Knowledge sharing, monitoring & evaluation and institutional learning.** The Challenge Program will create a unique opportunity for establishing a coalition of partners that will share a joint platform for action research and learning to accelerate pro-poor agricultural and rural transformation. A network using ICT-mediated knowledge sharing approaches will be established. Monitoring and evaluation will be implemented to stimulate institutional learning.

The SMART CP will enable unprecedented tracking of how market-based interventions and institutional innovations for the rural poor induce changes in the dynamics of poverty and asset accumulation. This will be done by identifying the drivers of upward socioeconomic mobility and agricultural transformation, particularly how technology innovation, markets, and innovations in agricultural institutions, determine shifts in investment and livelihood strategies of the rural poor. Such studies are readily adapted through new modules to address emerging issues, such as water scarcity, the role of women, social capital and social networks, migration, urbanization, HIV/AIDS, increasing connectivity in global markets and the effects of the supermarket revolution.

The work will be undertaken in two phases. The first three-year phase will emphasize capacity building and accelerate database development and analysis to inform policymaking and identify critical knowledge gaps for strategic analysis of development approaches in select areas. Building from the outcome of the first phase, the next phase will expand the micro-level knowledge base on production and marketing constraints, pathways in and out of poverty, household investment strategies, analysis of suitable local-specific intervention options, and impact of alternative policy options on livelihoods and resource use sustainability. Cutting-edge panel data, econometric methods, integrated qualitative-quantitative research methods, micro-level modeling efforts that explore village-level dynamics as well as macro modeling efforts such as regional computable general equilibrium (CGE) models, bio-economic modeling and GIS approaches, and with natural and managed experiments will be used to identify the causal effects of alternative intervention options. In addition, there is a role for detailed case studies that probe the key factors that have led to successful outcomes and reviews to distill the lessons from the wealth of studies that already exist.

Why a Challenge Program?

A Challenge Program is the natural way to organize CGIAR research efforts in support of System Priorities 5B and 5C, as recognized by the Science Council in its September 2006 background paper for ExCo-11, "Strategy for the Implementation of the CGIAR System Priorities for Research: Update and suggestions for a consolidated process." In the 2006 MTPs, each Center reported that it is working on these Priorities. Yet, production of useful new knowledge has not kept pace with changes in global and domestic agri-food markets. No clear set of comparable and generally accepted research methods related to markets and institutions has emerged. Perhaps more fundamentally, to date almost all CGIAR market research has comprised of one-off, cross-sectional studies that struggle to disentangle the complex causal ties between

market participation, institutional membership, productivity growth, and wealth accumulation. What remains unanswered is how markets and institutions shape dynamics and what is the payoff for a dollar invested today in a given type of market promotion or institution-building activity? Since market environments are easily adjusted through private sector activities and policy interventions, effective interventions can have favorable impacts on the poor, while poorly conceptualized ones can have ruinous effects. Hence the importance of rigorously establishing how to stimulate markets in a way that induces greater smallholder participation — whether directly as suppliers or indirectly as better-paid workers — promotes productivity growth through uptake of improved technologies, and sparks sustained wealth accumulation by the rural poor.

There is an urgent imperative for the CGIAR to identify how best the rural poor can be engaged in markets and in producer organizations to sustainably increase productivity and incomes. This requires a broader approach to identify bottlenecks at different stages and to develop and rigorously evaluate innovations in market institutions to reduce market failures. This calls for analyses of markets, policies and institutions at different levels, spanning micro, meso, macro and international dimensions, and with explicit incorporation of longitudinal analysis of impact.

The synergies across CG Centers and other partners would add value beyond individual institutional efforts. This will include reciprocal training on innovative methods and clear lessons learned through rigorous methods and different applications across varying conditions to establish what works consistently, what works conditionally, and what doesn't work. The work will attract leading global scholars to work with the CGIAR, thereby leveraging the best scientists and also add to its repertoire of superior science. This requires strengthening capacity to design and collect data using multiple research methods such as participatory evaluation, case studies and quantitative analysis of high-quality longitudinal micro-level data sets. Currently, there is minimum coordination among Centers in data collection and analysis. In addition, many Centers and NARS have limited capacity. Concerted efforts to coordinate capacity building and carefully designed comparative evaluations of diverse interventions across distinct subsectoral markets and locations can lead to the dissemination of expertise developed. Inter-CG Center partnerships alone are inadvisable since the basic research in theory and methods – and much of the cutting-edge empirical research in this area – originates in the ARIs, while the NARS (including universities in the South) have the local expertise and connections to most effectively contextualize results and introduce them into policy dialogues through advocacy and policy advice, including consulting to private industry.

Achieving global impacts

Learning from ongoing natural and managed experiments coupled with policy reforms and interventions, will have large-scale global impacts. Some of these include a) a better understanding of the critical limitations as well as potential of rural areas and identification of sources of growth; b) increased market access and integration; c) improved strategies for managing risk and vulnerabilities through income diversification; d) creation of awareness, evidence-based decision making and formulation of policy recommendations and development strategies by planners and policymakers; e) improved databases, methodologies, information, and training, leading to enhanced capacity for policy research in the national programs; and f) new policy, institutional, and technological options for stimulating market participation by and institutional innovation to benefit the rural poor. Some of the outputs include:

- Policy-relevant knowledge on the evolution and determinants of rural poverty and the drivers of market-led transformation;
- Best practices and institutional innovations for engaging the rural poor in markets;
- An analysis of the types of public/private partnership that work best in promoting pro-poor market-led rural development, including analysis of the roles and areas of intervention most amenable to effective collaboration;
- Strategies and policy options for unlocking the potential of markets, technologies and rural institutions to hasten income generation and upward socioeconomic mobility in marginal areas;
- Tools and decision support systems to facilitate and inform future sources of growth and agricultural development in marginal areas;
- Platforms for capacity building, learning, and informing policy decisions; and
- Historical information and longitudinal database at various levels (household, community, districts, and state/national) that support evidence-based decision making.