



System Priorities  
for CGIAR Research  
2005–2015

December 2005



Consultative Group on International Agricultural Research  
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## Summary

The overall goal of the research carried out by the Consultative Group on International Agricultural Research (CGIAR) and its partners continues to be to improve the livelihood of low-income people in developing countries through reduced poverty, food insecurity, malnutrition, gender inequality, and child mortality, to help cope with HIV/AIDS, and to foster better institutions, policies, and sustainable management of natural resources of particular importance to agriculture and poor people. The goal is fully compatible with the Millennium Development Goals (MDGs) and the CGIAR aims to make the greatest possible contribution not only to their achievement but also to the achievement of similar goals beyond 2015. This aim is reflected in the effort to set priorities for CGIAR research to 2015 reported here.

The vision for the longer term is one in which the CGIAR is a provider of international public goods through agricultural research aimed at the alleviation of poverty. The CGIAR aims to progressively devolve some current research [particularly aspects of breeding for germplasm enhancement and site-specific natural resource management (NRM)] to national agricultural research systems (NARS) with increasing capacity. Devolution and enhanced delivery to the poor in different localities will be effected through a range of partners. The CGIAR will move towards the solution of the complex system issues undermining moves out of poverty and the success of agriculture in developing countries, supported by genomics research and provision of science-based policy advice. It is clear that the staging of such a strategy will be different in regions where NARS have different strengths. Special attention will be paid to the building of partner capacity in sub-Saharan Africa (SSA).

Through an exhaustive Science Council (SC)-led process of participatory information gathering, analysis, synthesis, and debate, a set of 20 research priorities for the CGIAR, organized within five priority areas, has emerged. Three key criteria were employed to help identify the priorities: (i) the expected impact on poverty alleviation, food security

and nutrition, and sustainable management of natural resources taking into account the expected probability of success and expected impact if successful; (ii) whether the research is of an international public goods nature; and (iii) whether there are alternative sources of supply of the research and whether the CGIAR has a comparative advantage in undertaking the research.

The following **five System Priority areas for CGIAR research** resulted from the priority-setting efforts (they are not ranked):

1. **Sustaining biodiversity for current and future generations**
2. **Producing more and better food at lower cost through genetic improvements**
3. **Reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products**
4. **Poverty alleviation and sustainable management of water, land, and forest resources**
5. **Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger.**

CGIAR research is prioritized to contribute directly or indirectly to seven of the eight MDGs (Table 1). International publicly funded agricultural research, undertaken by the CGIAR and its partners, is particularly effective in achieving **MDG 1 – the reduction of poverty and hunger**, partly by helping smallholder farmers escape poverty, create wealth, and improve their competitiveness in the increasingly globalized market place, and partly by creating employment among the rural poor and making food available to poor consumers at lower prices. Thus there are four principal ways in which the CGIAR research is prioritized to contribute to this MDG.

Firstly, past emphasis on **research to help smallholders produce more staple food and fodder per unit of land, labor, and water in an environmentally sustainable manner** will be maintained. This research will include genetic enhancement of selected staple

**Table 1.** Direct and indirect impacts of CGIAR priority research on the MDGs

Millennium Development Goals	System Priority areas for CGIAR research <sup>a</sup>				
	1	2	3	4	5
1 Reduce extreme poverty and hunger	+	++	++	++	++
2 Ensure universal primary education		+	+		
3 Reduce gender disparity		++	++	++	++
4 Reduce child mortality	+	+	+	+	+
5 Improve maternal health	+	+	+	+	+
6 Combat HIV/AIDS, malaria and other diseases		++			++
7 Ensure environmental sustainability	++	++	+	++	++
8 Develop a global partnership for development	++	+		++	++

<sup>a</sup> + denotes indirect impact ;  
++ denotes direct impact

food crops as well as improved agroecological production systems. Genetic enhancement will focus on traits of particular importance to the poor, to include resistance to selected biotic and abiotic stresses with emphasis on drought and salinity, and improvement in the nutritional content of staple foods. In addition to the benefits derived by smallholder farmers, research on genetic enhancement and other productivity-enhancing research is expected to result in large benefits to poor consumers in both rural and urban areas through reduced unit costs and prices. While the CGIAR will develop a genomics platform to facilitate genetic enhancement, it is envisaged that an increasing portion of maintenance research and agroecological research will be taken over by national agricultural research institutions (NARIs).

Secondly, greater emphasis will be placed on **research to enhance incomes of smallholders through the production of high-value commodities and products**, with emphasis on fruit and vegetables, non-timber forest products (NTFPs), livestock, and fish. The very limited research currently undertaken by the CGIAR on fruit and vegetables will be expanded significantly along with increased research on processing of agricultural commodities and other aspects of the supply chain to help generate incomes for both smallholder farmers

and rural labor. Expanded productivity and production of fruit, vegetables, NTFPs, livestock, and fish offer great opportunities for income gains for the rural poor, partly because of the expected strong future demand for such products and partly because of the opportunities for adding value and employment in processing and other supply chain activities. Research will be undertaken to help enhance smallholders' incomes from livestock and fish in low- and high-productivity areas and to better manage intensification of livestock production. Improved nutrition and family income underpin the chances to enhance primary education.

Thirdly, **research on sustainable management of natural resources** will be prioritized to achieve sustainability and poverty alleviation goals, thus contributing to both **MDG 1 and MDG 7 – ensuring environmental sustainability**. The protection of biodiversity through the conservation of germplasm of key food staples, underutilized species, fish, and indigenous livestock will be prioritized, along with research on water, land and forest management, and related institutions and policy. Integrated land, water, and forest management research will be pursued at the landscape level along with research to facilitate agroecological intensification in both low- and high-potential areas. In response to increasing water scarcity,

research will be undertaken to improve water productivity at the farm, field and basin levels and to help ensure access to forest and tree resources by the poor. Research will be pursued to better understand and manage aquatic ecosystems for the benefit of the poor and the ecosystem. Research to help enhance potential positive – and cope with negative – effects of climate change will be prioritized.

Fourthly, **research on institutions, markets, and policy** will be prioritized to assist governments, farmer associations, and others to facilitate effective production, market development, trade, and related changes needed to enhance the benefits to the rural and urban poor. Science and technology policy, as well as policy to support sustainable management of natural resources, will be important parts of this research. Research on institutions, governance, trade, and policies, which contributes to the achievement of **MDG 8 – develop a global partnership for development**, is an integral part of such research. Emphasis will be on research that facilitates poverty alleviation and agricultural development within the emerging global changes in trade and science.

All CGIAR **research will include gender-specific analysis** to identify technologies and policies that are likely to enhance gender equality and empower women, thus contributing to **MDG 3**. Reduced poverty, food insecurity, and malnutrition are linked to **reduced child mortality (MDG 4)** as well as **improved maternal health (MDG 5)**. Improved nutrition is particularly important for the fight against **HIV/AIDS (MDG 6)**. Furthermore, increased labor productivity, to help cope with the effects of HIV/AIDS will be pursued in both genetic enhancement and sustainable management of natural resources. Thus, while the research priorities are aimed first and foremost at improved livelihoods and sustainable management of natural resources, they are developed with these related MDGs in mind.

The System Priorities (Table 2) are structured around five major groups of strategic research activities aimed at producing common outcomes. In aggregate, the priorities provide a set of specific goals for a portfolio of research activities around which the CGIAR will organize its scientific

and related capacities. The CGIAR also carries out research on particular cross-cutting topics or ecoregional issues through a number of implementation mechanisms; such as Systemwide Programs (SWP), Ecoregional Programs, Challenge Programs (CP), Task Forces and other modalities. It is anticipated that programs addressing important global or ecoregional research may be formed, drawing on appropriate combinations of priority science and partnerships, to address particular issues for defined lengths of time (see final chapter and Figures 2–4). **Cross-cutting programs** will be developed from elements of the 20 research priorities, with any additional research that is needed being provided by partners.

In addition, the CGIAR priorities listed in Table 2 respond to regional and national needs for international public goods research. Collaboration with regional organizations will occur where there is a match between the needs for international collaboration, as expressed by the region, and the CGIAR priorities. Since CGIAR priorities have been set with input from the regions, and given that the CGIAR has participated in deliberations on regional priorities, considerable complementarities exist between the two sets of priorities. However, since the CGIAR is global, and there are differing comparative advantages in tackling aspects of regional research, a complete match should not be expected.

The SC, building on the consultative stage of the priority-setting process described above, has reviewed the total research portfolio of the CGIAR projected to 2015. Seeking to meet key needs and capitalize on new science, the intention is to focus the CGIAR research agenda on a smaller number of Priority areas for research. The Priorities have goals commensurate with the mission of the CGIAR, and encapsulate major areas of science within the CGIAR's comparative advantage in its assistance to developing-country agriculture. Priorities are set so as to have measurable outcomes – specific links can therefore be made between priority setting and future monitoring and review functions.

The SC proposes that the Alliance of CGIAR Centers (formerly Future Harvest Centers) and the CGIAR Members agree to allocate

**Table 2.** System Priorities for CGIAR research 2005–2015

<b>Priority area 1: Sustaining Biodiversity for Current and Future Generations</b>	
Priority 1A	Conservation and characterization of staple crops
Priority 1B	Promoting conservation and characterization of under-utilized plant genetic resources to increase the income of the poor
Priority 1C	Conservation of indigenous livestock
Priority 1D	Conservation of aquatic animal genetic resources
<b>Priority area 2: Producing More and Better Food at Lower Cost through Genetic Improvements</b>	
Priority 2A	Maintaining and enhancing yields and yield potential of food staples
Priority 2B	Tolerance to selected abiotic stresses
Priority 2C	Enhancing nutritional quality and safety
Priority 2D	Genetic enhancement of selected high-value species
<b>Priority area 3: Reducing Rural Poverty through Agricultural Diversification and Emerging Opportunities for High-value Commodities and Products</b>	
Priority 3A	Increasing income from fruit and vegetables
Priority 3B	Income increases from livestock
Priority 3C	Enhancing income through increased productivity of fisheries and aquaculture
Priority 3D	Sustainable income generation from forests and trees
<b>Priority area 4: Poverty Alleviation and Sustainable Management of Water, Land, and Forest Resources</b>	
Priority 4A	Integrated land, water, and forest management at landscape level
Priority 4B	Sustaining and managing aquatic ecosystems for food and livelihoods
Priority 4C	Improving water productivity
Priority 4D	Sustainable agroecological intensification in low- and high-potential areas
<b>Priority area 5: Improving Policies and Facilitating Institutional Innovation to Support Sustainable Reduction of Poverty and Hunger</b>	
Priority 5A	Science and technology policies and institutions
Priority 5B	Making international and domestic markets work for the poor
Priority 5C	Rural institutions and their governance
Priority 5D	Improving research and development options to reduce rural poverty and vulnerability

(following a transition period not to exceed three years) 80 percent of the total CGIAR budget to the five Priority areas described in the following sections of this Report. It is recommended that donors provide funding for these priority areas in the future.

It is suggested that the CGIAR spend up to 20 percent of its budget outside the System Priorities for Research. The SC further encourages Centers to utilize at least half of that 20 percent for exploratory, innovative research work to develop new science and potential new future priorities.

Capacity building is a key activity to meet the overall goals of the CGIAR. Reflecting the CGIAR's partnership approach to agricultural research, program-associated capacity building, as well as research on institutional strengthening is considered to fall within the 80 percent budget allocation. Only the more

iterative types of course-related training unrelated to research are considered as falling within the additional 20 percent of budget allocated for other activities.

To adjust to these priorities (and to further refine them in the process) it is proposed that during the years 2006–2008 a program alignment be undertaken by Centers through Medium Term Plans (MTPs) and SC review of individual Center, CP and SWP MTPs.

As soon as the priorities have been agreed upon, the SC suggests that discussions be undertaken to refine the implementation practice for the priority research. This Report raises some of the strategic issues involved in the implementation of research priorities.

Center programs are expected to be time-bound and increasingly include exit strategies allowing for the products, and the program

itself, to be taken over by NARS. The existence of strong NARS accelerates opportunities for transferring aspects of research to partners and raises the requirement that the CGIAR not duplicate existing capacities. However, the continued existence of weaker NARS in several regions means that *strategic choices about the speed and staging of research, capacity building, and ensuring regional spillovers* from CGIAR research must be made according to partner strengths.

The *gendered nature of agricultural production* will influence research in areas with large numbers of women farmers (e.g., SSA), as well as influencing approaches to defining pro-poor traits for improvement, market chain research, biodiversity conservation, and opportunities for land tenure, among others.

There are opportunities to augment approaches and the rate of progress towards CGIAR goals through *the mobilization of new science*. For example, molecular biology-based research, including, where appropriate, genetic engineering and genomics, will play a major role in future agricultural research in many priority areas. However, the SC believes that the CGIAR should use the most appropriate research approach for a particular research endeavor, whether that relates to molecular biology, traditional plant breeding and related research, or agroecology.

It is expected that the proposed research will be carried out in *strong partnerships* with relevant agents. National and regional

agricultural research systems, advanced research institutions (ARIs) and agencies, the private sector, and non-governmental organizations (NGOs) all have a vital role to play in achieving our common goals. Strategic choices in dealing with the 'other 96 percent' of the world's agricultural research effort will be required, with the nature of the partnerships determined by the particular research. Elements of a successful strategy for collaboration with the private sector need to be integrated from Center to System level, through active research on *public-private partnerships (PPPs)*. The SC is interested in further strengthening the relevance of research through innovation systems and participatory research. Implementing the Priority research will also require that the CGIAR augment its *roles as catalyst, integrator, and disseminator of knowledge* in the overall global agricultural research system.

The aims of the implementation strategy will be to enhance the system's efficiency in tackling major strategic objectives, to support system priorities through a move towards corporate donorship, to remain focused on international public goods research (rather than development) at Centers and to limit unproductive contract research.

The SC will undertake a dynamic review of the priorities (including strategic studies and brief consultative processes) and expects to update the Priorities Report approximately five years from now, with a major reconsideration of the priorities in 10 years' time.



## Introduction

Constant change in the interlocking fields of science, agriculture, global trade and development requires that a research organization like the CGIAR System periodically reviews the global context in which it works, in order to adjust its research priorities to continue to meet its goals in the most effective manner. This report describes the approach and collaborative process adopted by the SC to help define the CGIAR's future priority areas for research over the period 2005–2015. Five Priority areas for CGIAR research are presented.

The Millennium Development Goals (MDGs) represent an international consensus on tackling the issues of poverty, malnutrition, hunger and other key constraints to development. CGIAR research is prioritized to contribute directly or indirectly to seven of the eight MDGs that can be addressed through agriculture, the continuing challenge of maintaining sustainable food production systems, the new agricultural paradigms encouraging competitiveness, and the situation of the poor in low-potential environments.

International publicly funded agricultural research, undertaken by the CGIAR and partners, is particularly effective in achieving **MDG 1 – the reduction of poverty and hunger**, partly by helping smallholder farmers escape poverty, create wealth, and improve their competitiveness in the increasingly globalized market place and partly by creating employment among the rural poor and making food available to poor consumers at lower prices. Thus there are four principal ways in which the CGIAR research is prioritized to contribute to this MDG. Reduced poverty, food insecurity, and malnutrition are linked to meeting the goals of **reduced child mortality (MDG 4)** as well as **improved maternal health (MDG 5)**. Improved nutrition is particularly important for the **fight against HIV/AIDS (MDG 6)**. Research on sustainable management of natural resources will be prioritized to achieve both sustainability and poverty alleviation goals, thus contributing to both **MDG 1** and **MDG 7 – ensuring**

**environmental sustainability**. Research on institutions, governance, trade, and policies, which contributes to the achievement of **MDG 8 – develop a global partnership for development**, is an integral part of the above research. Emphasis will be on research that will facilitate poverty alleviation and agricultural development within the emerging global changes in trade and science. The above-mentioned research will include gender-specific analysis to identify technologies and policies that are likely to **enhance gender equality and empower women**, hence contributing to **MDG 3**. Thus, while the research priorities are aimed first and foremost at improved livelihood and sustainable management of natural resources, they are developed with these related MDGs in mind.

The SC's intention is to link the establishment of priorities (and future priority setting) to the monitoring, evaluation and performance-measurement functions, vital for the efficient conduct of agricultural science and to meet the goals of the CGIAR and its global partners.

### The need for System Priorities

The SC's aim is firstly to help develop a more cohesive and better-focused, high-quality research program to alleviate poverty, hunger and malnutrition. Despite many individual research successes in the past and the CGIAR's important role in brokering and catalyzing international public goods research, there is an opportunity for the CGIAR System to have greater impact through a more consolidated research focus.

Secondly, there is a need to avoid dispersion of research. There has been a tendency to separate CGIAR research initiatives into a large number of projects (currently around 200) of different sizes, some of them rather small. At the same time that the CGIAR has undertaken a widening of its goals and its total budget has increased, there has been a relative decline in core funding, accompanied by selective funding of a large number

of specific projects negotiated with donors. Many such projects address particular (local) development problems and do not focus on the core strength of the CGIAR, i.e., as a research supplier of appropriate international public goods, knowledge, technology and capacity building that can be used widely. Moreover, the Centers compete for these funds, often leading to overlaps in their portfolios.

Thirdly, there is the requirement to mobilize research capacity across the CGIAR System. Projects addressing difficult issues for sustainable poverty reduction (e.g., smallholder productivity gains in Africa) need sharply focused, long-term and multi-pronged approaches involving research on different commodities, themes, and disciplines. The CGIAR as a system has unique comparative advantage in mobilizing research across Centers and in organizing complex coordinated projects. The CGIAR should, however, exploit this advantage further.

Fourthly, there are opportunities to enhance coordination and cooperation. Centers have shown increased willingness and capacity to coordinate and cooperate (through the roles of Center Directors' Committee (CDC), Committee of Board Chairs (CBC), System Office of the CGIAR, and development of the Alliance of the CGIAR Centers). Institutional mechanisms already exist to implement System-level projects through *ad-hoc* coalitions of Centers, SWPs, Task Force initiatives, and CPs, and the SC role in priority setting allows it to define, and to oversee the implementation of, ambitious Systemwide initiatives.

Well-defined System Priorities will help to develop more effective partnerships with NARS and advanced research centers, increase participation by stakeholders in priority setting, and assist donors in allocating their resources to the CGIAR projects with potentially large impacts. There are additional opportunities to mobilize contributions from other providers of research and extension activities to enhance the impact of the CGIAR's science and approaches. Specially taking into consideration that the CGIAR, although very relevant, accounts for only a fraction of global research efforts undertaken by several international,

regional and national organizations such as ARIs, private companies, national research institutes, universities, and foundations.

Fifthly, setting system priorities provides the opportunity to enhance accountability. CGIAR System Priorities, broadly accepted by stakeholders, and internalized into Center MTPs, will help put in place a performance measurement system to translate logframes and milestones into objective indicators of performance.

### A new process of CGIAR priority setting

The Alliance Centers and the CGIAR were created to apply science to the solution of problems related to poverty, agriculture, natural resources, food and nutrition. In the past, priorities for conducting this sort of research were set by decisions on relative priorities and resource allocation among commodities, facilitated by congruence analysis based on the value of production.<sup>1</sup>

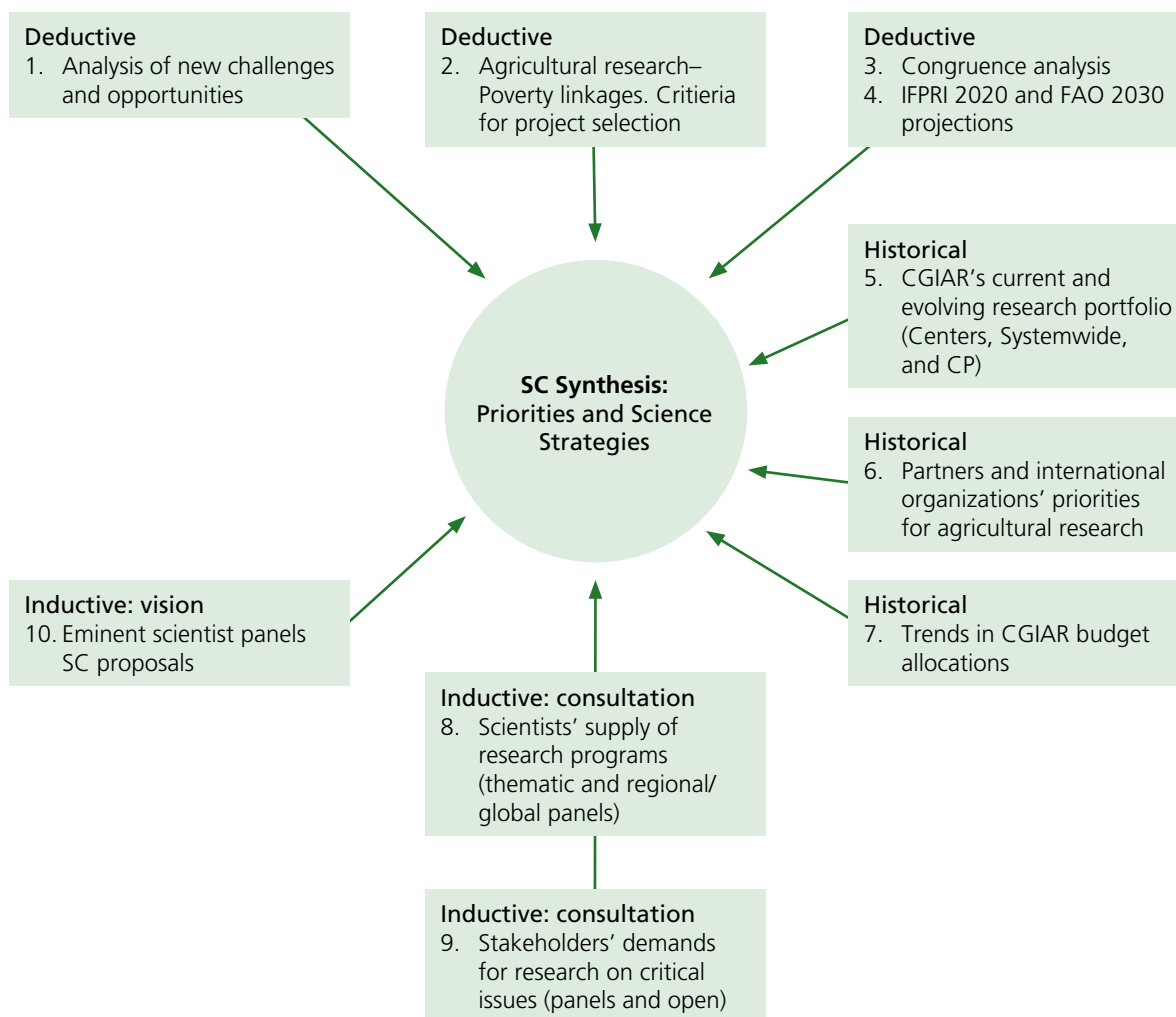
As requested by ExCo, the SC took the leadership in initiating a process of System-level priority setting. This consisted of a multi-pronged approach that had the distinguishing character of being both analytical and broadly consultative with stakeholders (including grassroots and NGOs), donors, and scientists both within the CGIAR System and in other research institutions (NARS and ARIs). The development of a preliminary set of System Priorities (and their associated sub-priorities) derived from a process of information gathering, analysis and consultations, and utilized three major approaches (Figure 1):

- **Deductive approaches** including a broad analysis of new challenges and opportunities; the development of a set of criteria to achieve poverty reduction through agricultural research that can be used to

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1 The former means of priority setting is now considered of limited value because of: (i) the complexity of goals, (ii) the value of production criterion not working for non-market values (e.g., involved in prioritizing germplasm conservation, or assistance to NARS), (iii) inability to encompass new issues and opportunities, and (iv) change in funding modalities.

**Figure 1.** Science Council’s approach to identifying CGIAR Priorities and Strategies



screen future proposals; an updated congruence analysis to establish the future relative importance to be given in the overall budget to commodities (15 crops) and sectors (crops, livestock, forestry, and fish) by regions, and the use of global and regional projections of future supply and demand for commodities in agriculture.

- **Historical approaches** have included review of the current and evolving research portfolios for: (i) Centers and the CGIAR; (ii) the research portfolios for other selected research institutions and international organizations indicative of the ‘other 96 percent’ contributing to agricultural research and development globally; and analysis of long-run trends in the CGIAR’s budget allocation across outputs, crops, sectors, undertakings, regions, and Centers.

- **Inductive approaches** have centered on a broadly consultative approach to identifying the demand for new research by stakeholders and of opportunities for the potential supply of research by expert scientists including members of the SC.<sup>2</sup>

### Results from deductive approaches

Agriculture, and the CGIAR’s research and research-related activities on agriculture in developing countries, can contribute directly to meeting several of the MDGs (as outlined

2 A more complete description of the approaches and analyses supporting the Consultative process, and the outcomes of this process, can be found in the *Report on CGIAR Priorities and Strategies for the Period 2005–2010: Outcomes of the Consultative Process* (Revised August 2004, Science Council Secretariat, Rome, Italy, 240pp).

above). However, against these over-riding requirements, there is acknowledgement that the international context for agriculture is itself changing. The SC's approach examined these changes in order to identify agricultural research needs appropriate for meeting the global challenges.

**Approach 1 identified New Key Challenges and Opportunities in Agriculture.** Within the last half a century the world has changed rapidly and so has the **food security challenge**. Urbanization and globalization are becoming pervasive, **private sector involvement** in agricultural research has been increasing rapidly around the world, and global **concerns about the sustainable management of resources** have been rising. The effects of **population pressure and poor land and water use practices** are noticeable in the: (i) degradation of natural systems such as forests and fisheries; (ii) degradation of intensively cultivated lands; (iii) exploitation and erosion of marginal lands; (iv) water resource depletion; and (v) depletion of genetic diversity. At the farm and landscape levels, it is necessary to target research and development specifically towards technologies that enhance productivity while at the same time conserve resources. Improving opportunities for **protecting and increasing incomes of the poor** may be as important to their food security as providing them with new productivity-enhancing technologies. Since the Green Revolution, crop staples have been a key component of nutrition and food security. However, there are many other food and non-food commodities and resources, utilized in farming or taken from nature, which **ensure nutrition, productivity, incomes, and better livelihoods** of farmers, fishers, forest dwellers, and pastoralists in developing countries. Trade liberalization and increased competition facing small-scale farmers mean that the global food security challenge has over time become increasingly **multidimensional**. **Climate change** and instability are projected to become increasingly apparent through the next decades. Developing nations will require assistance to orient agriculture and agricultural practices into less-vulnerable choices and pathways.

**New Scientific Opportunities.** Recent years have witnessed an unprecedented increase in the power and range of molecular biology

to amplify and extend investigations across plant and animal species and to address the organisms, disease agents and abiotic stresses of most concern to developing-country agriculture. A parallel explosion in computing and informatics has augmented data acquisition and storage, synthesis and transfer. Modelling, and the ability to combine data from different sources, can not only inform germplasm studies and the search for new genes and functions, but also promises to revolutionize understanding of processes affecting the management of natural resources. Thanks to the strategic accumulation of data, tools, and modelling resources in the coming decade, one can expect the development of a more predictive approach to agriculture, the evolution of land and seascapes and the effects of climate, thus providing insights for the development of long-term agricultural and environmental policy.

**Responding to the Globalization of Markets.** Globalization will have impacts on growth and income distribution. Without targeted research to help develop new opportunities, the poor may be affected adversely by the liberalization of global markets. Reducing transactions costs associated with market access will be a key factor in enhancing the competitiveness of small-scale farmers. National economies and users will face choices between responding to the **economic incentives offered by new markets** versus **multiple use** approaches optimized for other parameters such as social and environmental services.

**Potential and Challenges of the 'New Agriculture'.** There are opportunities for developing countries to take advantage of the new scenario for the future of agriculture. This will include balancing needs for the production of traditional staples, with diversification towards high-value products (including, for example, fruit, vegetables, fish, livestock products, horticulture, medicinal plants, etc). There will be greater focus on post-harvest improvements to increase cost efficiencies, or to increase the value added to products. Such market-oriented adjustments and increased competitiveness require greater consideration of product quality, and emphasis on production to market food chains, labelling (for product and human health and environmental

safety), and on managing and paying for environmental services. Organization of small-scale farmers will be required to ensure their access to these supply chains and markets.

**Regional Emphasis.** Meeting the MDGs, and the vision of the CGIAR, will be most difficult in Africa. Sub-Saharan Africa is characterized by widespread poverty, the high relative dependence of populations upon agriculture or the extraction of natural resources, the low performance of agriculture at the aggregate level, poor infrastructure, and additional challenges from human disease, climatic instability and civil unrest which serve to increase the vulnerability of large numbers of people. There is the opportunity to join in consolidated partnership approaches for the enhancement of African agriculture laid out by regional priority setting and the New Partnership for Africa's Development (NEPAD). Global research approaches can be expected to provide relevant outcomes and spillovers to areas with common concerns (including South Asia, the West Asia/North Africa region (WANA) and some countries in Southeast Asia).

**Approach 2 considered World Poverty Concerns.** In the last 50 years, the world has changed fundamentally from one that was predominantly rural based to one where almost half the population is living in urban areas. Using agricultural research to reduce urban poverty through the resulting economic growth, employment creation, cheaper foods, and improved quality diets will consequently be increasingly important in the future for the CGIAR in meeting its poverty reduction objective.

The very poor tend to be associated with marginal production environments in rural areas. New technologies appropriate for these marginal and risky environments are still largely missing, and constitute an evident priority for the CGIAR. Identifying small-scale farmer constraints to technology adoption and use continues to be a priority issue for consideration and planning.

Whilst the overall contribution of agriculture to GDP tends to decline with development, sustainable productivity improvement

through agricultural research remains a key means to assisting the poor and marginalized within wider development strategies. The indirect effects of agricultural productivity gains in poverty reduction must, therefore, remain a priority for the CGIAR, particularly in reaching the landless and urban poor.

**Approaches 3 and 4 detailed World Food Concerns.** Projections made by the International Food Policy Research Institute (IFPRI) suggest that many of the CGIAR's major commodities remain critical for developing countries' access to food. Rising food deficits in SSA and WANA are important in rice, maize, soybeans, and low-value fish. Wheat deficits [in all regions except Latin America and the Caribbean (LAC)] are largely associated with rising urban consumption, and alternative sources of supply exist in the international market. Deficits in ruminant meat in WANA, Southeast Asia, and East Asia are predicted to be important. The implication is that maintenance research on productivity of the identified staples, and new emphasis on non-traditional exports as sources of foreign exchange earnings would be appropriate. World market prices for wheat, maize, and rice, adjusted for inflation, are the lowest they have been in the last century. Commodity prices for pulses have also dropped – to about half of what they were in 1989/90.

Towards 2030 [according to the Food and Agriculture Organization of the United Nations (FAO)] the developing countries will become increasingly dependent upon cereal imports. The most serious imbalances for cereals will be experienced in wheat and coarse grains, in WANA, East Asia, and SSA. Increased yields will be met primarily through increased intensification and technological efficiency in reducing yield gaps. New science has an important role to play in meeting these needs. Changes in the commodity composition of food are expected to occur in developing countries with a relative stabilization of *per capita* consumption of cereals, roots and tubers, and pulses (the latter somewhat in decline), and marked increases in vegetable oils, meat and milk, and dairy products. There will need to be relatively large increases in

the production of meat (beef and veal, mutton and lamb, pork and poultry) in developing countries. The annual trade imbalance in milk and dairy products (including demand for these in feeds) for developing countries will be 39 million t by 2030. Fish consumption is likely to increase, but there are uncertainties about the final level of production that can be attained. More modest projections of demand at 150–160 million t per annum will still mean that fish consumption may stagnate or even decline in SSA and WANA.

These projections thus stress the dual challenge of meeting increasing demands for staple foods (that can only partially be met through trade) and for diversification to enhance the routes out of poverty through high-value crops, animal products, and fish.

### Results from historical analyses

*Approach 5 examined the Current and Evolving CGIAR Research Portfolio.* The current research priorities of the CGIAR are represented *de facto* by the portfolio of projects being undertaken by the Centers. A review of the 196 projects presented in the Center MTPs for 2004–2006 provided general indications of what the CGIAR is doing today:

The Centers continue to conduct needed **commodity improvement research** (23 projects) in their mandated commodities.<sup>3</sup> Improvement is carried out through **genetic enhancement research** (8) which encompasses breeding approaches and new genetic biotechnology approaches, and **farming systems research** (25) which is undertaken in a commodity-specific fashion, or more often in general improvement approaches to the key agroecosystems of developing countries where the commodities are grown or raised.

Whilst farming systems research encompasses aspects of resource management, there is

a large body of Center research which concentrates on **integrated natural resource management (INRM)** (39) directed principally at water, soils, watersheds, fisheries, forestry, forages, and pastures aimed at augmenting the sustainability of agricultural and natural production systems. Commodity, INRM, and farming systems research are integrated in some **ecoregional programs** (6) run by Centers as research networks or as SWPs.

The **conservation and use of biodiversity** (26) supporting agricultural productivity is carried out through Bioversity International (formerly the International Plant Genetic Resources Institute, IPGRI) programs, the operation of gene banks by the plant commodity Centers, the Generation CP, the SWP on Genetic Resources, and in conjunction with INRM research in natural ecosystems (forestry, fisheries) or agricultural systems.

There are smaller but emerging bodies of research on **climate change** (2), the links between **agriculture and human health** (1), and the **SWP on Gender and Diversity** (1).

There is a large body of **policy research** (24 projects) conducted by the CGIAR Centers. This is wide-ranging across Centers addressing **markets, trade and globalization** (11); **poverty research** (3), and aspects of food safety and nutrition. There are sectoral or regional assessments (e.g., for livestock, or the semi-arid tropics), individual high-priority issues (like genetic resources policy); and governance issues, particularly for common pool natural resources (such as forestry and fisheries).

To enhance performance, Centers have adopted **participatory approaches** (4) to assist design, dissemination and adoption of interventions; **impact assessment** procedures (8) aimed both at Center impacts and the effects of external factors on sectors or commodities; and the conversion of publication systems into true **knowledge management systems** (8) for Center efficiency and for the benefit of partners and stakeholders.

Similarly, there is a major component of the portfolio directed towards **NARS capacity building** (7), implicit in conducting research through partnership, but also as a specific

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3 Summary of the CGIAR research portfolio as presented in the Center MTPs for 2000–2006. The number of projects of any particular type is given in brackets. This should be considered as indicative and not definitive since the categorization is of a general nature based on assumed major undertakings, when in fact Center projects are tending towards greater integration, and multi-disciplinarity.

goal in some regions, commodities, and sectors, and subject to analysis through research on institutions and processes of development change.

This brief characterization of the current CGIAR research portfolio is of use in considering new or additional priorities and in determining the future evolution of the System's agenda. New priorities are also being developed by the Centers on the basis of emerging issues. Amongst these, it is possible to note three major areas: (i) a heightened concern for knowledge management; (ii) a focus on systems of innovation amongst farming or resource management communities and NARS; and (iii) more explicit examination of the linkages between agriculture, health and trade.

#### ***Approach 6 considered the Priorities of Partners and International Organizations.***

The SC analysis considered the comparative advantage and priority portfolios of a number of other players: (i) **NARS** account for nearly 96 percent of agricultural research and development (R&D) investments in the developing world, contributing a substantial share of the unprecedented rate of agricultural productivity growth seen over the past three decades. NARS are very diverse in size and capacity but they act and react with increasing numbers of partners and stakeholders. They are now being viewed within a wider innovation system (including farmers and foreign suppliers). (ii) **Apex NARS bodies** such as the Global Forum for Agricultural Research (GFAR), have recently developed authoritative regional priorities and programs which represent the demand side of priority setting. (iii) **The Development Banks and other research providers** have strategies aligned with the MDGs and/or have expertise that can be deployed in partnership to augment research progress. (iv) **The private and civil society sectors:** relationships amongst stakeholders in agriculture have changed dramatically; there has been a marked rise in the contribution of the private sector in some aspects of research; and of the civil society sector in defining relevance of research and partnerships, and for delivering research results. There are strong possibilities for augmenting public-private partnerships between the CGIAR and commercial companies, princi-

pally in biotechnical applications on behalf of the poor. Similar and complementary linkages can be formed with many of the 'other 96 percent' of organizations that undertake and fund aspects of agricultural research in its widest sense.

Confronted by the same changing externalities as the CGIAR, the NARS are also facing new priorities. NARS are being challenged to strengthen their policy and regulatory frameworks for intellectual property rights (IPRs), biosafety, trade in genetically modified products, food safety, and strategies for accessing the new technologies. The strengthening of NARS to meet these emerging needs is central to the success of the CGIAR. There will be increased demands for knowledge management to enhance the workings of these communities of practice and research consortia, and there are major opportunities to capitalize on the new information and communication technologies (ICTs) in carrying out this collaborative mission. New priorities for agricultural research must be planned and delivered within these contexts in order to be relevant and to achieve objectives.

#### ***Approach 7 considered the Historical Budget Allocation.***

Historical analysis of the CGIAR resource allocation to commodities and sectors shows a steady reduction in allocations to cereal crop research. In 2002/2003, forestry (14 %) and fisheries (5 %) shares of the research budget had grown to anticipated levels and research on fish, forestry, and livestock show increasing trends in resource allocations extrapolated to 2010.

In terms of CGIAR undertakings, productivity research has shown a steady decline (although it still remains the largest category, at 36 % of expenditure in 2000), with increasing allocations to the environment (18 %), policy (13 %) and the conservation of biodiversity (which received a 10 % share of all resources in the year 2000). Provision of capacity-building assistance to NARS remained at around 22 % of total expenditure.

Since the founding of the CGIAR, SSA and Asia have received the main streams of resource flows. Most recently, there has been a further increase in funds allocated

to SSA, which received about 46 % – or nearly half of all expenditure – for the period 2002/2003. Asia’s levels of resource allocation have been ‘stable’ at around one-third of CGIAR funding, while the LAC region now receives 13 % of funds, down four percentage points from the 17 % level in the 1990s. There has also been a gradual decline in funding for the WANA region that is now receiving 9 % of resources allocated, down four percentage points from a maximum level of funding of 13 % achieved in the late 1980s and early 1990s.

### Results from consultations

**Approaches 8 and 9 followed a highly Consultative Approach for CGIAR Priority Setting.** Firstly, a set of some 20 position papers were written by experts on the key issues in agricultural development and research and were shared with the other participants in the priority-setting exercise and the public at large.<sup>4</sup>

Constraints were then further identified and elaborated through discussions by a series of regional panels, and by a global panel. Each panel was constituted virtually, and made up of some 20 experts with different disciplinary and organizational backgrounds. To broaden the consultation and to seek majority opinions, the list of activities was offered to stakeholders through an open electronic forum. More than 800 participated, including significant numbers of NGOs and NARS representatives.

On the ‘supply’ side, thematic panels of scientists were asked to translate priorities into researchable activities. These panels proposed researchable themes (sub-activities) within each of the categories of activities identified by the earlier steps. Priorities were then established by region. To do this, regional panels of scientists were asked to identify additional areas and to allocate given incremental resources to researchable sub-activities identified by the thematic panels.

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4 See the *Priorities and Strategies Consultation* webpage where these are collected, at <http://www.rimisp.org/cgi-ar-ps2>

**Final Expert Consultation.** Draft research priorities (initially described across 10 priority areas) were developed by the SC synthesizing current research approaches and new priorities and opportunities identified and developed over the two-year period. Outline descriptions of research prioritized under the 10 areas were shared with the CGIAR and its stakeholders in October 2004, and the approach was widely discussed in several fora, including at the CGIAR’s Annual General Meeting in 2004. During January and February 2005, the SC organized discussion meetings on each of the ten priority areas, to examine and refine the rationale and possible research content for each area. Approximately 30 participants took part in each of the different meetings, including invited scientists, CGIAR Center researchers and SC and Secretariat members. Some of the draft priority areas were substantially revised and consolidated on the basis of the outcomes of those meetings. Finally, the Center Deputies for Research Committee provided comments on a subsequent draft of the outcomes of those meetings.

### Criteria for identifying priorities for CGIAR research

The consultative process of priority setting has led to the identification of a number of potential topics for CGIAR research. Each responds to important issues in the new agricultural paradigm emerging with the globalization of agriculture. These need to be assessed through specific criteria. Potential impacts from new undertakings should be determined, and balanced against current undertakings of the System as a whole.

In identifying the priorities for research, the SC used the following three criteria: (i) Expected impact of the research on the major CGIAR goals (poverty alleviation, food security and nutrition, and sustainable management of natural resources) taking into account the expected probability of success and expected impact if successful; (ii) Production of international public goods; (iii) Alternative sources of supply and CGIAR comparative advantage in the conduct of the research.

Particular emphasis was placed on identifying research which has a clear pathway (future food and livelihood situations) to **poverty alleviation**, and which impacts many, or many groups, of the world's poor through any of the following ways:<sup>5</sup>

- Increasing the production of **staple foods** in countries where food price effects are still important and/or that have a comparative advantage in growing these crops
- Increasing agricultural **productivity** in many **less-favored lands**, especially heavily populated low-potential areas
- **Reducing risks** in agriculture, in particular in high-value market-oriented production, and the vulnerability of rural households to shocks of both idiosyncratic and covariate nature
- Helping smallholder farms across the board diversify into **higher-value products**, including livestock products, especially in countries with rapidly growing markets for such products and/or access to suitable export markets
- Increasing **employment** and income-earning opportunities for landless and near-landless workers in surplus labor regions
- Developing **more nutritious and safer foods** to enhance the diets of poor people
- Undertaking agricultural research in ways that are more **empowering of the poor**, in particular by helping them acquire the capacity to tailor technology to their specific livelihood strategies, with particular attention to women farmers and excluded groups.

Research to enhance **environmental sustainability** was considered to encompass: (i) preventing the loss of agricultural and related biodiversity; (ii) productive and sustainable use of natural resources; and (iii) promoting the rehabilitation of natural resources and ecosystems underpinning the livelihood strategies of the poor.

The **expected impact** of priority areas was evaluated taking into account the **expectation of success** (more risks may be taken for higher expected gains) in meeting the specific goals through particular research

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5 See Hazell P. and Haddad L. 2001. *Agricultural research and poverty reduction*. IFPRI Discussion Paper No. 34. International Food Policy Research Institute: Washington DC.).

pathways under a reasonable timeframe to achieve success. In addition, the **cost effectiveness** of a particular research avenue was evaluated in relation to the costs of alternative approaches and the cost of research relative to the expected impact.

The CGIAR focuses on the production of **international public goods**, i.e., goods which are non-exclusive in access and non-rival in use, and which have application in more than one country (and preferably in more than one region). Working on global issues augments the opportunities for spillovers into several developing-country regions. This constitutes part of the CGIAR's comparative advantage. CGIAR investment in developing international public goods can complement investment by both the private sector and national governments, which primarily develop more restricted benefits or local public goods.

The **comparative advantage** of the System to conduct the proposed research was evaluated on the basis of: (i) existing comparative advantage of the CGIAR relative to alternative suppliers i.e., ARIs, NARS, and the private sector (given expected respective capacities in 5–10 years time), and (ii) the possibilities for a high degree of leveraging through partnerships with key players in the near future.

## New System Priorities for CGIAR Research

The SC, building on the priority-setting process described above, discussed and finalized the System Priorities for CGIAR Research to 2015 at its third meeting in April 2005.<sup>6</sup> Seeking to meet key needs and capitalize on new science, the intention is to focus the CGIAR research agenda on a smaller number of Priority areas.

### The five System Priority areas identified are:

1. **Sustaining biodiversity for current and future generations**

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6 That Report was then considered by ExCo at its meeting in May 2005. The Report was subject to further review by SC in September 2005. The Priorities were endorsed by ExCo in December 2005, and by CGIAR Members in December 2005.

2. **Producing more and better food at lower costs through genetic improvements**
3. **Reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products**
4. **Poverty alleviation and sustainable management of water, land, and forest resources**
5. **Improving policies and facilitating institutional innovation to support sustainable reduction of poverty and hunger.**

The Priorities have goals commensurate with the mission of the CGIAR, and encapsulate major areas of science within the CGIAR's comparative advantage in its assistance to developing-country agriculture. Priorities are set in order to have measurable outcomes to allow specific links between priority setting and future monitoring and review functions. The five listed System priority areas are not ranked.

The SC proposes that the Alliance Centers and CGIAR Members agree to allocate (following a transition period not to exceed three years) 80 percent of the total CGIAR budget to the five Priority areas described in the following sections of this Report. It is recommended that donors provide funding for these priority areas in the future.

It is suggested that Centers spend up to 20 percent of their budget outside the research priorities. The SC further encourages Centers to utilize at least half of that 20 percent for exploratory, innovative research work to develop new science and potential new future priorities.

To adjust to these Priorities (and to further refine them in the process) it is proposed that during the years 2006–2008 a program alignment be undertaken by Centers through MTP planning and SC review of individual Center, CP and SWP MTPs.

## System Priority 1: Sustaining Biodiversity for Current and Future Generations

### Summary

The CGIAR should continue and extend its key role in the conservation of genetic resources for food and agriculture. The focus will continue to be on the genetic resources of crop plants, but there will increasingly be opportunities through under-utilized species with potential for income generation by the rural poor, including trees, livestock, and aquatic genetic resources. However, the CGIAR should not act alone, but must become a well-defined component of a rational, coordinated, forward-looking global system with clearly described areas of responsibility.

The CGIAR's focus must move towards the use of collections rather than conservation for its own sake. Use, particularly in germ-plasm enhancement, should be encouraged, by making available highly characterized core cultivar subsets, more extensive accessions of well-described wild relatives and, for the first time, defined genetic stocks.

### Rationale

Genetic and functional diversities of plants and animals are the building blocks of different agroecosystems and the basis of improved agricultural performance and production. Much of the diversity rests in under-studied wild relatives of major and minor crops, livestock, and fish indigenous to the countries served by the CGIAR. In some areas of the world, the advent of monocropping, industrialization, and habitat degradation threaten to marginalize or extinguish indigenous genetic diversity of plant and animal species useful for agriculture. There is a continuing need to collect, conserve, and characterize this diversity in relation to sustaining and augmenting future agricultural production.

The CGIAR has made important contributions to the development of in-trust collections of staple crops and forages to protect agricultural biodiversity and to provide for the future enhancement of production through breeding. However there are many plant and animal species

which contribute to protecting smallholder farming and improving assets, for which there are as yet no rational systems of conservation at the global level. In many cases, the conservation and characterization of new and underutilized plant species, as well as indigenous animal and fish breeds, either does not exist, or needs to be put on a modern, forward-looking basis. The CGIAR recognizes the role and contribution of FAO in this area and seeks to provide its scientific and policy expertise to advancing the establishment of a global system of conservation in collaboration with FAO and its partners.

It is particularly important in all aspects of the work undertaken by the Centers that due regard be given to the legal status of the materials under study and development. For many crop species, but by no means all, both cultivated varieties and wild relatives will be included within the multilateral system of the International Treaty on Plant Genetic Resources for Food and Agriculture. In the case of species of neglected or under-utilized crops, only a few will come under the multilateral system. Working in partnership with national institutions will be particularly important, as will due regard for access and benefit-sharing regimes.

### Priority 1A: Conservation and characterization of staple crops

#### Rationale

The CGIAR has placed major emphasis in the past on the collection, conservation, and distribution of staple crops of importance to the poor in developing countries. This is both an international public good and a means of augmenting the CGIAR's and its partners' improvement programs. The continued success of wide-crossing programs [e.g., the New Rice for Africa (NERICA) varieties for use in West Africa] and the potential for direct use of novel adaptive variation suggests that characterization of hardy relatives of staple crops will remain important to CGIAR research. This Priority area continues the focus of CGIAR activities

on those species for which it maintains collections, and which are covered by the International Treaty on Plant Genetic Resources for Food and Agriculture. This principally includes staple crops and forages.

The wild relatives of crops provide a reservoir of untapped, potentially important genes for crop improvement. This is particularly so for genes governing tolerance or resistance to biotic and abiotic stresses, but also for genes for other important adaptive traits. However, wild relatives are greatly under-represented in most of the CGIAR Center collections. A concerted effort is needed to study the remaining distribution of such species and ensure that the accessions collected adequately represent the broad range of genetic diversity within them. There is a need to apply modern and efficient means for the collection, long-term conservation, evaluation, and characterization of germplasm. Enhanced information and communication technologies provide means for improving the documentation of these processes. Through appropriate wide-cross breeding techniques and genetic engineering technologies, the desired traits need to be transferred into breeding populations for further development. (The use of wild relatives was also identified as a priority for research on breeding and genetic improvement and this is elaborated under Priority area 2.)

**General goal:** *Conserve plant genetic resources of priority crops for food and agriculture and their wild relatives, and characterize them for intrinsic characters and characters of utility to the poor.*

**Specific goal 1:** *Improved strategies and methodologies developed for ex situ, in situ and on-farm conservation and characterization.*

**Scope of research:**

- Develop strategies and methodologies for *ex situ* conservation, particularly of vegetatively propagated crops and wild relatives
- Develop sustainable strategies and methodologies for *in situ* and on-farm conservation, in the context of international public goods.

**Specific goal 2:** *Collection, conservation, and dissemination of genetically diverse material (including cultivars and wild species), as appropriate within the context of an agreed rational global system of conservation.*

**Scope of research:**

- Conduct analyses to prioritize early collection of threatened populations
- Prioritize relevant internationally under-represented materials
- Develop with partners international strategies to ensure conservation of, and access to, key plant species for agriculture.

**Specific goal 3:** *Detailed characterization of informative subsets of genetically diverse materials (core cultivar collections and representative wild relatives).*

**Scope of research:**

- Develop core collections of cultivars and wild and weedy relatives
- Apply molecular techniques to increase efficiency of screening procedures and describe diversity at the molecular level
- Evaluate for traits of importance to the poor (e.g., drought tolerance, biotic stresses, nutrient use efficiency).

**Specific goal 4:** *Genetic and genomic stocks (e.g., DNA banking, mutant collections, mapping populations, isogenic lines) assembled, conserved, and distributed.*

**Scope of research:**

- Assemble and conserve genetic stocks developed by others
- Develop new genetic stocks and plans for dissemination.

**Specific goal 5:** *Knowledge about the genepools conserved, generated and disseminated.*

**Scope of research:**

- Conduct ecogeographic studies of genepools
- Conduct and compile assessments of diversity
- Develop information systems (including SINGER – the information network of the CGIAR SWP for Genetic Resources).

## Priority 1B: Promoting conservation and characterization of under-utilized plant genetic resources to increase the incomes of the poor

### Rationale

There is under-appreciation, under-investment, and under-development of promising plant taxa that might be exploited for income, health, and nutrition of communities in developing countries. The term 'under-utilized plant genetic resources' (or UPR) has been adopted to describe these species. To augment the availability of promising species, and for research to augment opportunities for their equitable exploitation, it is necessary to conserve and characterize genetic resources of these taxa.

There is potentially a large number of such species, including forest tree species and shrubs. Much of the research on such species is conducted outside the CGIAR. Thus the focus of the CGIAR will be to: (i) select carefully the species of interest; (ii) engage the alternative suppliers as partners; and (iii) focus on the gaps in the research agenda.<sup>7</sup>

Unlike the species being addressed by Priority 1A, not all those selected for conservation and research under Priority 1B will be covered by the International Treaty for Plant Genetic Resources for Food and Agriculture. Wild or cultivated species may be targeted in such an approach, including important perennials (illustrative examples could, for instance, include guava, custard apple, fonio, or medicinal plants). There may be a need to identify new approaches in genetic conservation and characterization. However, it is not anticipated that the CGIAR would

necessarily establish new germplasm collections; rather it would work by assisting partners (who have comparative advantage in developing collections with international access for these species) to do so. To this end, it is expected that the CGIAR will extend its range of partnerships (including private–public partnerships) and should remain sensitive to the development of such opportunities for the international good. The CGIAR's goals will be to promote opportunities for food, and improved nutrition and health of the poor, and interventions should be planned accordingly.

*General goal: Conserve and enhance the contribution of under-utilized plant genetic resources (UPGR) to the income, health and nutrition of the poor.*

*Specific goal 1: Strengthen knowledge of UPR and identify opportunities for their use by the poor.*

#### Scope of research:

- Survey extent and distribution of diversity of potential species
- Determine available information on important species
- Engage alternative suppliers in the CGIAR program
- Produce tools for conservation of neglected and under-utilized species
- Ensure linkage of characterization to breeding programs for new species.

*Specific goal 2: Germplasm of key under-utilized plant species is collected, conserved, and characterized.*

#### Scope of research:

- Design means to optimize support and to maintain collections of UPR held by others
- Where necessary, establish new collections for the conservation of UPR
- Where necessary, identify new habitats/ ecosystems of UPR and support conservation actions
- Develop generally applicable methods for the on-farm maintenance and other systems of conservation of UPR *in situ* in the context of international public goods
- Link newly characterized species to breeding programs (link to Priority area 2).

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<sup>7</sup> Criteria for identifying the range of species to be addressed include: (i) The taxon covers several countries and a large potential area; (ii) There are no existing major collections; (iii) Exploitation of these species focuses on their use for food income or health; (iv) There are clear opportunities to enhance health–food linkages; (v) There is a relatively high level of dependence on the species by the poor, or there are clear opportunities for the poor to benefit from the further exploitation of the species; (vi) The species can contribute to the sustainability of production systems (diversification); (vii) It is feasible to establish means for the medium- to long-term conservation of these taxa.

It is assumed that the scope, and time to completion of research will differ according to the state of experimental development of a particular UPGR and its relatives.

Research on three categories of species is distinguished: Type I: semi-wild orphans; Type II: species that have already passed breeding screens; Type III: species appropriate for more advanced scientific breeding.

For Type I species, short- to medium-term conservation research activities will include evaluation of the sustainability of landraces, their functional and chemical characterization and identification of the role the species may play in poverty alleviation, intrinsically or through adaptation for health and better nutrition, or market capacity. Work will include designing the organization of *ex situ* and/or living collections, and identifying superior accessions to be passed for breeding (linked to Priority area 2).

For Type II species, collection activities will start similarly in relation to the identification of major plant families relevant for contribution to the agriculture of the poor. This will be followed by the collection of wild species, characterization of diversity at the level of genes and functional traits, identification of populations required to complete representative collections for selected species, and provision of reserves of secondary and tertiary gene pools.

For Type III species, collections will be accompanied by taxonomic analyses to establish that the full range has been sampled. Subsequent research might begin with the coordinated establishment of breeding populations, random inbred lines etc. where progress could be aided by molecular methods.

*Specific goal 3: Improved processes, institutions, and capacity are developed and promoted to enhance the conservation and use of UPGR for the benefit of the poor.*

*Scope of research:*

- Conduct research and associated activities on the establishment of: (i) networks; and (ii) institutional mechanisms to link knowledge of UPGR germplasm and its conservation and equitable use to communities and farmers.

This research provides material, methods and linkages to Priority area 2 (germplasm enhancement), Priority area 3 (high-value crops), Priority area 4 (where NRM includes diversified agricultural systems) and to Priority area 5 (through the needs to enhance policy institutions, including PPPs, dealing with UPGR as well as the development of capacity building and mobilization).

## Priority 1C: Conservation of indigenous livestock

### Rationale

Poor livestock keepers depend on the ability of their indigenous, locally adapted livestock breeds and strains, to hedge against the impacts of harsh and highly variable and unpredictable production environments. Indigenous livestock provide an important source of food for the rural poor, who cannot afford to buy livestock products in the market. Indigenous breeds are usually preferred by small-scale farmers, the main target group of the CGIAR, since they are optimally adapted to their farming systems. In addition, they form a reservoir of genetic traits of potential future use. The focus of the priority research will be on farm animal genetic resources.<sup>8</sup>

Given the multifunctional importance of livestock to the rural poor (e.g., smallholder farmers and herders) and the value of livestock products in health and nutrition, especially of vulnerable groups (such as pregnant and lactating women, and children), an emphasis on the role of livestock diversity for the livelihoods of rural communities is justified. The program will need to address the major problems confronting the use,

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8 To avoid dispersion of effort, initial research will be focussed on farm animal genetic resources. Although wild relatives of livestock are few (including, for instance, jungle fowl, wild yak, wild hogs, and wild camelids), they are important, since their genetic analysis provides insight into the domestication of farm animals, and in the genetic relatedness of domesticated breeds. Following the development of international strategies detailing approaches to livestock genetic resource conservation, the CGIAR may reconsider its comparative advantage in contributing to research on wild relatives of livestock.

development, and conservation of indigenous breeds, and in particular:

- The increasingly rapid loss of livestock diversity and the implications of such loss for producers and production systems in the longer term
- Poor knowledge of local breeds and understanding of their value
- Lack of appropriate strategies for maintaining and using the little understood inherent genetic attributes of local breeds
- Technical and economic constraints to livestock conservation (both *in situ* and *ex situ*)
- Weak human and institutional capacity for supporting the management and use of livestock diversity
- Inappropriate policies hampering livestock conservation, exchange and use.

Demonstrations of the value of livestock diversity and the benefits of livestock diversity to health, nutrition, and livelihoods, and to the productivity and stability of agroecosystems are required. This forms an important aspect of informing appropriate policy formulation for indigenous livestock. Research into indigenous breeds will contribute to improving livelihoods and reducing poverty, to enhancing food security, nutrition and health, and environmental sustainability through two strategies, i.e., enhancing the husbandry of indigenous breeds, and improving stocks through breeding. Both approaches provide the opportunity for farmers to enhance assets and remain interested in supporting conservation strategies. These approaches must be managed correctly, as ill-conceived attempts to improve farm productivity through cross-breeding of indigenous breeds with exotic breeds have exacerbated the loss of diversity.

Addressing these issues requires multi-disciplinary research and multi-stakeholder involvement from local to global level. Often the lack of information about local breeds, their values and attributes, and poor or nonexistent programs for their management, development, and use are the root causes of the loss of diversity.

National subsidy systems and international policies on the introduction of exogenous breeds, semen and the use of veterinary medicines, as well as marketing regulations

should be assessed for their negative incentives for maintaining indigenous livestock. Policy research should address the promotion of appropriate access and benefit-sharing arrangements that promote conservation and use of livestock diversity. In order to achieve the MDGs, conservation and characterization *per se* is not sufficient, and use of the conserved collections and populations should be promoted as well. In situations where cross-breeding is the preferred choice, a secured supply of indigenous stocks is essential.

Addressing these issues requires the involvement of communities, researchers, and policy-makers. Despite the efforts of the CGIAR Centers, FAO and others, overall investments to date in livestock genetic resources are limited.

*General goal: Maintain and enhance livestock genetic diversity as the basis of further production improvements.*

*Specific goal 1: Indigenous breeds of livestock are characterized at molecular and phenotypic levels including analysis of genetic relatedness amongst important populations.*

*Scope of research:*

- Collect information on breeds as a prerequisite for decisions on what to conserve, since the high costs of conservation preclude broad-scale approaches
- Document indigenous livestock diversity including their distribution, characteristics and risk status
- FAO is undertaking an inventory of global Animal Genetic Resources and thereby assessing country capacity for breed characterization. The CGIAR can contribute with the FAO in the development of coordinated protocols for molecular characterization and comparability of diversity
- Phenotypic characterization should include comparative productivity data in different production systems
- Develop research protocols for the field to investigate adaptive traits of local breeds and their functionality and physiological mechanisms
- Develop criteria for decision-making for conservation. In the face of the accelerating loss of diversity, the importance of such work needs to be highlighted.

**Specific goal 2: Influence the establishment of policies conducive to the appropriate exchange, use, development, and conservation of livestock diversity.**

**Scope of research:**

- Demonstrate the impact of policy interventions and provide policy options that create an 'enabling environment' for enhancing the use of diversity in strengthening livelihoods and for livestock conservation
- Develop insights into the consumer and livestock owners' choices or management practices, which exacerbate trends towards genetic erosion
- Demonstrate the economic, social and environmental benefits of diversity crucial for justifying and targeting investments and commitments for the conservation and use of indigenous breeds
- Conduct research on legal and regulatory aspects of exchange of genetic material, including access and benefit-sharing arrangements, to inform the development of any international agreements on livestock genetic resources which might possibly be initiated by the FAO Commission on Genetic Resources for Food and Agriculture. This should be done in inter-institutional partnership.

**Specific goal 3: In situ and ex situ conservation options are assessed and identified.**

**Scope of research:**

- Re-assess *ex situ* approaches (e.g. advances in cryopreservation technology and reductions in its costs) and pressures on diversity (especially culling due to disease), to balance development and use emphasis on a re-assessment of *ex situ* approaches, alongside the further development of *in situ* conservation methods.
- Focus on the poor, where the predominant species will be chicken, small ruminants and cattle, prioritizing animal populations according to the following criteria:
  - Endangered populations
  - Remaining wild relatives of livestock
  - Populations in the center of domestication.

There is therefore a need to:

- Investigate *in situ* and *ex situ* conservation options including the development of maintenance strategies for low-number unique breeds
- Treat research into the need for *ex situ* conservation as complementary (not an alternative) to *in situ* conservation of low-number unique indigenous breeds
- Develop access and benefit-sharing policies/protocols as an essential component for this research to be effective
- Use new developments in reproductive physiology to enhance the feasibility and efficiency of *ex situ* conservation
- Utilize indigenous breeds in cross-breeding programs and improve preferred traits; this is possible in the short term to the extent that stocks have been already properly characterized.

## **Priority 1D: Conservation of aquatic animal genetic resources**

### **Rationale**

Aquatic animals constitute the basis of the livelihood of large sectors of the population in developing countries. Fisheries represent one of the major remaining 'hunting grounds', but generally the yield of capture fisheries is declining due to over-exploitation. Wild fisheries are dependent upon aquatic animal diversity, particularly in tropical and artisanal fisheries, which encompass wide species diversity. Wild fish are exploited for nutrition, income (either as food fish, feed, or ornamentals) and contribute to the integrity of aquatic ecosystem services. Conservation and use strategies have to be developed in order to protect biodiversity and its use in an equitable fashion. Conservation and management of aquatic biodiversity has some general parallels with the conservation of plant and livestock diversity, but with additional emphases on habitat protection. The sustainability of coastal and inland fisheries is dependent on the component genetic biodiversity of aquatic ecosystems. This is treated as it relates to the specific goals for the sustainability of fisheries under Priority area 4. The priority for the conservation of aquatic

animal genetic resources (under Priority area 1) is therefore confined to conservation of species for aquaculture.

Aquaculture is playing an increasingly important role in filling the gap between demand and supply, and it is growing at a relatively fast pace in several countries. Carps and tilapia predominate in smallholder systems on most continents. In aquaculture, most of the improved strains of fish are introduced outside their native range. It is recognized that one of the main pathways for entry of alien aquatic species into natural systems is the accidental escape of farmed fish. To ensure that aquaculture is developed in a sustainable manner, the problem of alien species and stocks has to be addressed.

The development of an inventory, and the characterization of the key species used in developing country aquaculture are required for conservation and appropriate management of both domesticated strains and wild stocks. The information generated will be important for the initiation of genetic enhancement programs and for the future genetic management of the resulting improved strains. With regard to *ex situ* conservation, for finfish, only cryopreservation of milt is feasible, and some developing countries have already started gene banks. Improved knowledge about building gene bank accessions for aquaculture species, and viable alternative options, would help developing countries to consolidate their genetic conservation and use programs.

**General goal:** *Maintain genetic diversity as a basis for improvements in aquaculture.*

**Specific goal:** *Develop an inventory and assess the value of important wild and improved stocks of aquaculture species, and formulate plans for their better utilization in aquaculture and for in situ and ex situ conservation.*

**Scope of research:**

- Inventory important wild and improved stocks and threats faced by tilapia and carp species cultured widely by poor farmers
- Based on the inventory, prioritize stocks to be characterized using genetic markers and production parameters
- Estimate the potential economic value of prioritized stocks and develop strategies for their conservation (involving *in situ* or *ex situ* methods as appropriate)
- Assess conservation and use strategies including protected areas in relation to use
- Evaluate the use of cryopreserved milt for conservation and genetic improvement and develop plans for building and sustaining gene banks
- Based on best practice, promote the conservation and use of aquaculture species and populations
- Analysis of the performance of PPPs for conservation and use of aquatic animals and the role played by PPPs in the protection of biodiversity, knowledge and benefit sharing.

This research links to the improvement of fish genetic resources for aquaculture (Priority area 2) and to the sustainable management of fisheries and aquatic ecosystems (under Priority area 4), the latter including strategies for conservation *in situ*.



## System Priority 2: Producing More and Better Food at Lower Cost through Genetic Improvements

### Summary

The key role of the CGIAR in providing food security through continued increased production of the major staples must be sustained, but with an increasing emphasis as a provider of novel genes for adaptation and yield enhancement. Specific attention should be paid to drought tolerance and biofortification of relevance to the poor. Genetic enhancement activities, usually in collaborative arrangements, should also extend to some high-value crops, livestock, and fish.

Focus will be imparted by more closely tailoring the CGIAR program to NARS needs. In general, the CGIAR will move its efforts upstream to provide technologies, genes and enhanced breeder lines rather than finished varieties. The CGIAR should seek to combine forces with strong NARS to provide international public goods to serve partners with less capacity. Although the CGIAR is expected to be involved with more plant and animal species, all new initiatives will incorporate clear time-bound strategies to aid financial and resource planning.

### Rationale

The CGIAR has traditionally had most success in meeting its goals for sustaining and improving the availability of food commodities for rural and urban populations through breeding and genetic enhancement methods. There are new and emerging opportunities to combine the analytical power of molecular science for trait capture with traditional approaches, and to speed the timeframe for research. Priority area 2 is an input to the accomplishment of the long-term goals shared by the CGIAR and the MDG of alleviation of poverty, hunger and unsustainable natural resource management.

The CGIAR is ideally placed to carry out international public goods research in this area, since it is able to make specific links between characterization, conservation, and enhancement activities for important food, feed, and fodder species e.g., through gene

pools encompassing disease resistance, stability, and the environmental traits required to meet the MDGs. Phenotyping capacity is therefore key to the CGIAR's role in deploying existing genes (whether identified through characterization of in-trust accessions, or genes characterized by other ARIs) for the benefit of the poor. It also has a comparative advantage in forming alliances with other organizations to increase the effectiveness of germplasm enhancement programs. There are close and long-standing links to farming systems in different developing-country regions, and the CGIAR's major impacts will be through the deployment of improved cultivars and the capture of benefits by poorer farmers and consumers.

To some extent, breeding and research in established crops are currently focused on defending yield gains (maintenance against evolving pest pressures and changing environments) rather than increasing the yield ceiling, as in the past. However, the projected requirements for yield increases in staples demand that research continues to improve the yield as well as maintain the current levels. The need for higher yield potentials is particularly important where land will be diverted to other higher-value crops (see Priority area 4).

For both animal and plant improvement, a large effort should be made to alleviate some of the effects of stresses, particularly water shortage, and to improve efficiency of production per unit of input. The general approach encompasses different sorts of genetic improvement methods, and quantitative genetic approaches for sustained gains may be as important as quantum advances through genomics. This also applies to breed improvement in farmed fish and livestock, as well as to other higher-value species and commodities.

It is recognized that accomplishment of some of the goals of this Priority area will require more than just genetic science, including whole organism biology and

physiology, ecophysiology and novel agronomies and, in particular, the development of effective seed distribution systems<sup>9</sup> etc. Because of its broad nature and the different applicability to different goals, such additional research is not described in detail here. However, the ramifications are that: (i) future genetic enhancement programs will be conducted with an array of partners – including emerging national systems and the various forms of the private sector (exemplified generically by the genetic technology providers in the North, as well as smaller but key players in seed distribution in the South); (ii) innovation and capacity building will be required at all levels of the germplasm enhancement pathway; (iii) the CGIAR's role will be limited necessarily to a smaller number of important projects; and (iv) sharing and devolution of tasks to NARS will be critical.

## Priority 2A: Maintaining and enhancing yields and yield potential of food staples

### Rationale

Yields in the main food crops have been rising since the 1970s but the rates of increase are slowing down in developing countries. The future production requirements to meet the growing human population and demands identified<sup>10</sup> for staple commodities in developing regions are well above what is being achieved today. Continued research is vital to protect the gains in yield made to date, and to increase the genetic yield potential. Additional constraints to the improvement of yields will come from the competition for land and water resources, and the degradation of land and soils occurring in some production systems (issues discussed in Priority area 4). To augment the yield in staple crops remains the key challenge for the period 2005–2015 and beyond.

New techniques for plant characterization and breeding make it possible to address yield barriers to stabilize production under

biotic stress, and to increase the production of main food crops per unit of water, land, and labor. Genetic enhancement can also contribute to the CGIAR's overall strategy to increase the quality of food and food products (to meet consumer requirements and raise market opportunity) and to enhance the nutrition of the poor. Whereas in the past the crop improvement gains have come from crop-based institutes and breeding programs (both at the CGIAR and national levels), technological advances in genetics and genomics provide new opportunities to develop platforms of research that can serve individual commodity and regional needs more generically.

Clearly there are needs to integrate existing technology with the problem-solving capacity of the new science. Given the fast rate of evolution and the range of actors in the overall field of molecular science, there is opportunity to create momentum and increase efficiency in meeting the goals of the CGIAR through new partnerships (particularly with ARIs, providers of science and improved germplasm, and increasingly with advanced NARS). The CGIAR should assume leadership of, and not shy away from, the use of genetic engineering, where appropriate, as a legitimate breeding technology.

Further, with the advancement of the technological capacity of some NARS, and with investment in a few crops by the private sector (e.g., in tropical maize) some rationalization of research effort between the CGIAR and its NARS partners and the private sector is required. The CGIAR, therefore, expects to gradually reduce some of its conventional breeding work in this area. Exit strategies need to be developed in regions where NARS have capacity to continue conventional plant breeding (for non-market, poor farmers) and where the private sector has an increasing role in the market economy. There will thus be the need to develop long- and short-term research strategies, joint research planning and policies (linked to Priority area 5) to enhance sharing of germplasm and technologies with partner NARS and capable regions. This will free the CGIAR to: (i) work on new major issues of public goods research; and (ii) focus on crops and commodities of broad applicability to meeting food demands in other regions.

9 Where 'seed' in this context applies to aquaculture seed systems as well as to those of crop plants, trees etc.

10 See section on World Food Concerns in the Introduction.

**General goal:** Deliver sustainable productivity gains through genetic enhancement of staple crops to improve livelihoods and food security of the poor.

**Specific goal 1:** Enhance the capacity and efficiency of genetic improvement programs through approaches linking characterization and use.

**Scope of research:**

- Develop and promote the breeding capacity of the System to incorporate traditional and novel technologies: particularly the linkage of the collection, conservation and characterization activities (under Priority area 1) to use in improvement programs
- This will provide the means to utilize raw improved germplasm, and collected relatives, through the expression of the CGIAR's general breeding capacity, phenotyping, quality laboratories, marker laboratories etc.
- Link the necessary maintenance research for staples to meet continuing threats from diseases<sup>11</sup> and abiotic stresses to new technological approaches to preserve the value of germplasm developed through research. This approval should have short- and long-term goals
- Enhance capability and infrastructure that will be required to capture value in integrated (conventional and genomics research) approaches to genetic enhancement, e.g., establishment of genomics platform(s) including informatics-related capacity
- Establish means, where appropriate, to utilize and enhance technologies such as participatory breeding, accelerated phenotyping capacity, collections of early lines carrying advantageous alleles, R (resistance) gene deployment strategies and speed-breeding processes
- This consolidation would be expected to assist the achievement of all the other biotechnical and germplasm-sharing goals identified under Priority area 2. Outputs

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11 It should be noted that this priority area assumes that individual species/commodities will be improved through breeding programs taking into account the major (regional) disease stresses likely to be encountered. As such diseases differ by plant species and production system, the diseases and other biotic stresses are not themselves prioritized as research foci.

will include information, phenotyped populations, cloned genes, breeders' lines, varieties, and novel agronomy systems (in concert with integrated natural resource approaches at the farm level – see Priority area 4)

- Simultaneously, the existence of a genetics platform and molecular marker capability is expected to enhance the characterization activities carried out under Priority area 1.

**Specific goal 2:** Identify and develop pro-poor traits in crops.

**Scope of research:**

- Work on pro-poor traits (including food-feed uses) aimed at the stabilization and improvement of yields
- Enhance productivity, adaptability and stability of crops important to the poor by robust genetic protection of crops from abiotic and disease stresses (linked to research conducted under Priority area 4, noting farming systems as repositories of agrobiodiversity).

Research will include emphasis on the development of:

- Production per unit land e.g., through disease resistance, or resistance to other biotic stress (e.g., resistance to the parasitic weed, *Striga*)
- Production per unit water<sup>12</sup>
- Production per unit labor (this includes breeding for reduced labor inputs to diminish the requirement for child and female labor and for regions affected by

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12 Note discussion under Priority 2B. However, a combination of approaches may include: (i) Breeding for varieties with higher yield per rate of transpiration (e.g., improve harvest index when drought occurs at critical periods, high transpiration efficiency (e.g., C3 => C4), short-duration ('drought escape' mechanism), deep rooting system ('drought avoidance' mechanism); (ii) Strategic research on manipulating plant architecture (plant ideotypes) and exploitation of genetic variants (e.g., mutants) for water and nutrient use efficiencies, weed suppression (linking to NRM research through Priority 4); (iii) Cool-season plants to benefit from winter rainfall/cold-tolerance; (iv) Exploitation of developmental traits and expression polymorphisms (e.g., manipulation of flowering time, maturity, seed structure and composition, embryo size, harvest index) to enhance savings in water use and reductions in the labor required for crop agriculture; (v) Partitioning of metabolites across plant structures for food, health, feed, and available energy requirements.

- HIV/AIDS or other health constraints on agriculture)
- Production per unit nutrients
- Improved quality
- Provision of breeders lines to NARS.

Criteria for crop choice include:

- Identification of crop dependence or opportunity (food availability, nutrition, or income)
- Magnitude of problem faced by the poor
- Consideration of alternative and complementary routes to alleviation of the problem by different types of intervention
- Quality of solution
- Time to delivery
- Likelihood of success
- CGIAR comparative advantage, alternative supplies.

Socioeconomic research will be required to orient high-impact research choices in partner NARS in regions with low current capacity.

## Priority 2B: Tolerance to selected abiotic stresses

### Rationale

The productivity of many of the current farming systems serving populations of the poor is limited by climatic conditions or abiotic stresses such as erratic water shortage, and environmental (e.g., temperature) stresses or soil stresses. A major means of improving productivity per unit of land, water, and labor, and reducing risk to the small-scale farmer, would be to enhance stress tolerance – and hence productivity in some of these low-potential agricultural environments. The world is experiencing global warming and increased frequencies of climatic instability, predisposing crops to temperature and water shocks during the sensitive reproductive stage.

The CGIAR should focus its research on tolerance to: drought<sup>13</sup> and salinity. It is considered that a major emphasis on

drought tolerance should be pursued as a global research issue affecting the stability of the farming systems of the poor, with a high likelihood of success from long-term investment. Greater investment in drought tolerance would be able to take advantage of advances in plant genomics, and would lead to spillovers for new research on salinity tolerance because of the underlying biological similarity between these two adaptation mechanisms. There is a possibility of developing crops genetically modified for both these traits (plant genes with new promoters, same-species applications).

*General goal: Enhance the tolerance of crop species to selected abiotic stresses and so increase agricultural productivity and reduce risks in unfavorable agricultural environments.*

### Scope of research:

- Develop phenotyping capacity for priority abiotic stresses
- Collect and evaluate diverse genotypes to identify tolerant sources
- Identify the genetic basis of the traits [map quantitative trait loci (QTLs)] from tolerant genotypes
- Identify markers for introgressing the trait into productive genotypes
- Identify the genes underlying traits for developing improved markers and transformation approaches
- Identify the physiological aspects of drought and salinity tolerance.

## Priority 2C: Enhancing nutritional quality and safety

### Rationale

Micronutrient malnutrition is an insidious form of malnutrition affecting millions of poor people with inadequate amounts or variety of foodstuffs. As this is most widespread amongst the poor living largely on single sources of staples (such as cereals, roots, tubers, or pulses), improving the micro-

13 Drought is defined as the coefficient of variation in yield (performance) across years of differing rainfall. The measurement of success would be the demonstrable (> 10%) performance advantage of new cultivars under stress at farm level. Crop-specific milestones must be

developed. Drought tolerance in stressed environments is differentiated from flexibility of water use in normal environments – see Priority 2A – although insights into both traits would be expected to result from research on drought tolerance.

nutrient content of such staples is considered to be the most effective way of overcoming nutritional insufficiency and the morbidity and disease to which it predisposes. The CGIAR will evaluate the possibility of increasing the content and bioavailability of selected micronutrients (vitamin A, zinc, and iron in the first instance) in the edible parts of plants through germplasm enhancement, and the feasibility of reducing human malnutrition through strategies focusing on such enhanced crop varieties. In the future, consideration may be given to the possibility of enhancing other nutrients (e.g., folate, selenium). Strategies to maximize the impact of biofortification will be improved by priorities that seek to increase consumption of animal protein or fruit and vegetables (i.e., by increasing the bioavailability of biofortified iron). It is probable that nutritionally enhanced varieties (in which the 'added-value' is invisible to the consumer at market) will have to be linked with favorable agronomic traits to enhance adoption. Linkages of this work to research on Priorities 2A and 2B are expected.

For some staples of importance to the poor, potential use is compromised by the presence of compounds that can have adverse effects on human health through ingestion over long periods (e.g., cyanogenic compounds in cassava, neurotoxin in grass pea). Similarly, storage of crops under sub-optimal conditions (faced by the poor) can make them subject to microbial contamination and accumulation of toxins (with aflatoxin being the most significant example). There are opportunities to reduce or obviate the human health effects of constitutive and microbial toxins affecting critical staples through genetic enhancement and breeding.

The research directly addresses the MDGs of combating malnutrition, and child and maternal mortality. If successful, it could have major effects on both urban and rural populations.

**General goal:** *Enhance the content and availability of micronutrients and to reduce potentially toxic compounds in staple commodities for enhanced human nutrition.*

**Specific goal 1:** *Increase the content of micronutrients in the edible parts of crop plants through improved biotechnologies and breeding.*

**Scope of research:**

- Initially focus on enhancing the concentrations of micronutrients iron (to combat anaemia), zinc (for immune system function and resistance to disease) and vitamin A (for maintenance of good vision, particularly in childhood, and cellular development)
- Conclude plant breeding and pre-breeding feasibility studies on rice, maize, wheat, cassava, beans and sweet potato in the first instance to demonstrate the validity of the biofortification strategy. There are already good indications that the availability of vitamin A can be enhanced in some grains and tubers
- Subsequently, improve useful varieties for the best nutritional and agronomic traits in each crop, using adaptive/decentralized breeding methods and seed production where feasible
- Following proof of concept, extend research to additional crops (banana/plantain, barley, cowpea, groundnut, lentil, millet, pigeonpea, potato, sorghum, and yam) for which the knowledge base for biofortification has yet to be developed.

**Specific goal 2:** *Evaluate biofortification strategies and introduce the best means to enhance the diets of nutritionally disadvantaged populations in developing countries.*

**Scope of research:**

- Assess promising lines for micronutrient bioavailability using *in vitro* and animal models, and subsequent efficacy studies involving human subjects, to evaluate nutritional impact of the most promising lines intended for release
- Augment research to understand economic and social factors that determine the dietary quality of the poor and their micronutrient status. Advocate policy based on that research, coordinated communication activities supporting dissemination, and adoption of micronutrient-enhanced varieties
- Evaluate dissemination of nutritionally improved varieties to determine the effectiveness of the biofortification strategy on malnutrition after adoption
- Whilst germplasm enhancement of selected commodities for nutritional content is considered short- to medium-term research (particularly if transgenic crops

are estimated to be the means of choice), the demonstration of impact on human malnutrition from the approach requires medium- to long-term research.

**Specific goal 3: Reduce the content of constitutive or microbial toxins in selected staples that affect quality, food safety and human health.**

*Scope of research:*

- Focus on developing acyanogenic lines of cassava and lines of grass pea with reduced neurotoxin levels. Conduct research on selected staples to identify ways to lower susceptibility to microbial contamination (and aflatoxin production) in concert with integrated technology, institutional and policy strategies to address storage and health effects.

## **Priority 2D: Genetic enhancement of selected species to increase income generation by the poor**

### **Rationale**

Smallholder farmers have relatively limited opportunity to escape poverty solely through the production of staple crops. However, there is great scope for improving incomes through higher-value fruit, vegetables, fodder and feed crops, tree products, livestock and fish, or by increasing the diversification of farm and natural resource enterprises to encompass appropriate new opportunities linked to markets. Diversification is also important in the context of improving household nutrition. The CGIAR will work on selected higher-value species already shown to be of use to the poor or selected according to the criteria advanced in Priority area 1. For those crops on which an international-level effort is required, the CGIAR will identify the most appropriate international agencies undertaking gene discovery and improvement research relevant to the species in question, and seek to develop research consortia to assist the exploitation of these species by the poor.

**General goal: Enhance opportunities for the exploitation of high-value commodities by the poor.**

**Specific goal 1: Increase the yield and stability of high-value plant species and products through genetic enhancement.**

*Rationale:* Increasing the yield, stability and diversity of high-value products for market has potential to add significantly to the incomes of poor farmers and rural laborers. Such commodities include fruits and vegetables, livestock forages, and some crops that have dual value as food and feeds. These commodities have only recently been addressed from the point of view of livelihood opportunities for the poor. The CGIAR has the chance to capitalize on international partnerships, including consortia and its own platforms for gene discovery research to enhance the productivity of selected key crops of value to the poor.

*Scope of research:*

- Enhance the productivity and quality of fruit and vegetables and other high-value crops through genetic and physiological improvements and breeding. Target traits for genetic enhancement may include: yield improvement research for traditional and 'exotic' species, nutritional content, water-use efficiency, control of flowering, post-harvest quality traits, selection and rapid propagation of species (perennials), and pest and disease resistance
- Enhance fodder species for growth in low-potential environments whilst reducing anti-nutritional components for livestock
- Augment the feed component of selected food-feed crops to increase crop utility and value.

**Specific goal 2: Develop improved germplasm of selected non-timber forest products.**

*Rationale:* Non-timber forest products (NTFPs) are a specific category of high-value products that can provide enhanced incomes to forest-associated peoples. An emerging opportunity is the production by smallholders of trees and shrubs with medicinal value. Constraints to be overcome in the appropriate exploitation of NTFPs include issues with domestication and potential loss of chemical composition for some promising target species. However, the large number of potential species means that the CGIAR will apply highly selective criteria and evaluate

means of conducting research to ensure the production of international public goods.

*Scope of research:*

- Identify and evaluate tree species and their major NTFPs for their potential use to augment incomes of small-scale farmers or forest-associated peoples
- Catalyze research on the properties and efficient processing (including for fuel, fiber, fodder and food, nutraceuticals, and pharmaceuticals) of selected, prioritized species
- Determine the genetic variability and plasticity of the potential species as a basis for improvement
- Augment the production of selected NTFPs so that the trees can be grown and the benefits captured and sustained by smallholders.

*Specific goal 3: Improve the tolerance of smallholder livestock to biotic and abiotic stresses.*

*Rationale:* Germplasm enhancement is a critical component of CGIAR research aimed at increasing benefits to poor livestock producers, and generating income and employment opportunities along the value chain through rural-based livestock sector growth (Priority areas 3 and 4). The livelihoods of small-scale livestock keepers can be improved by increasing livestock productivity and animal disease control, and hence enhancing keepers' ability to take advantage of market opportunities. An increase in the productivity of livestock held under smallholder conditions is considered as likely to come from the enhancement of hardy varieties (indigenous breeds – see Priority area 1) as from the use of exotic stock.

*Scope of research:*

To increase animal productivity and to increase access to national and regional markets research will be carried out on:

- Production: improving animal breeds (particularly for feed efficiency) and indigenous breeds able to thrive in harsh environments. Development of genetic management techniques for improved stock. Species and breeds of small stock not the subject of research by the private sector but of high relevance to the farming and feeding systems followed by the poor will be included

- Animal disease resistance: the focus will be on identification of genes for trypano-tolerance in cattle, helminth-resistance in sheep and goats, based on earlier parasitological and breeding work in cattle in SSA, and cattle, sheep and goats in SSA and Asia, and linked to international consortia mapping bovine and ovine/caprine genomes.

*Specific goal 4: Improve aquaculture and production traits in tilapia and carp germplasm.*

*Rationale:* Fish demand will rise sharply and there are emerging opportunities through the development of aquaculture to secure improved incomes and to contribute to food security. The successful and sustainable development of aquaculture in the developing world will be conditional on more detailed understanding of the scope for, and dynamics of, growth in the sector. Opportunities for small-scale farmers depend upon evaluation of the associated risks, on sustained investment in development of technologies that are adapted to the needs of poor farmers, and on improved information on markets and marketing. The integration of selective breeding and genomics/genetic approaches to aquaculture improvement for traits such as growth, disease resistance, and other production traits suited to developing country situations, will be a key component of meeting increases in demand.

*Scope of research:*

- In conjunction with activities under Priority area 3, undertake collaborative research to enhance the capacity of developing countries to carry out genetic improvement programs, focusing on tilapia and carps in the first instance, and to measure the potential environmental cost of engaging in such activities
- Continue to develop genetic characterization and improvement methods, and training of developing-country scientists in risk analysis. Research approaches will integrate quantitative methods of genetic improvement for aquaculture species with molecular approaches, leading to improved strains of fish for aquaculture in developing countries
- Include the design of means for the safe deployment of such improved strains in research.



## System Priority 3: Reducing Rural Poverty through Agricultural Diversification and Emerging Opportunities for High-value Commodities and Products

### Summary

The research identified under this Priority addresses the opportunity to provide additional income for the poor through diversification and production of a range of agricultural products. Research on fruit and vegetables, livestock, fish, and forest and tree products is designed to augment productivity, and income-generating opportunities for the poor, whilst managing the conditions of growth of individual sectors and the links to markets. This enhances earlier research approaches to fish and livestock and tree products, and expands the CGIAR's focus<sup>14</sup> from staple commodities. The CGIAR will expect to link to international sources of expertise for commodities or approaches that have not been systematically addressed by the CGIAR previously. Approaches will link biological to socioeconomic and market research in consideration of factors affecting the production to consumption chain. There are increased opportunities through the selection of some commodities (small livestock, backyard aquaculture, home gardens etc) and post-harvest value addition, to target income-generating opportunities for poor women and communities.

### Rationale

Rural households typically pursue livelihood strategies that include not only farming systems (based on crops, livestock, forestry and agroforestry, and fish), but also non-agricultural home-based micro-enterprises (processing, handicrafts), and off-farm activities (such as wage employment in agriculture, employment in non-agricultural activities, and migration). It is the mix of these income strategies that eventually provides them with pathways out of poverty. Rural development strategies that offer these pathways must consequently look at agricultural activities in the context of these

multiple pathways and how they are inter-related. This often requires designing approaches to rural development from a territorial perspective, where the potential offered by agricultural research is a component, often the essential one, of a broader regional and local approach to poverty reduction (see Priority area 5). This implies that agricultural research needs to be coordinated with the other regional and local interventions that can provide pathways leading away from poverty. Where a blueprint approach to technological innovations has proved unsuccessful in some locations because the dimensions required to capitalize on the potential these new technologies offer for poverty reduction are missing, an integral territorial approach offers largely unexplored potential. This is particularly applicable to SSA, where the full benefit from investments in agricultural research has rarely been accomplished. Given the heterogeneity of local conditions, these territorial approaches need to be based on extensive participation of local stakeholders, both public and private.

Smallholder farmers can increase their agricultural incomes through greater sales of high-value commodities such as livestock, dairy products, fish, fruit, vegetables, spices, and ornamentals. These products are typically perishable, of high quality-specific value, and increasingly sold through specialized markets. Labor opportunities are provided at various points (production, harvest, post-harvest, and marketing) along the supply chain for new, higher-value commodities. This part of world agriculture is growing rapidly, and is becoming increasingly capital-intensive and vertically integrated. The requirement is to identify critical areas for trade, marketing, capital market, and regulatory reforms that can facilitate the integration of small-scale and poor developing-country farmers in rapidly growing global markets for high-value crop and animal products in a sustainable manner, and thus increase and diversify their incomes in the long term.

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14 The CGIAR has conducted work on selected fruit (particularly *Musa*) and vegetable crops at a low level in the past. This Priority area does not include cash crops such as tea, coffee, or cotton where there are private-sector sources of research and marketing support.

To participate in growing formal urban and export markets, producers need access to well-organized post-harvest chains that can handle the processing and marketing requirements. Agricultural processors and traders, on the other hand, face increasing pressures to certify the safety of production practices (such as to avoid pesticide residues in the final product), exact quality attributes, and timely deliveries. Informed policies and a conducive regulatory environment increase the incentives for agro-processors to use the produce of small-scale farmers as inputs, and improve their capacity to meet the product attributes required in a rapidly modernizing agricultural marketplace.

### Priority 3A: Increasing income from fruit and vegetables

#### Rationale

With prices for most of the global staple commodities projected to remain stable or fall in the near future, increasing the yield, stability and diversity of high-value products for market has potential to add significantly to the incomes of poor farmers and rural laborers. Such commodities include fruit and vegetables. These commodities have not been systematically considered by the CGIAR previously, or have certainly not been addressed from the aspect of livelihood opportunities for the poor. Moreover, added higher value can be gained by protecting harvests of staples and other commodities more effectively, or developing products, which provide higher returns. Production and diversification choices are intimately linked to the development of market opportunities, and the need for poor farmers to retain market access in the face of the growth of supermarkets and international and commercial regulation of food and environmental safety. CGIAR research in this area should focus carefully on the provision of international public goods. It is suggested that the CGIAR System concentrate on biological, socioeconomic, and policy research relevant to several high-value food crops.<sup>15</sup>

Emphasis should be placed on working through those crosscutting research themes that consider the supply–market chain and market intelligence. CGIAR research in this area should focus carefully on the provision

of international public goods such as the development of policies and institutional arrangements to link small-scale farmers successfully to markets and trade. A key aspect of the approach will be to focus on food safety and quality issues as they affect developing countries and their smallholder producers. New partnerships and modes of collaborations will have to be developed to link traditional players to consortia aimed at reaching the poor.

*General goal: Improve the income of small-holder producers and consumers through research relevant to major high-value fruits and vegetables.*

Here the intent is to improve income generation through strategic research on high-value horticultural crops. A major secondary effect of this research is the contribution that will be made to nutritional security through expanded availability of fruit and vegetables. The mode of operation is through crosscutting themes, networking and partnerships. In this new area, and with the emphasis on partnership and tasks according to comparative advantage, the CGIAR may seek to facilitate the development of a Global Horticulture Network amongst existing centers of expertise to help prioritize activities.<sup>16</sup> Associated activities may include regional information hubs, the facilitation of linkages among the NARS, the CGIAR System, private sector, ARIs and the design of a global variety testing nursery system.

*Specific goal 1: Identify key species for research and assess their factor and product markets.*

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15 Selection of fruit and vegetable species, and the scope for research by the CGIAR, should be made considering regional evaluations and including the following criteria: (i) Area under target crops and expected beneficiaries in 5, 10, 15 years; (ii) Proportion of that area cultivated by farmers (below an appropriate poverty line); (iii) Prospective change in income and stability for these farmers due to research output; (iv) Prospective income gains for farm laborers; (v) Gains (in nutrition and through cheaper consumption of these crops) for poor consumers.

16 The CGIAR will seek close collaboration with other providers of research in this area, including ARIs, research agencies (e.g., Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), The World Vegetable Center (AVRDC), Northern universities) and emerging networks.

#### *Scope of research:*

- Identify market opportunities for the poor
- Conduct research on product choices and market behavior
- Identify requirements for technological and variety change needed to help small-scale farmers participate successfully in such markets, and systems for design, transfer, and capacity building related to those technologies
- Identify institutional, organizational and national public-sector support services, and policies to enable farmers to participate in the markets.

#### *Specific goal 2: Enhance production of selected fruit and vegetables through improvement of farming systems.*

#### *Scope of research:*

- Identify 'pro-poor' traits or the identification of opportunities for the poor to exploit specific market traits (e.g., yield improvement research for traditional and exotic species, nutritional content, post-harvest quality traits, control of flowering, selection, and rapid propagation of perennial species)
- Identify pest and disease resistance needs and opportunities
- Develop markers for specific traits and species e.g., micro-satellites, and the linkage of improvement research on key species to other enhancement research (see below and Priority 2D)
- Design improved production technologies for selected species, including integrated pest management (IPM) and water-use efficiency.

This would be a new area for the CGIAR but would have linkages to existing or planned research in the following areas: Priority area 1, which would include the conservation and characterization of high-value crops; Priority area 2, which might include genetic improvement of specific traits (flowering, water productivity, shelf life, nutritional values, post-harvest traits, biotic and abiotic stresses etc); Priority area 4, including water productivity and planning at the crop and field level; Priority area 5, in relation to policies to reduce risks and vulnerability of smallholders; and capacity building in the area of markets, strengthening of producer organizations and public-private-NGO partnerships, and networking of researchers.

## **Priority 3B: Income increases from livestock**

### **Rationale**

Livestock are a crucial part of the livelihood systems of many poor rural, peri-urban and even urban populations in developing countries. Livestock also play a key role in many farming systems and in decreasing the vulnerability of households. However, current international and national policies, as well as existing livestock services, are often geared intentionally or inadvertently towards large-scale production. The enhancement of livestock development alone will therefore not necessarily contribute to poverty reduction. On the contrary, without proper targeting, livestock development may contribute to the crowding out of poor livestock keepers from evolving livestock commodity markets. Pro-poor and integrated programs for livestock and livestock services development are, therefore, required. This Priority focuses on the protection and enhancement of livestock production and livestock products in ways that will augment the income (and other) benefits for smallholders.

Worldwide, livestock use 3.4 billion ha of grazing land (as well as the production of about a quarter of the land in crops). Expansion of quality feed and fodder supply, particularly at the livestock-crop interface (i.e., food-feed cropping) will need to take place to enhance productivity. New low-cost feed and disease control innovations will enable poor livestock producers to increase the productivity of their efforts and consequently also their incomes. New livestock services will provide poor people with help in controlling communicable diseases and reduce their vulnerability to risks.

Coping with the unbalanced growth in the livestock sector, with industrial systems covering more than 80 percent of the incremental demand, requires an understanding of the features of rapid structural change associated with the ongoing livestock revolution, and its driving forces.

There is the opportunity to use the expansion of the sector to include the small units in a better way – to date, the growth in intensified systems has been largely led by capital. However, not all courses of livestock

system evolution are the same. For instance, the response in dairying to demand has not yet led to large single enterprises like pigs and poultry. Such change is often facilitated by policy distortions in the form of subsidized grain and of other inputs to intensive and industrial livestock production, such as favorable tax regimes for large-scale investments, access to credit, differential infrastructure development, etc, and the neglect of externalities (mainly environmental but also public health).

There is, therefore, a need to conduct research into the environmental and public health implications (including emerging diseases) of geographically concentrated production with rapidly growing unit scales. Ways should be explored to direct the growth stimulus from burgeoning peri-urban sites into rural areas where the livestock sector is often the only viable possibility for income and employment generation, but where environmental and public health implications related to expanding livestock production can also be effectively managed and minimized. Here the primary public goods at stake are social equity, environmental pollution (the problem of disposal of waste and emissions), and animal and public health (food safety), including the risk of emerging diseases (zoonoses). Policies and institutions are required to address these issues, some of which (such as the impact of increased feed demand on global food security, and emerging diseases) may gain a global dimension. Mitigation of such effects is an international public good, not solely concerned with poverty. However, the benefit to the poor from this research derives from better knowledge of their inclusion in, or exclusion from, in the process of livestock sector growth. This is expected to lead to the development of more equitable policies for the sector.

*General goal: Augment the productivity and sustainability of livestock enterprises in developing countries.*

*Specific goal 1: Identify opportunities for livestock growth in high-potential areas and implement them sustainably.*

*Scope of research:*

This will be accomplished by research in three related areas: on inputs to increase

productivity; on the reduction of production risks; and on access to, and competitiveness in markets. Research on inputs will include:

- Animal health research to develop low-cost vaccines and diagnostic tools appropriate for smallholders
- Research on epidemiology and economics – prioritizing the diseases that affect the livestock of the poor, and modeling – to predict impact of system changes on diseases
- Genetic enhancement and management research to increase the biomass, quality, and abiotic and biotic stress tolerance of food, feed, and forage crops
- Appropriate technology to make feeds (alternatives for concentrates) available for monogastrics (poultry and pigs)
- Genetic improvement of livestock (linked to Priority 2D) focused on: (i) breeding goal; (ii) development of selection criteria for robustness (including disease resistance) and productivity; (iii) gene identification; and (iv) design and implementation of breeding scheme (pure breeding, crossbreeding, and including use of reproductive tools)
- Research to improve input supply and provision of services.

Where production risks include bio-physical factors such as diseases and extreme weather conditions (requiring improved resilience and robustness of the farming systems), research will include:

- Conservation through use of animal genetic resources (linked to Priority area 1)
- Improving total productivity while maintaining adaptive capacity (resilience, robustness)
- Integrating alternative feed resources into livestock production systems (maintaining diversity)
- Diversifying production systems (ruminants/poultry or fish/crop/livestock) and ensuring alternatives
- Research on bio-safety aspects of production.

Research on markets will include:

- Understanding the nature of changing demand for different product attributes (including food safety), that could displace smallholders from the growing market. This will involve evaluation of emerging price differential for different product attributes

- Research on the supply chain will include definition of price formation along the value chain, the relative competitive position for smallholders and alternative sources of supply
- Evaluating of different forms of collective action to support different institutional options. This involves certification systems, overcoming transaction costs, distribution of benefits and risks between smallholders and market agents; and evaluation of effectiveness
- Managing impact of trade and trade agreements (linking development of smallholder systems with development in markets and changes in policy)
- Managing the rapid rise in the concentration in the retail food sector and evaluating the associated changes in food safety and other standards
- Improving integration of rural livestock production zones with expanding urban markets.

*Specific goal 2: Management of the intensification in livestock production improved to limit the negative impacts on the poor and the environment.*

#### Scope of research:

Research will require an analysis and documentation (including methodology) at global, regional, and national levels of the social, environmental, and health impacts of rapid structural change in the livestock sector.

Research to meet social goals will include:

- Exclusion of smallholders
- Impact of waste and emissions on environment and human health
- Importance of spatial distribution of livestock production on the environment
- Impact of changing norms and standards on the comparative advantage of smallholders, the environment, and human health
- Impact of changing animal disease patterns on human health.

Research to meet environmental goals:

- Enhancing efficiency of resource (water, energy, feed, and land) use along the value chain
- Importance of spatial distribution of livestock production
- Production, processing and distribution
- Impact of changing norms and standards.

Research to meet public health:

- Impact of changing disease patterns
- International trade in feed, animals, animal products (including semen and embryos), and veterinary health products
- Production, processing, and distribution
- Impact of changing norms and standards.

Following identification of risks and opportunities for developing countries and smallholder participation in the intensification of the livestock sector, strategies or technologies will need to be developed to help manage the transition from more traditional production systems to intensive modern production systems so as to minimize social costs.

Production research will focus on:

- Control of product quality through certifiable good stock
- Feed and pharmaceuticals
- Contingency planning against infectious diseases
- Introduction of good agricultural and manufacturing practices, including waste management.

Institutional research will focus on:

- Strengthening producer and trader associations
- Strengthening skills for management of risk
- Strengthening skills for dealing with vertical integration in value chains
- Strengthening of regulations and laws for international commodity exchanges.

Policy research should address:

- Policies for handling externalities of intensive animal production (e.g., zonation, tax systems).

The importance of food safety research is addressed under Priority area 5 in relation to markets.

### Priority 3C: Enhancing incomes through increased productivity of fisheries and aquaculture

#### Rationale

Fish are high-value commodities, which make key contributions to livelihood and nutrition at local and national scales in many developing regions. It is necessary to sustain

the benefits from existing aquatic resources (see Priority area 4C) and to augment the production of fish and other living aquatic resources taking into consideration the long-term sustainability (both ecological and economic) of any enhancement activities. To secure opportunities for the poor, special efforts are required to ensure the equitable distribution of benefits from such undertakings, in both coastal and inland systems. This Priority addresses the augmentation of production and marketing of fish for enhanced income.

Increasing fish production is most easily effected through aquaculture and bringing new small bodies of freshwater into fish production. However, other production systems include the partitioning and communal ownership of rivers or lakes, integration of fish capture or culture into inland farming or coastal systems, stocking, enhanced reservoir fisheries etc. Technological approaches – which broaden the application of the many successful trials in augmenting fish production at the pilot level, taking various input levels and marketing constraints into account – are required. The question of property rights, however, remains critical to rational exploitation of these water bodies but has different dimensions with respect to aquaculture and fisheries. CGIAR research within this area needs to address the issues facing key production systems in developing countries. It should tackle the equitable access to benefits from raised production (such as enhanced nutrition or improved economic or social function) as well as simply increasing quantity (production or productivity) of aquatic resources.

Over half of global fish exports by value originate from developing nations. Many developing nations rely on exporting seafood as one of the primary sources for export earnings. The majority of those exports go to developed nations, leaving poor producers in developing nations vulnerable to risks from changes in trade and macroeconomic policies, sanitary and phytosanitary (SPS) requirements, technical barriers to trade, and to changes in consumer demand for particular attributes, for example, environmentally friendly processes in the production of fish.

The poorest fish producers do not always gain those market benefits provided by

increased production and trade. In most cases, this is due to market organization and structure within the domestic economy and the lack of institutions to transfer benefits from growing exports to smallholders. In addition, developing nations generally do not produce value-added seafood products due to tariff barriers, thus losing the potential jobs such value-adding would create. There is, therefore, a need to integrate small-scale producers with marketing mechanisms and to examine and support means by which emerging industries can meet the food and product safety requirements of international and domestic markets.

*General goal: Increase livelihood benefits for poor people by increasing the supply of aquatic resources.*

*Specific goal 1: Provide a portfolio of options that addresses the needs of the poor aquatic resource user and allows equitable accrual of benefits from improved productivity.*

*Scope of research:*

- *Ex ante* evaluation of carrying capacity, analysis of scale issues relating to environmental effects of improving fish production within and around water bodies and the development of strategies for the mitigation of environmental effects
- Comparative analysis of private and public sector roles in the management of aquatic resources (particularly, fisheries, aquaculture, water sector, environment, legislation etc)
- Determine how to link indigenous and biotechnology methods for improved feeds for growout and hatchery (identifying cost-efficient alternatives to fish meal and oil for those not able to react to market changes)
- Identify where aquaculture at different scales (integrated aquaculture–agriculture practices up to intensive commercial scale) is biologically, socially, economically, and institutionally feasible and assess the policies needed to support such a development
- Design enhanced fisheries or aquaculture technology options that can be adapted to the different biophysical conditions and market opportunities and constraints, with specific assessments of the environmental impact of technologies, and identification of the opportunities for the poor.

**Specific goal 2:** *Augment the capacity of developing nations by creating institutions and policies that help them meet fish and seafood safety requirements in the most cost-effective manner.*

**Scope of research:**

Analysis of best practices for complying with international and domestic SPS regulations for the economy, for fishery and aquaculture sectors, and poor fish producers in developing countries

- Analyze risks to aquaculture producers in the form of technical barriers to trade related to food safety, through regulation of residues of such chemicals as vaccines and antibiotics, and their potential impacts on developing countries
- Develop new tools for disease control in aquaculture, such as internationally accepted antibiotics, vaccines, and diagnostic tests
- Analyze least-cost means of certifying smallholder production for SPS and other food safety requirements as required by importing nations
- Determine the costs of compliance with ecolabeling and other environmentally related programs in developed countries, and their impacts on market access and trade of seafood from developing countries
- Analyze desirable institutional changes at the domestic and international levels leading to pro-poor outcomes of globalizing seafood markets in developing countries.

### Priority 3D: Sustainable income generation from forests and trees

**Rationale**

The sustainable management of forests is aimed specifically at sustaining their value for the poor (or local communities). Such management requires an improved understanding of the full range of products and services provided by forests, together with knowledge of product demand, and the institutional and policy contexts in which they are exploited. Demands for benefits and services from forest resources occur at the national level, at the level of markets for products and services and demand from

society (including the urban sector). Products include food (and livelihood security), fodder, fuelwood, biomass, medicines, etc. Research is required to identify market opportunities for tree and forest products, which may be accessed by the poor and which do not threaten sustainability or other forest uses. Included amongst the range of forest products and services are non-tangible benefits: social, ecological, and environmental values must be translated into economic values to provide relevant information to decision-makers.<sup>17</sup> Enhancement of policy-making is required to encompass important upstream/downstream interactions in forest and product use, degradation versus deforestation, and potential conflicts between users. Policy research must, therefore, be informed by knowledge of the biological processes, the understanding of market and social-economic drivers of demand, and the need to develop trade-offs amongst users. For CGIAR research, it is particularly important to identify pathways for the appropriation of benefits by local people and communities, and small-scale farmers.

**General goal:** *Enhance livelihoods, and sustainably secure and harness the value and benefits of forest and tree resources.*

**Specific goal:** *Improve opportunities for the market exploitation of a range of forest products by the poor.*

**Scope of research:**

- Determine and quantify the existing markets for the varied types of forest products
- Identify and promote marketing approaches, which add value (e.g., through processing, or product development for NTFP) that support local communities and forest users
- Provide policy advice and ranges of options, which allow for trade-offs in forest use between stakeholders, services and products.

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<sup>17</sup> Examples of environmental services that forests provide include biodiversity, soil conservation, soil fertility, water quality and quantity, carbon storage, social-cultural-ecological resilience; and (at a slightly different level) potentials for deriving income and status from ecotourism. Environmental services are not necessarily interchangeable (e.g., species extinction of globally significant biodiversity may or may not affect carbon storage).



## System Priority 4: Poverty Alleviation and Sustainable Management of Water, Land, and Forest Resources

### Summary

Sustaining natural capital and reducing risk are key components of an overall strategy for poverty alleviation. CGIAR research is prioritized to enhance the stability and sustainability of agricultural productivity through three means. Firstly, by improving knowledge of the interactive factors relating to resource and agricultural management and by providing assistance to decision-making and trade-offs amongst objectives at the landscape level. Secondly, it will identify within resource sectors (such as water, fisheries, and forestry) better ways to sustain productive resources and to enhance the poor's share of benefits. Thirdly, there is a focus on combating land degradation in farming systems to underpin other CGIAR research on enhancing productivity, and to ensure developing countries do not fall behind the challenging production targets for staples that remain to be met in the future. Emphasis will be placed on the nexus of agricultural and NRM research. Outputs will be new knowledge, decision-support models and best practice examples for management, institutional development, and policy advice. The research will be designed to have wide applicability and spillovers to a range of regions and across resource types. The approach will be characterized by partnership with a range of stakeholders in NRM so that externalities from all relevant sectors are considered in improved management of resources by and for the poor.

### Priority 4A: Integrated land, water and forest management at landscape level

#### Rationale

Farms are embedded in wider landscapes and political contexts by which their capacity to provide livelihoods ultimately is determined. Poor forest dwellers are often associated with forest patches in forest–agriculture mosaics. Watercourses permeate lands in different ways and change opportunities for farming and income across the landscape.

The core problem in many parts of the world (but particularly at high population densities such as those in East and Southeast Asia) is the demand for more food under increasing competition for scarce natural and socioeconomic resources. This leads to conflicts in land use objectives and resource use, and increases in agricultural production have to be achieved with less land, water, labor, and other resources. Degradation of land and other resources, particularly water, has sometimes ensued. It is clear that to meet the needs of the poor – whether farmers in low-potential areas, raising livestock on smallholdings or pastures, in forests, in coastal or inland water fisheries – their socioeconomic and resource endowments and the political contexts in which they live will be critical to solutions. The systems require to be sustained and institutions developed for their management. The units of analysis are at both the local level (the immediate household or community) and the landscape or coastal region level.

However, there are challenges in working at the landscape level. There are multipurpose land uses within landscapes and multiple land users (individuals, groups, and other entities who are stakeholders in landscape use). Consideration of landscapes (rather than single resources) moves the focus from individual products to the provision of multiple products and ecosystem services. (The relationships between ecosystem services and climate change are complex where known.) There are multiple scale issues of use and management (across different actors). There can be quite extensive externalities on land use and management from other sectoral undertakings.

The research issues are confronted by a lack of information on the complex problems noted above. There is, therefore, the need to establish knowledge, data, and methods in order to ensure progress in management of agricultural landscapes. There is a need for benchmark selection for strategic and other types of research. Because of the large number of actors involved, there is a need both to disseminate knowledge and to work

in participatory and empowering approaches (NARS/CGIAR/service providers partnerships), and policy and institutional outputs will be as important as technologies and practices.

To date, different approaches are followed (by the CGIAR and others) at different scales, to tackle agricultural problems, which include:

- Technology-oriented, at field/farm scale: examines methods to increase production while increasing resource use efficiency
- Policy-oriented, at regional to national scales (or aimed at markets)
- Participatory, at household to national scale: explicitly takes into consideration the active role of resource managers and planners (at different levels) in the research process.

The requirement is to develop effective tools and methods to integrate the outputs from these different approaches and to produce resource and production management solutions that are coherent at different scales and equitable amongst resources and their users. Assistance is required by NARS (still mostly organized along disciplinary lines) to understand and integrate the different levels of information required to optimize agricultural and land-use planning and poverty alleviation at the landscape level. The intention is to treat a small number of benchmark sites in this way to derive lessons from approaches. There is utility in conducting research at the water basin level (although other landscape definitions are possible according to the scale of the problem being addressed).

Poor and marginalized groups often depend to a greater extent on natural resources (forest resources, fisheries, and common pastures) than others. This dependence increases the vulnerability of the poor if access to the resources is curtailed. Achieving equitable access to forest resources is a current issue with benefits from the exploitation of forest resources and products going to people other than the poor (or an inequitable proportion/value is captured by people other than the poor). Forests are often subject to overlapping systems of property rights, which becomes particularly clear in off-farm areas. If governments hold the majority of the rights they are often unable to distribute the accruing benefits in

a fair and equitable manner. Sectoral policies are usually unsympathetic to the situation of the poor (e.g., tree tenure and logging bans prevent farmers from growing or harvesting trees) and integrated research approaches across sectors and landscapes are required.

Water is an essential but limited commodity in a variety of agricultural and non-agricultural uses directly impacting on the livelihoods of multiple users in a water basin. There is going to be increasing competition and potential for conflicts among users and uses. If such conflicts are to be resolved, greater integrated management and cooperation are required. However, research approaches to increasing the availability of water will benefit from the inclusion of all relevant resource and sectoral uses.

Effective management of natural resources has often been constrained in the past by tackling issues in isolation, as though they were sector-specific. However, natural resources are affected not only by different patterns of resource exploitation but also by dynamic vertical and horizontal interactions with other sectors. On the horizontal scale are interactions ranging from the local to transboundary levels (agricultural production policies leading to over use of groundwater; migratory or straddling fisheries stocks with transboundary regimes for fisheries and water management; effects on water quality from fertilizer and pesticide regulation in agriculture; forest exploitation versus conservation for biodiversity protection, carbon, or water storage). On the vertical scale are the increasing influence of global environmental conventions and governance approaches and their effects at the local level. Improving the governance of natural resources, therefore, requires the development of policies and institutions that optimize sustainable use across sectoral interests. Currently, productivity in many production systems is declining because of lack of control over negative externalities.

Natural resource economies and institutions in poor countries are often predominantly informal and outside the ambit of direct regulatory action by governments. In such situations, regulation and use of direct policy instruments may be ineffective or not even feasible. Analyzing the functioning of

local natural resource political economy (and across contrasting situations) can enable the identification of best-bet indirect levers to influence their workings (e.g., managing groundwater through energy pricing policies).

The CGIAR's analysis and interventions should seek to advance multiple outcomes (ecological sustainability, livelihood security, overall resource productivity, and social well-being). The specific goal of this research addresses two key policy and governance issues relating to multiple use of resources, namely: (i) establishing inter-sectoral effects of property rights regimes; and (ii) examining new (including indirect) incentive mechanisms for NRM for their effects on communities, livelihoods, and sustainability. The CGIAR has comparative advantage in these aspects of research (building on the conduct of the range of work outlined in Priority area 4) in developing-country benchmarks and regions around the world. Similarly, the CGIAR can address these issues at different levels: from international frameworks and resource governance regimes, to the local level effects of policies and institutions on smallholders and resource managers in developing countries.

This landscape level research is needed to properly contribute to sustainable agriculture and use of natural resources, as espoused in several of the MDGs. To optimize productivity, it is necessary to understand trade-offs amongst options and to help target strategies towards the poor. The CGIAR's comparative advantage is in such multidisciplinary approaches, brokering research, working at the nexus of agriculture and environmental issues, synthesizing across sites and research components, and in the provision of methods and policy advice as international public goods.

***General goal:** Improve land-use practices to contribute to increased and sustained productivity, optimal conservation, reduced conflicts and equitable use of land, water, and forest resources in multiple-use landscapes.*

***Specific goal 1:** Develop analytical methods and tools for the management of multiple-use landscapes with a focus on sustainable productivity enhancement.*

*Scope of research:*

- Develop approaches and associated tools to conduct trade-off analyses for food productivity, ecosystem services and land conservation
- Conduct gap analysis of information needs to enhance productivity in a sustainable manner
- Quantify and understand material flows
- Understand how different stakeholders use and manage the landscape
- Understand the drivers for land use change and degradation at landscape scale
- Develop methods, tools, and indicators for monitoring and impact assessment
- Identify the impact of landscape fragmentation on ecosystem services
- Understand the relationships between land use and climate change.

***Specific goal 2:** Enhance the management of landscapes through changing stakeholder awareness and capacity for social-ecological planning at landscape and farm levels.*

*Scope of research:*

- Understand linkages between resource management and value-adding opportunities
- Identify the role of governance and institutions (especially property rights) in management of landscapes and conflicts
- Identify how institutions should be adapted to facilitate change
- Identify entry points (inside and outside of agriculture) for enhancing land management in landscapes
- Identify benchmark landscape units within key landscapes (this will be conducted at a small number of areas of key ecoregional and global significance)
- Identify principal constraints to sustainability and improved productivity of systems
- Value and determine means of compensation for ecosystem services
- Project likely scenarios of development for benchmark landscapes
- Evaluate the consequences of large scaling-out of farm interventions on landscapes.

***Specific goal 3:** Establish effective rights and opportunities to ensure that the poor benefit equitably from forests and tree resources.*

#### *Scope of research:*

- Through comparative case studies, identify complementary, overlapping, and conflicting forest tenure and rights over species and impacts on wealth and power
- Identify the impacts of the alternative governance structures and institutional arrangements, and of dynamics of transition from one form of governance to another and implications for the poor (e.g., decentralization and devolution processes)
- Identify (conditional) principles for applying property rights, looking across larger landscape units
- Develop and conduct action research, tools, and approaches to deal with diverse and differentiated rights and tenure arrangements
- Develop and test new options with policy-makers
- Identify mechanisms for creating space for the voices of the poor and marginalized in governance and conflict management.

#### *Specific goal 4: Optimize long-term productive use of water resources in river basins.*

#### *Scope of research:*

The intention is to optimize basin level water productivity through: (i) improving productive use of water resources by the poor at the river basin level; (ii) creating employment for the poor and reducing cost of food; and (iii) paying for environmental services.

- Develop and apply tools and methods for auditing and analyzing potential gains, losses, synergies, and trade-offs
- Develop strategies for improving productive use of water resources by the poor in river basins
- Develop strategies for increasing employment opportunities for the poor through creation of more jobs per unit water used
- Develop scale, effectiveness, and modalities of payment for environmental services
- Analyze specific threats to long-term sustainability posed by changes in climate, population pressures, and land use.

#### *Specific goal 5: Create multiple benefits and improved governance of environmental*

#### *resources through the harmonization of inter-sectoral policies and institutions.<sup>18</sup>*

#### *Scope of research:*

- Identify policy instruments and institutional design features that enhance security of individual and collective property rights for productive, equitable, and sustainable management of multiple-use landscapes
- Assess impacts of sectoral and macro-level policies on natural resource systems in contrasting situations
- Develop and test design principles for environmental service mechanisms in situations with greater or lesser formal control
- Evaluate potential impacts of environmental certification schemes in different institutional contexts
- Identify and assess impacts of resource sector-specific policies on other sectors and their channels of transmission
- Identify trade-offs among resource sectors (especially productivity, ecological integrity, livelihood implications) and evaluate policy instruments and institutional mechanisms
- Identify and promote best practice for improved governance of natural resources to achieve consistency and synergies.

### **Priority 4B: Sustaining and managing aquatic ecosystems for food and livelihoods**

#### **Rationale**

Aquatic ecosystems encompass a wide range of highly productive and biologically diverse inland and coastal systems, including rivers and their associated floodplains, reservoirs, lakes, estuaries and coastal lagoons. Many of these systems are shared and transboundary in nature and widely distributed in the developing world, where they sustain the livelihoods of millions of people, mainly from

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18 The major linkage is to empirical and analytical studies conducted under other elements of Priority area 4 (priorities 4B – 4D including water, aquatic ecosystems, and soils) and Priority area 3, (exploitation of forest products, aquaculture, and fisheries), but there are links to all areas of CGIAR research.

capture fisheries. Despite their importance, these ecosystems and the resources they provide are also vulnerable to changing management practices at both catchment and local levels and many have been overfished or seriously degraded in recent decades. Generally, open access and weak governance (perverse incentives and poor implementation of existing controls at multiple levels) lie at the core of most of these problems. Indeed the issue of poor governance is generic to small-scale fisheries in developing countries (including coastal marine fisheries, inland water fisheries and aquaculture developments). Research must examine the broad underlying issues of governance, trade and inter-sectoral linkages. Innovative ownership and management arrangements need to be developed, including the participation of fishers and their communities, on the basis of social, institutional, and policy research and capacity building of stakeholders for active participation. While solutions must be found for each individual fishery, a wider comparative research program is needed to examine fisher and community incentives and responsibilities for compliance and identify longer-term trends and best-practice examples. The stabilization of capture fisheries is a critical part of the production equation for this sector.

To address these issues it is proposed that priority be given to research on governance and management systems that will sustain and/or improve livelihood benefits to the poor from these ecosystems, and to the provision of information on the value and management requirements of aquatic ecosystems and their resources.

***General goal:** Safeguard and enhance the livelihoods of the poor by sustaining and augmenting the value of aquatic ecosystems and their resources.*

***Specific goal 1:** Identify viable governance and management systems that sustain aquatic ecosystems and increase the sustainable benefits that poor households derive from these ecosystems and their resources.*

***Scope of research:***

The CGIAR will contribute with international and national partners to addressing this Priority (applicable to both coastal and inland water/river fisheries) by leading the develop-

ment of methods and approaches, and the dissemination of information gleaned from comparative studies across regions and ecosystem types. This will include research to:

- Improve understanding and implementation of property rights, formal and informal management systems, community-based/co-management, incentives and financial mechanisms, regulatory controls and compliance. The research will consider multiple scales including national and international transboundary levels
- Identify opportunities for pro-poor income diversification and improvement through use of fisheries and other aquatic resources. This will include development of: (i) poverty-mapping tools that can be used to identify the poor and how they benefit from these aquatic ecosystems; and (ii) tools for assessing the constraints that prevent them from doing so
- Identify alternative livelihood options for fishing households in those areas where there is over capacity, and development of strategies and financial mechanisms for supporting these households to move out of fishing.

***Specific goal 2:** Develop tools for biological assessment of aquatic ecosystems and their resources, valuation and management in data-poor environments and development of the capacity to use and apply them.*

***Scope of research:***

This will include the development of tools to:

- Assess fisheries stocks
- Assess the value of fisheries and other aquatic resources in contributing to poverty alleviation and the wider economy, and the impact of management practices upon poverty and achieving other benefits from fisheries
- Determine the water quantity and quality regimes that are required to sustain fisheries and other ecosystem benefits
- Assess impacts on aquatic ecosystems (biodiversity, habitats, processes) and fisheries, of basin level processes including upstream–downstream and cross-sectoral linkages
- Share information geared to management action (e.g., through rapid assessment tools or specific analyses) to complement more formal reporting of national and regional assessments etc. made by FAO.

## Priority 4C: Improving water productivity

### Rationale

The increased food production associated with the Green Revolution was linked directly to increased water use in irrigated agriculture. There have been well documented benefits to farmers and the poor. In some cases, excessive use of water and poor drainage has resulted in damage and irreversible mining of the underground water. Alternatives and efficiencies in water use must be sought.

In contrast there has been little use of strategic water application in rainfed agriculture. Here the judicious use of small amounts of water can have large benefits. Thus the use of water in agriculture is a continuum and there are inevitably trade-offs between sources in different regions: increases in the productivity of rainfed agriculture lessen the need for irrigation.

At the landscape catchment level, there is the need for agriculture to share available water with other users. There are multiple uses of water within the wider area of agriculture – livestock, fish, agroforestry – and in processing and for industrial and household uses. There are still basic questions about the amount of water needed to sustain agriculture. There is inequality of access to the resource, and who benefits from it. There are as yet poor policies governing the real cost of irrigated water. Provision of additional water is a key ingredient in supporting farmer productivity and improved livelihoods. New water sources, however, need to be developed in a sustainable way. For instance, agriculture is already encroaching on wetlands without a clear evaluation of trade-offs in water use.

The nature of water increases complexity in management (transboundary transit and sharing, temporal/spatial variability, multiple users, multiple jurisdictions, and more inter-sectoral linkages than any other resource). Moreover, water scarcity and rapid economic development increase water pollution. This leads to further conflicts over water resources, and the increased risk of farmers and the rural poor being left out in water and related decision-making processes. To support food production, enhance rural

livelihoods, and sustain the environment, there is thus a need to manage and use water more judiciously in all its applications, but particularly in agriculture, the major water user. Investment in new water supply – while still necessary and justified from a comprehensive point of view in many countries and sectors – has generally become increasingly difficult from a financial and environmental point of view. With reduced options in supply side management, demand side management options (policies, institutions, e.g., economic incentives) increase in importance. Enhanced water use and management requires adequate governance systems and policies and institutions that guide water allocation and use, across multiple uses and space, as well as time. It is, therefore, necessary to develop research related to: governance, property rights and conflict management, water-dependent livelihoods and exit strategies, inter-sectoral and inter-scale policy-making, prices/incentives, transboundary institutions, and identification of the impact of policy reform and policy processes.

*General goal: Increase water productivity in irrigated and rainfed environments to enhance livelihood aspirations of rural and urban poor.*

*Specific goal 1: Improve management practices that enhance the productivity of water.*

### Scope of research:

Research will be conducted at field, farm, and regional levels to optimize water use<sup>19</sup> through:

- Policy research that relates the true cost of water to farm costs
- Crop–soil–water management practices at field level (e.g., water-conservation technologies within field, supplementary irrigation) where the key principle is to reduce non-productive outflows and maximize water-use efficiency (economic return of enterprise per unit of water used)
- Crop–livestock diversification at farm level
- Water-harvesting beyond field to the catchment: where the key principle is to redirect water flows to field.

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<sup>19</sup> This area links to Priority 2A on breeding for transpiration efficiency, and Priority 4D focused on the water productivity aspect of improving productivity.

Socioeconomic and institutional research will augment incentives for farmers to cooperate in water productivity-enhancing technologies. The emphasis will be on putting together options using a systems approach that can be adopted by farmers, and the conduct of new science, e.g., linking Priority area 2A on breeding for transpiration efficiency, and Priority area 4D focused on optimizing the integration of resource use to stabilize and improve productivity.

**Specific goal 2: Enhance the sustainable development of water resources.**<sup>20</sup>

*Scope of research:*

- Assess investment options for all sources of freshwater and marginal water development for poverty reduction and environmental sustainability (in line with MDGs) – this will include a cost–benefit analysis of energy costs and trade-offs in the exploitation of new sources of water
- Develop policies and management options for sustainable use of fresh and marginal quality water
- Identify options for the diversification of livelihoods across wetlands while sustaining their ecological functions.

**Specific goal 3: Improve water-focused policies and institutions.**<sup>21</sup>

*Scope of research:*

Research to develop strategies and structures for effective governance systems for water and related resources:

- Understand what is involved in effective governance systems in different environments, including (formal and informal) property rights systems, indigenous management systems and legal frameworks under which different people participate in water and related decision-making
- Understand and enhance linkages between upstream and downstream water stake-

holders, and inter-sectoral policy linkages, to develop the means to internalize the externalities in basin management and use

- Analyze and identify the implications of decentralization for water governance systems
- Identify the mechanisms for overcoming constraints to development and application of effective governance systems.

Research to support governance systems with better informed policies and institutional mechanisms that focus on providing benefits to the poor from water and related resources:

- Develop participatory mechanisms that ensure the concerns (including indigenous) of the poor are addressed effectively in decision-making processes
- Devise economic incentives that allow the poor to better manage water (quantity and quality) across uses, across space (including transboundary), and across time
- Assess and demonstrate the impact of different water policy reforms and policy processes of implementation
- Identify new mechanisms (e.g., water rights and water markets) for sustaining and conserving water access and its benefits
- Understand trade-offs in water management and use and develop mechanisms that benefit the poor
- Develop policies and mechanisms for dealing with resource degradation due to over-use (and formulate exit strategies)
- Develop mechanisms for conflict resolution.

**Priority 4D: Sustainable agroecological intensification in low- and high-potential environments**

**Rationale**

The mining of nutrients and degradation of land and soils are key constraints to productive farming at all levels of intensification. Resource-poor farmers in low-potential environments<sup>22</sup> will remain disadvantaged, as they cannot achieve the necessary income

20 Linkages with other priority areas will primarily be with Priority area 2 (on breeding for transpiration efficiency, drought, and salinity tolerance) and other aspects of Priority area 4 at the farm and landscape level.

21 Research in this area will link to: Priority area 5 (organizations/governance/ develop policy instruments); other aspects of research under Priority area 4 (aquatic resources/land use management at landscape level/forest resources); and Priority area 3 (environmental externalities of livestock).

22 ‘Low-potential environments’ include inherently low-potential areas, by reasons of climate or resource endowment. The focus of the research under 4D includes such areas as well as those areas that have greater potential that is not being realized because of land degradation.

using degraded land to climb out of poverty. New research and policy development must, therefore, be targeted at the resource-poor farmers. In many areas, but particularly in Africa, means must be found to reduce the excessively high nutrient cost to farmers. For some, the land may be 'irreversibly degraded' as rehabilitation will be beyond their means. Research is required on the optimal combinations of organic matter, nutrient, and water supply that effect nutrient uptake efficiency. The issues are exacerbated in dry areas, but the scope does not exclude higher rainfall or irrigated areas, which have been adversely affected by land degradation.

Livestock play important roles for the poor in the provision of livelihood, human nutrition, recycling of soil nutrients, traction and transport, and insurance against risk. There is only limited potential for creating benefits to the more marginal areas, distant from markets and with no quality feed surplus, such as in extensive pastoral areas. However, it is here where poor people often entirely rely on the multiple functions of their livestock for their livelihood. Improved access to, and control of, assets (animals, land, water, capital, and credit) will reduce vulnerability and risks, and help support the natural resource base. Availability and access to feed resources is a growing constraint for many poor livestock keepers in low-potential areas. Enhancing the efficiency of crop–livestock interactions will in part govern the means to stabilize and sustain mixed farming systems in low-potential areas.

Poverty associated with land degradation results in conflict, and out-migration. It is necessary to identify the most binding constraints to productivity in areas of current low productivity – including biophysical and socioeconomic constraints – and to identify effective means to mitigate such constraints. An additional factor may be of the lack of labor in HIV/AIDS-affected areas (but job creation is important in other areas). Improving land management and raising the potential for productive farming will assist a number of farmers to raise income and food security. Improved land management will contribute to carbon sequestration. However, analysis is required to evaluate the number of cost-effective solutions to reversing land degradation. Part

of the solution may also be the optimization of, or reduction in the numbers of farmers seeking to exploit degraded areas.

However, land degradation is not solely an affliction of inherently low-potential environments, and there is increasing evidence of the progressive degradation of intensified systems in high-potential farming areas. Global production of staples is required to increase substantially to meet pressing population growth. In addition to the requirement to sustain and improve genetic yields (see Priority area 2A), yield growth is being threatened by resource base factors and such trends as: regional and national level shifts in production area (e.g., loss of favorable agricultural land to other uses); scarcity of water (irrigation water, groundwater depletion, shifts to other uses and wastewater reuse); salinity in irrigated systems; nutrient depletion and changes in nutrient balance (particularly potassium nutrition); interaction between nutrient supply and insect/disease incidence and severity; and changes in soil quality at the field level. These changes are reflected in a decline in the total factor productivity of intensive cereal systems, which unchecked will reduce the capacity to meet the food demand for the major cereals.

Efficient land and cereal use are linked with livestock production (feed grain production, recycling of livestock manure), forestry, and fisheries. System diversification is taking place with access to markets and information for the 'new' crops and management techniques. In many areas, there is adoption of knowledge-intensive agroecological management but there is a need to scale-up adoption among greater numbers of farmers and wider areas.

There is thus a major requirement to augment research on the appropriate agroecological intensification of land use to meet the rising demand for yield increases in staples and the simultaneous diversification of options to high-value crops and products. As with other uses of natural resources there must be an emphasis on trade-offs. This is a more complex goal than research simply on nutrient cycling at the farm level. The aim should be to establish ecological principles to aid balanced approaches in the future.

**General goal:** Reverse land degradation and sustain increases in food supply in a range of agricultural systems using ecological principles to ensure environmental integrity and food security for urban and rural poor through improved soil, land, and ecosystem management.

**Specific goal 1:** Improve understanding of degradation thresholds and irreversibility, and the conditions necessary for success in low-productivity areas.

*Scope of research:*

- Understand driving forces and processes that lead to irreversible degradation under heterogeneous conditions (interactions and comparisons between fields, farms, farming systems, and across ecoregions)
- Assess livelihood/diversification options with a focus on management of organic matter, reduced nutrient mining and increased nutrient efficiency
- Identify policy, infrastructure, market, institutional, and organizational constraints and opportunities
- Develop indicators of degradation for different socioecological systems
- Devise options to increase adaptive capacity and reduce vulnerability and risk of land degradation.

**Specific goal 2:** Protect the livelihoods of rural livestock keepers in low-potential areas.<sup>23</sup>

*Scope of research:*

The CGIAR gives high priority to reducing resource degradation by livestock, and enhancing the genetic basis of livestock production through improved breeding schemes. The emphasis will be on asset protection and income diversification, and the conduct of participatory and conventional research to:

- Reduce common property resource degradation (land, water, wildlife) by developing novel forms of institutional arrangements. The benefits to the poor will be increased to the extent possible from rangelands by identifying synergistic interactions between crops and livestock in the use of land and water
- Reduce production risks and vulnerability by identifying livestock services suited to mobility and low infrastructure endowment
- Stabilize production and productivity by developing low-cost technologies suited to

low-potential environments, with a focus on the management of feed resources and the control of infectious diseases

- Enhance the genetic base of widely used livestock production systems by utilizing available indigenous genetic diversity and knowledge, the identification of productive traits for genetic improvement, and their incorporation into breeding strategies for marginal environments including indigenous knowledge.

**Specific goal 3:** Identify domains of potential adoption and improvement of technologies for improving soil productivity, preventing degradation, and for rehabilitating degraded lands.

*Scope of research:*

- Design and test innovative diversification options within farms e.g., conservation agriculture (soil and water management), crop rotations with legumes, mixed cropping, tree systems, integrated crop–livestock approaches
- Develop appropriate methods of integrated soil fertility, including the opportunity for fertilizer use, to maximize nutrient-use efficiency and minimize nutrient mining
- Develop integrated pest and disease management strategies
- Evaluate trade-offs between goals of short-term productivity and long-term sustainability
- Operationalize technology development and targeting within a livelihood context, noting gender differences and opportunities
- Develop methodology and frameworks for extrapolating CGIAR benchmark work to broader scales
- Provide linkages, capacity building, and information amongst actors to alleviate key constraints.

**Specific goal 4:** Evaluate the production potential of high-productivity systems and their constraints and trends.

*Scope of research:*

- Develop robust simulation models for crop yield potential, yield stability, and yield gaps in diverse environments at local, regional, and global scales to assess future food security scenarios and impact of climate change
- Develop decision-support tools for moving intensive systems closer to their potential

- Develop decision-support approaches for priority setting for resource allocation by policy-makers.

*Specific goal 5: Improve soil quality to sustain increases in productivity, stability, and environmental services through greater understanding of processes that govern soil quality and trends in soil quality in intensive systems.*

*Scope of research:*

- Identify most important soil properties governing soil quality in major farming systems, their critical thresholds and trends
- Understand the extent of nutrient mining, particularly in potassium and other micro-nutrients in the major cereal food systems
- Maximize nutrient cycling and balance to sustain and/or improve soil quality
- Prevent and/or reclaim salt-affected soils
- Develop conservation farming practices and residue/by-product management practices that maintain and improve soil quality among the different enterprises
- Improve management practices that enhance carbon sequestration, water quality, soil hydraulic properties, and minimize greenhouse gas emissions.

*Specific goal 6: Design methods to manage and enhance biodiversity to increase income, reduce risk and vulnerability through IPM, crop diversification (and rotations), and genetic diversity within crop species.*

*Scope of research:*

- Develop models and decision-support tools to explore biophysical and economic diversification opportunities efficiently at farm, regional, and policy levels
- Identify how to use crop genetic diversity to increase productivity and reduce abiotic and biotic risk
- Identify opportunities for IPM to reduce dependency on pesticides, increase productivity, and achieve product quality that meets international standards
- Address emerging pest and disease complexes in response to intensification and global change (involving both cereal and conservation tillage systems; and crop–livestock and other agricultural systems)
- Evaluate the deployment of genetically modified organisms (GMOs) (for host-plant resistance) as a component of IPM, and their impacts on biodiversity, and

on the provision of other environmental services.

*Specific goal 7: Optimize productivity at high-input use (e.g., labor, nutrients, pest control practices, water, seed, and feed) through understanding and managing spatial and temporal variation.*

*Scope of research:*

- Understand spatial and temporal processes in nutrient cycling and nutrient balance to optimize nutrient use efficiency and yield while minimizing nutrient losses, and develop appropriate management practices based on this understanding
- Understand the interaction between water and nutrients to increase use efficiencies of both inputs
- Develop conservation tillage practices that optimize trade-offs among profitability, productivity, and environmental services and are adoptable by smallholder farmers.

*Specific goal 8: Identify social, economic, policy and institutional factors that determine decision-making about managing natural resources in intensive production systems and target interventions accordingly.*

*Scope of research:*

- Develop and deploy knowledge-based methods for input use at the farm level
- Investigate new models of delivering consolidated, knowledge-intensive information options for ecological intensification, and establish innovative new partnerships to deliver them
- Develop tools and methods to acquire high-resolution data that describes the state and changes in land, climate, and water resources as a basis for decision-making
- Assess the impact of globalization on trends in land use in high-productivity systems and the impact on food security and equity
- Analyze policy and institutional constraints to adoption and diffusion of ecological intensification technologies
- Develop institutional innovations and policy options for facilitating adoption of ecological intensification technologies.

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23 There will be linkage through this work to Priority areas 2 (germplasm enhancement, physiology), 3 (livestock improvement), other areas of 4 (water and land management), and 5 (rural institutions).

## System Priority 5: Improving Policies and Facilitating Institutional Innovation to Support Sustainable Reduction of Poverty and Hunger

### Summary

The CGIAR has identified research on policies and institutions that will augment its own capacity as well as that of its national partners to target and conduct agricultural research with increasing efficiency, and to create solutions and enabling environments for the alleviation of poverty. Research on science and technology policy will include a forecasting function and research on critical areas affecting access, generation and sharing of technologies for agricultural improvement, and for sustaining biodiversity and natural resources. This will include work on intellectual property, incentives, and the formation of partnerships. To support new approaches augmenting the contribution of higher-value commodities to poverty alleviation, new research initiatives in international and domestic markets will be undertaken with particular focus on food and product safety. Research will be conducted on rural institutions to increase the ultimate impacts of CGIAR research and possibilities for the equitable sharing of outcomes. The focus will be on producer organizations and the evolving partnerships along the production to consumption chain focusing on innovation at all levels.

### Rationale

It is understood that the research described in Priority areas 1–4 will only be successful when the outputs are implemented by collaborating partners and stakeholders in such a way as to reach the poor. Building the capacity of people and institutions is considered an integral function of that research and to constitute a major international public good provided by the work of the CGIAR. The program-associated training and capacity building of the CGIAR is expected to continue. In addition, as described in Priority area 5, the CGIAR will also invest in research to: (i) enhance its research and the placement of system resources in a dynamic way; (ii) increase the capacity of smallholders to benefit from international and domestic markets; (iii) identify means of strengthening rural organizations; and (iv) identify agricultural research and development pathways to reduce rural poverty.

### Priority 5A: Science and technology policies and institutions

#### Rationale

The contemporary science and technology situation is far different from even just a decade ago. There is a general slowdown of funding for publicly performed R&D, a rise in private-sector based funding of science in some parts of the world, and a notable shift in perceptions among policy-makers, producers, consumers, and others about the demand for, generation of, regulation, and use of, new technologies. There are also substantial shifts in the rights claimed over intellectual property. The nature and progress of these changes have been uneven internationally; among countries, as well as among sectors or agencies within countries. In addition, there are still unresolved questions about the appropriate public roles in enhancing the benefits of technological change in agriculture for poor people. In the past, the CGIAR has played a pivotal role in research leading to the development of new agricultural technology targeted to poor countries and stimulating the transfer of technologies among countries. The changes noted above raise substantial questions about the continuing roles and functions of publicly and privately funded agricultural R&D in the years ahead, requiring careful and timely analysis of necessary changes globally and within countries and their relationship to the broader science and technology community worldwide.

*General goal: Enhance the contribution of agricultural science and technology so as to reduce poverty and bring about development, through improved capability, to innovate as well as to offer new options and insights into ways of making more effective use of agricultural science and technology.*

Each research theme has implications for the CGIAR and its global, regional, national, or sub-national partner organizations.

*Specific goal 1: Enhance technology strategies and priority setting.*

#### *Scope of research:*

Within the context of the changes described above, the aim is to define the options and opportunities for optimizing the contributions of R&D and determine the best application of research resources. The CGIAR should adopt and implement the concept of a Technology Forecasting function or 'Observatoire' for research trend development. This will require the CGIAR to:

- Monitor changes in the research environment at the global, regional, sub-regional and national levels for implications for strategies and priorities
- Carry out *ex ante* and *ex post* research evaluation for accountability and allocation purposes
- Develop and maintain appropriate agricultural science and technology databases (the intention is to access and use internationally available data sources in conjunction with CGIAR results, rather than to develop and maintain static databases)
- Develop quantitative and qualitative information on the changing environment and institutional change [e.g., enhancing the start made by the Agricultural Science and Technology Indicators (ASTI) initiative]
- Identifying the evolution and complementary role of the CGIAR and other partners on information systems: e.g., risk assessment information systems (RAIS) and ARI's information systems
- Develop appropriate processes and mechanisms for allocating research resources.

*Specific goal 2: Improve policies and capacity in national systems to conform with and sustain the principles of international treaties relating to genetic resources.*

#### *Scope of research:*

- Conduct research to enhance national conservation policies and strategies. This may include policy and legal research, and specific areas of institutional research and strengthening
- Use the results of the research to assist national systems to develop appropriate policies on plant and animal genetic resources to conform with and sustain the principles of the International Treaty on Plant Genetic Resources for Agriculture and the Convention on Biological Diversity.

*Specific goal 3: Improve incentives for technology generation, access and use.*

#### *Scope of research:*

There have been extensive failures of public extension systems in many developing countries:

- Evaluate and understand the causes of this deficiency to better devise institutional innovations, (for instance, risk-reducing technologies may provide higher incentives to adoption in dry or low-potential areas); gender-specific approaches will be appropriate depending upon technology and region).
- Coupled with the active research programs of the CGIAR, analyze the implications of a range of incentive mechanisms that can enhance international cooperation in research, NRM, sharing of methodologies and technologies, and the generation of international public goods. Research to encompass various forms of intellectual property rights – e.g., farmers and plant breeders' rights, participatory research, patents, trade secrets, and trademarks – as well as contracts, grants, prizes, tax-related instruments etc. on the generation, access, and use of agricultural technologies.

*Specific goal 4: Improve the regulation of new technology.*

#### *Scope of research:*

- Analyze the human health and environmental implications ('footprints') of new technologies. The emphasis here is on developing new knowledge and protocols to strengthen science-based approaches to regulating new agricultural technologies and institutional arrangements for their implementation.
- Include research issues related to bio-safety (e.g., technology release, land set-aside, and related regulations), trade (spanning national and multilateral issues, including Codex), and input and food labelling. The approach includes not only public regulation, but also self-regulation and regulation by the market.

*Specific goal 5: Enhance the structure, conduct and performance of knowledge-intensive institutions.*

#### *Scope of research:*

The research in this area will emphasize issues related to: the structure, organization and performance of public and private research agencies as well as relationships between

themselves (systems research). This entails defining relevant science scenarios, organizational adaptations and management change processes to improve the impact of R&D on poor people. Included are notions of joint venture research arrangements that involve the development and delivery of technologies. Research areas will include:

- Constraint identification in moving to new agricultural paradigms
- Research on institutional organization and management (including formation and management of new institutional arrangements, such as research consortia, public/private partnerships, and institutional learning and innovation)
- Capacity building in areas such as priority setting (e.g., for commodities in the face of market demand), impact assessment and research management, and policy formulation (which do not necessarily flow from project-associated training)
- Capacity building in areas of direct importance to the priorities of the CGIAR (e.g., concerns with poverty and with sustainability of resource use)
- Knowledge management (development of tools and methods on the basis of CGIAR experience for use by NARS and their university suppliers of science)
- Structured approaches to needs-based training (NARS, university, and mid-career training), including catalyzing the CGIAR involvement with the Open University and learning best practice approaches derived from these experiences.

## Priority 5B: Making international and domestic markets work for the poor

### Rationale

The growing globalization of the food system over the last few decades has far-reaching consequences.<sup>24</sup> The imposition

of new food safety regulations shifts responsibilities, and the economic consequences for meeting regulations, from importing to exporting countries. The setting of international norms is challenged by often quite different national regulations and capacities for production, monitoring, risk assessment, and certification of food quality. There is, therefore, scope for food quality regulations to be interpreted by developing countries as barriers to trade, and for these countries to have their export trade limited by bans or other measures related to food and product safety. The establishment and oversight of food safety regulations are considered as international public goods. For developing countries to ensure their continued access to international markets for food and agricultural products, they require particular assistance with three specific provisions of the SPS agreement: (i) equivalence in meeting and certifying standards; (ii) risk assessment; and (iii) regionalization.

Of the emerging food regulatory issues in relation to trade, the most contentious relate to process attributes to achieve quality goals. Such processes could also be taken to include the genetic transformation of materials incorporated into foodstuffs. The multilateral framework of rules governing process attributes is less well developed than for most other areas of food regulation. While it would be preferable to shift from process to product safety measurement in most cases of food safety, environmental certification and labelling depends upon process (e.g., means of harvesting) issues. Process issues for both goals have many similarities and parallel requirements (e.g., establishing chains of custody for processed materials). Countries cannot, therefore, exclude process issues and need to establish monitoring and certification capacities relevant to both food and environmental safety.

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24 The world trade in agricultural products is approaching US\$600 billion annually, with developed countries exporting slightly more than developing countries but importing substantially more. Bulk commodities (grains, oilseeds) now make up only one sixth of trade in agricultural products; trade in the many diverse processed and high-value food products now exceeds 80 percent of global commerce. Food and product safety regulations are governed at the multilateral level [by the World Trade Organization (WTO)], and predominantly by the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS). The latter is concerned

with protecting plant, animal, and human health and life within the territory of the importing country from specified hazards (including pests, diseases, contaminants and toxins). Other relevant agreements bearing on trade and food safety of agricultural products include the standards set through the Codex Alimentarius Commission, the Technical Barriers to Trade Agreement (TBT), the Agreement on Trade-related aspects of Intellectual Property Rights (TRIPS) – through such issues as the adoption of intellectual property or exclusion through for example, geographical indicators, and the Cartagena Protocol on Biosafety.

While international standards form an important element of non-tariff barriers to trade, regulations imposed by the private sector are, in some cases, considered to be more stringent and often more rapidly developed and imposed than those by the public sector. Moreover, for certain commodities (e.g., livestock sub-sectors in some developing countries), international food chains, and large commercial companies influence the formation of national policy and regulations. Therefore, research into trade and food safety standards should accommodate both public- and private-sector requirements. The potential effects of the relaxation or abolition of subsidies to agriculture in the North will be a contributory element for study as it may have major transitional effects on developing regions, particularly SSA.

*General goal: Increase adaptive capacity of smallholders and poorer operators to exploit opportunities provided by international and domestic markets and to offset the negative impacts of global changes.*

*Specific goal 1: Enhance livelihoods and competitiveness for smallholder producers and food safety for consumers influenced by changes in national and international markets.*

*Scope of research:*

- Understand changing consumer (market) preferences for food quality and food safety and its impacts on the poor through the market chain. The rise of restaurant and supermarket chains and wholesale control over sources of supply are major drivers affecting production patterns for food products from the local to the international level. This will require the identification of trends and issues in markets on all scales that offer robust opportunities for sustained commercialization of high-value agricultural commodities.
- Improve understanding of risk levels and risk sources for domestic and exported food products in developing countries as a means towards improved formulation of regulations and standards. The requirements of SPS are that risks be established on the basis of scientific principles and that risks are quantified based on timely and specific assessments (i.e., relevant to the commodity and food product

concerned). Research will be required to examine sources of contamination and disease in food harvesting and production chains for selected key agricultural commodities. Research will encompass the epidemiology of disease and pest organisms affecting food safety, development of disease monitoring tools, risk modeling capacity linked to assessment of the social and economic impact of risk-reduction strategies. Partnership with national research organizations in the execution of this work will enhance their capacity for future analysis. The research results will prioritize sources of risk, evaluate existing methods of risk management and identify areas where improved technology or management methods are required. Results will assist national, regional, and international players in dialog on the future development of public and private standards (see also Priority area 3).

- Assess the costs and benefits of different options for smallholders in adjusting to new market conditions to food quality and food safety. This will include analyzing options for addressing policy and transaction cost barriers to increased participation of smallholders, the rural poor, and women in high-value sectors. Health-related issues are also included. Examine the costs of compliance with standards (quality, health) by smallholder producers (and their organizational arrangements) for domestic, regional, and international trade. Clarify the links between risk, improved certification and food safety concerns to improved terms of market participation by, and employment of, the poor (with linkages to Priority area 3).

*Specific goal 2: Improve the marketing environment for smallholders by improving the efficiency of domestic markets.*

*Scope of research:*

- Understand structure, conduct and performance of domestic markets for agricultural commodities across different countries to evaluate the general implications of market imperfections for small-scale farmers and food-insecure people
- Establish linkages of market infrastructure with food security and income of small-scale farmers and poverty levels
- Understand the interaction of product, input, asset and credit markets under

diverse policy and governance environments and their implications for rural poverty.

## Priority 5C: Rural institutions and their governance

### Rationale

The CGIAR must better understand how rural organizations [including farmer organizations, women's producer organizations and private–public–civil society organization (CSO) partnerships] can be strengthened and how they and other rural innovation systems contribute to sustainable agricultural development and enhanced technological and institutional change.

The CGIAR's research in this area will need to focus primarily on farmer organizations and the influences they exert because of their increased bargaining power, namely: (i) on the research and development agenda, and (ii) on pricing in agricultural markets. Research will also include the design of public institutions concerned with management of the agricultural sector. Research on the changing roles of producer, consumer, and civil organizations in technological innovation processes will need to identify the ways in which their roles may enhance the impacts of R&D on poor people. Such research should be carried out with respect to identifying the effects of gender, and would be sensitive to the implications of changing forward and backward linkages along the entire product supply chain (including pre-, on- and post-farm elements that involve input supplies, primary producers, processors, and marketing entities). The increasing level of organization allows for the better distribution of new knowledge and technologies to the individual farmer.

Few institutions have the capacity to meet all the varied challenges associated with agricultural research for development. Forming national, regional, and international partnerships is the means to address complex issues in research, but many developing countries have little experience in the development and management of such partnerships. Research is required on how to set up effective and equitable partnerships, which will provide affordable benefits for national

programs and the poor in developing countries. The treatment of intellectual property in private–public contracts for research requires to be explored to meet the needs of both collaborators.

*General goal: Enhance the role that rural organizations and innovative institutional partnerships play in maximizing impact from agricultural research and in creating marketing platforms for smallholder producers.*

*Specific goal 1: Identify mechanisms for the strengthening of producers' organizations and for modes of participatory research.*

### Scope of research:

While the effects of strengthened farmer organizations are well understood, it is more difficult to understand and predict when and how farmers are effectively able to organize themselves. Participating in the strengthening of farmer organizations and comparing the lessons from many cases, allows generic guidelines to be formulated that contribute to the development and governance of farmer organizations.

- Conduct research on: (i) credit and micro-finance mechanisms; and (ii) design, monitoring, and evaluation of participatory processes within farmer organizations.

This will be required in order to obtain the maximum benefits from the existing organization and to understand the effect of the structure and culture of the organization (including women's producer organizations) on the sharing of new knowledge and technologies.

*Specific goal 2: Identify new forms of partnership with NARS, the private sector, public extension agencies, NGOs, and producers' organizations, and public agencies from other sectors, such as environment and health to enhance the conduct and impact from agricultural research.*

### Scope of research:

The CGIAR's efforts in identifying and improving appropriate research and development partnerships will increasingly build on collaborative models themselves, within which partnership issues are explored; solutions are developed, tested and made available through networks of collaborators. Emphasis should be placed on the process of

innovation in the system as a whole. This will include sensitivity to: (i) implications for forward and backward linkages; (ii) natural resources management; and (iii) contributions to knowledge and technology generation.

In these new partnerships, regional and sub-regional organizations will be major partners, with the appropriate research suppliers and stakeholders in development. Choice of modality by region depends on the goals, endowment, income level, and the degree of development of the countries to be involved. Size of countries will also be an important criterion: for instance, effective biotechnology capacity is expensive and more readily attained by larger rather than smaller countries; small countries will be more interested in international value chains than in domestic value chains.

### **Priority 5D: Improving research and development options to reduce rural poverty and vulnerability**

#### **Rationale**

The rural poor are characterized by insufficient asset holdings, low returns to their assets, numerous market failures and unfavorable terms of market participation, large institutional gaps, and lack of access to public goods and services, in particular to improved agricultural technologies, resulting not only in poverty but also in vulnerability to risks of change in their biophysical and economic environments.

Natural and human disasters disproportionately affect poor people and marginal areas, often causing irreversible loss of productive assets (e.g., land, livestock, and businesses) and long-run impacts on human capital development due to short-term illness, malnutrition, and the withdrawal of children from school because of the need for child labor.

Growing evidence suggests that shocks can trap people in long-term poverty, reversing progress associated with asset accumulation and productivity gains, thus reproducing poverty across generations. Shocks can also increase the rate of rural to urban migration and dependence on family and public transfers. Reducing exposure to risk and improving households' capacity to manage risk, both *ex ante* or *ex post*, can encourage

greater investments in productive activities, selection of technologies with higher expected returns and entry into higher-value markets (that also typically bring higher risk). New technologies and institutions to manage risk are necessary to reduce risk and vulnerability in rural areas.

*General goal: Enhance impact of agricultural research in promoting options for the reduction of rural poverty and vulnerability.*

*Specific goal: Identify agricultural research and development pathways, in order to implement options to reduce rural poverty at global and regional levels.*

#### *Scope of research:*

- Improve characterization of the rural poor (assets, context, depth and duration of poverty, vulnerability, basic needs, and choice of livelihood strategies) in relation to agriculture, forestry and fisheries production systems and their environment, including patterns of adoption of improved technologies and NRM practices and participation in higher-value product markets
- Identify options for the rural poor to access, acquire, protect (in the case of shocks) and use assets to improve their livelihoods and move out of chronic rural poverty
- Improve the quality of the context (markets, institutions, public goods, policies and governance) where the poor use their assets and reduce the risks affecting livelihoods of smallholders and the rural poor
- Identify and evaluate means to improve *ex ante* risk management through livelihood diversification, formal and informal insurance mechanisms, financial and in-kind savings, futures and forward markets, and improved information systems
- Identify and evaluate means to improve the availability and effectiveness of *ex post* risk-coping mechanisms through credit, safety nets (not just food-based, but also inputs distribution, asset restocking, etc.) and more efficient, accessible and stable asset and labor markets
- Analyze the effectiveness of rural development strategies and programs to reduce rural poverty and vulnerability; and design new strategies to achieve those goals combining agricultural and non-agricultural sources of employment and income.

## New Research Priorities and their Strategic Implications

### New Priorities for the CGIAR

This Report represents the CGIAR's first attempt to guide research through Systemwide priorities, compared with earlier portfolios that have been aggregated from Center priorities. There are several new elements and approaches contained in the five Priority areas and 20 specific Priorities presented in this Report. The major new areas are identified in Table 3.

These new approaches include the following:

- Within the CGIAR's continuing mission and goals, a comprehensive approach to the alleviation of poverty through agricultural research is described, and specific contributions to the global efforts to address the MDGs are identified
- The priorities reflect the mandate of the CGIAR to undertake research for development and not development activities as such
- There is an explicit focus on income generation among the poor, as well as the elaboration of criteria through which new high-value species and research will be chosen. In addition to their traditional contributions to human nutrition and services to natural and farming systems, livestock, fish, and tree products are emphasized as sources of additional income
- The CGIAR will prioritize research to raise the contribution of fruit and vegetables to income generation (and nutrition) and explore the possibility of developing of new partnerships
- There is additional emphasis on market research to promote the participation of the poor as well as to increase benefits from such participation. Quality and food safety are stressed as targets for commodity improvement, in addition to yield. Research needed by poor farmers and poor countries to meet non-tariff barriers in international trade is prioritized
- Genetic conservation and enhancement activities will be linked to focus on 'for use' strategies. New genetic enhancement approaches will encompass the devolution of breeding activities to appropriate NARS and capacity building to enhance the rate of transfer to NARS with currently lower capacity. The development of a genomics platform to help solve problems of particular importance for poor farmers and utilizing the opportunities created by molecular biology are prioritized
- There is a new major focus on improving key staples for drought tolerance
- Following the successful establishment of international in-trust collections of plant germplasm, it is opportune for additional emphasis to be placed on research on animal and fish genetic resources to support emerging international frameworks for conservation and use in these areas
- Also envisaged is a more fully integrated approach to the productive management

**Table 3.** Major new research emphases in the CGIAR System Priorities 2005–2015

A re-emphasis of the CGIAR's role in research on major long-term issues
Development of specific systemwide contributions to the MDGs
Research for development – not development <i>per se</i>
Explicit focus on income generation among the poor
New collaborative approach to research on fruit and vegetables
Research on trade, markets, and food safety
Enhanced focus of research on drought, soil acidity, and temperature stress
Application of modern molecular science
Landscape-level approaches to the management of agricultural and natural resources

of natural resources at the landscape and farm levels, with a particular emphasis on water productivity, and the avoidance of degradation and rehabilitation of degraded lands and soils

- For policy and research management, emphasis is on review, analysis, and planning of research investments for sustainable poverty alleviation, in creating operational environments for the CGIAR and its partners and the optimization of collaborative research opportunities at all levels.

### Focusing on Priorities

As mentioned in earlier sections, to enhance system focus the SC proposes that the Alliance Centers and the CGIAR Members agree to allocate 80 percent of the total CGIAR budget to the 20 Priorities described. It is suggested that Centers may spend up to 20 percent of their budget outside the research priorities. The SC further encourages Centers to utilize at least half of that 20 percent for exploratory, innovative research work to develop new science and potential new future priorities. A three-year transition period is suggested to arrive at the 80 percent goal.

### Capacity building

The CGIAR Priorities maintain the focus of the System on research. However, the conduct of international agricultural research, combined with the provision of world-class opportunities for capacity strengthening, is a comparative advantage of the CGIAR. Enhancing capacity in developing countries has been a major accomplishment of the CGIAR in the past. This approach will continue through program-related opportunities and through involving appropriate partnerships to enhance innovation and learning. Additionally, specific research on institutions is designed to identify the best means for policies and institutions to support new agricultural research and create pro-poor benefits. All these types of program-associated capacity strengthening (i.e., integral parts of the priority research) are considered to fall under the 80 percent allocation to System Priorities for research. The CGIAR's contributions to free-standing capacity strengthening, which is not an integral part of the research, is expected to be covered within the 20 percent of the CGIAR

budget that is not covering System Priority research.

### What has been omitted?

The 20 research Priorities included in this Report have been progressively distilled and reduced throughout the application of the three criteria to identify priorities (described in the Introduction) with specific goal statements and the proposed scopes of research.<sup>25</sup> There has been a strict emphasis on research for development, and not development *per se*, and the application of the international public goods criterion. Indeed, one of the results of this exercise will be a reduction in development-related activities within the CGIAR. The SC is confident that a stricter application of the criteria to sharpen the scope of research will open up new opportunities for longer-term impact through strategic research activities. For example, in line with this reasoning, the Priorities propose research on seed delivery systems, but the CGIAR should not itself enter into the delivery of such systems. Similarly, despite acknowledging the humanitarian services provided by CGIAR efforts in times of need and the rehabilitation of agricultural systems following conflict, country-specific activities of this type having low research content are not prioritized (Table 4). Where urgent cases occur that require, for instance, germplasm from the in-trust collections held by the CGIAR, it is of course appropriate that seed be provided to the extent possible. In general there are other agencies with a mandate and experience in disaster relief.

In the process of consultation and review, some potentially high pay-off research areas (such as work on nitrogen fixation) have been excluded because the chance of success is currently considered low. In contrast, a focus on drought tolerance has been promoted because of the high expected impact and the probability of success in the timeframe of this planning period. There are of course opportunities for Centers to follow research in other potentially high pay-off

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25 Earlier stages of the consultative process developed 32 proposals for topical research not currently or systematically embraced by CGIAR research, in addition to the portfolio of research projects conducted by the 15 Centers.

**Table 4.** Examples of activities that do not fall within the CGIAR Priorities for Research 2005–2015<sup>a</sup>

Activities that develop national infrastructure and provide local rather than international public goods, e.g., country projects
Development assistance and disaster relief planning, e.g., 'Improved natural disaster or post-conflict preparedness and mitigation' and 'Mitigating human and environmental effects on rice-based livelihoods'
Consultancy services on country-specific development issues, or on donor projects conducted by others, that rest within the comparative advantage of other agencies, e.g., 'Large-scale interventions to enhance human capital'
Research on human diseases and their vectors – except where there is a direct intervention to be made through agriculture, e.g., 'Mitigating adverse impacts due to malaria and other water-related parasitic diseases'
Curriculum development and teacher training for local institutions, e.g., these aspects of 'Strengthening educational institutions and systems'

<sup>a</sup> It is not feasible to make a list of everything that might be excluded from the Priority research. This brief list rather illustrates activities that are currently being proposed or undertaken that would not fit into the new Priorities.

areas, not highlighted in this Report, such as apomixis or perenniality, within, however, the 20 percent budget that falls outside the specified Priority areas. The SC expects these sorts of opportunities, provided they meet the other criteria, to be taken up.

Similarly, the consultative process has changed the expression of some of the areas for research, originally given high priority. As an example, despite acknowledgement by the SC that post-harvest processing has large potential to create rural employment, post-harvest research is currently not identified as an individual research Priority for the System. This is, in part, because key elements of post-harvest research (such as marketing and acceptance of fortified products, research on mycotoxin contamination, and food safety as it affects developing-country trade in international and domestic markets) are all described within allied priority areas. Other aspects of research – for instance, on post-harvest processing technologies – are considered to be too local in their application to warrant a consolidated CGIAR Priority at this time.

The criterion of 'comparative advantage' has been utilized to distinguish between suitable research topics as follows: (i) to support priority research for which the CGIAR currently has capacity and comparative advantage (e.g., enhancing yield and quality traits in staple crops of importance to the poor); (ii) to support research which is considered of high priority, in areas where the CGIAR has limited experience but where

there is a high probability of leveraging international expertise so as to conduct the research in partnership (e.g., research on the production of fruit and vegetables); and (iii) to exclude potentially important research for which either the CGIAR has no mandate, or is being adequately undertaken by others, or the CGIAR is unlikely to forge effective partnerships in the timeframe of the planning period (e.g., research on human diseases and genetic enhancement for which the private sector has a comparative advantage). However, over time there are expected to be dynamic changes in comparative advantage. This criterion will, therefore, be used in particular to evaluate and review priorities, and the division of labor amongst research partners, in the future.

### Strategic considerations for the CGIAR in the implementation of research priorities

The System Priorities have been established within the framework of the Vision and Mission of the CGIAR.<sup>26</sup> This includes seven

26 TAC Secretariat. 2000. *A Food Secure World for All: Towards a New Vision and Strategy for the CGIAR*, CGIAR Technical Advisory Committee, FAO, Rome, Italy. The seven planks include the focus on people and poverty; mobilization of modern science; geographic priorities and a regional approach to research; new partnerships in science and development, a task force approach, and playing a catalytic role in developing-country agricultural research.

planks or approaches to guide the development of CGIAR strategy. The current Priorities have been developed with a global focus and the following sections outline how these strategic considerations will contribute to the formulation and implementation of research.

### Cross-cutting themes

The Priorities are structured around five major groups of research activities aimed at producing common outcomes – such as the conservation of agricultural biodiversity, or improved income opportunities for the poor from the exploitation of higher-value commodities. Considered together, the CGIAR Priorities provide a set of specific goals for a portfolio of research activities around which the CGIAR will organize its scientific and related capacities. However, the System will continue to carry out programmatic research on cross-cutting global, ecoregional, or sectoral research topics through a combination of the 20 research Priorities identified.

The principal crosscutting theme is the focus on poverty, which orients the majority of the research priorities. This is evinced from the level of research planning (e.g., dynamics of rural poverty, trait identification for genetic improvement) through the conduct of research, to the assessments of the effects of new agricultural technology, NRM practices and policy on the poor.

The CGIAR also carries out programs on particular topics or regions through a number of implementation mechanisms (SWPs, Ecoregional Programs, CPs, Task Forces,<sup>27</sup> and other modalities). Such programs draw on a number of the scientific and integrating capacities of the System according to the nature of the research challenge being addressed. It is anticipated

that additional topical or regional research programs could be formed in the same way, bringing scientific expertise together from across the CGIAR matrix for particular issues or lengths of time.

As an example, a coordinated program on **nutrition and health** could be assembled directly drawing on CGIAR strengths in the characterization of genetic resources (Priority area 1), research to improve yield and biofortification of grains for (micro) nutrient content (Priority area 2), enhancement of livestock and aquaculture to augment protein supply (Priority areas 3 and 4B), the improved management of water (Priority area 4), food safety in relation to storage (Priority area 2C), and markets and trade (Priority area 5). This would be an approach to which the CGIAR could contribute according to its scientific comparative advantage in agriculture and sharing with partner expertise in the health sciences (Figure 2).

It is suggested that similar programs could be developed for research challenges of great global significance (such as **climate change**) or **research approaches for particular ecoregions** (Figures 3 and 4). In line with a more explicit cross-sectoral approach to NRM, **research on forest and tree resources** is not identified under a single Priority. Nevertheless, a portfolio of research has been developed according to the CGIAR's comparative advantage, and these activities and cross-linkages are detailed in Figure 5. The key consideration in such crosscutting programs is that they draw on, and are limited to, the 20 Priorities identified. Should research be called for by crosscutting programs outside the set of 20 Priorities, it will be sought from partners.

### Mobilization of New Science

A strict commodity focus has been avoided in setting Priorities. Instead, research with a system focus is promoted. The main reasons are that: (i) much of the genomics and other upstream work that needs to be done is generic and can be most effectively and efficiently carried out across related species rather than on a commodity basis; and (ii) much of the production by small-scale farmers takes place within a multi-commodity system.

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27 "The CGIAR will adopt a task force approach to address major, clearly identifiable problems where there is an opportunity for an impact to be made and/or where there are intractable problems that need a concerted approach by multiple actors and agencies within and outside the CGIAR System." Such task forces need to be managed and to have clearly defined objectives, outputs, scientific and financial resources, timeframes and accountability mechanisms. The task force approach has many similarities to the Systemwide approach but there is an emphasis on their rapid application to specific emerging problems and their time-bound nature.

**Figure 2.** Illustrating how Priorities could contribute to a cross-cutting program on nutrition and human health<sup>a</sup>

Priority area 1	Priority area 2	Priority area 3	Priority area 4	Priority area 5
<b>Sustaining biodiversity</b>	<b>Genetic improvement</b>	<b>Diversification and high-value commodities</b>	<b>INRM</b>	<b>Policies and institutional innovation</b>
1A: Conservation of PGR for food and agriculture	2A: Maintaining enhancing yield of staples	3A: Income increases from fruit and vegetables	4A: Integrated land, water, forest management at landscape level	5A: Science and technology policy and institutions
1B: Promoting conservation/characterization of UPGR for income	2B: Tolerance to abiotic stresses	3B: Income increases from livestock	4B: Sustaining aquatic ecosystems for food and livelihood	5B: Making international and domestic markets work for the poor
1C: Conservation of indigenous livestock	2C: Enhancing nutritional quality and safety	3C: Enhancing incomes through production of fish and aquaculture	4C: Improving water productivity	5C: Rural institutions and their governance
1D: Conservation of aquatic animal genetic resources	2D: Genetic enhancement of high-value species	3D: Sustainable income from forests and trees	4D: Agroecological intensification in low-/high-potential areas	5D: Improving research and development options to reduce rural poverty and vulnerability

<sup>a</sup> Strong color represents major research focus, light color represents contributory research

- 1A, 1B Characterization of germplasm for nutritional qualities
- 2C Biofortification of germplasm for (micro)nutrient quality
- 2A Germplasm enhancement for labor flexibility traits (to assist debilitated human populations)
- 3A, 3B, 3C, 4D Diversification of production for improved nutrition
- 2C Improving post-harvest processing to maintain safety and nutritional value
- 5B Biosafety and health of traded (plant) products
- 3B, 3C, Biosafety and health of traded livestock and seafood products
- 3B Enhancing livestock production (e.g., milk) for nutrition of the young
- 2D, 3C Improved nutrition by increasing protein availability through aquaculture
- 2C, 5A Improved policies focused on nutrition and biosafety

Similarly, the Priorities are defined by specific goals and the likely scopes of research rather than by technologies. This stems from the SC's belief that the CGIAR should use the most appropriate research approach for a particular research endeavor. For example, molecular biology-based research including, where appropriate, genetic engineering and genomics, will play a major role in future agricultural research in many Priority areas. In the planning and development of new research programs, researchers are urged to select the most appropriate approach whether that relates to molecular biology, traditional plant breeding and related research, or agroecology.

The changing context for agricultural research and adoption of the new Priorities has strategic implications for the system.

These include shifts in scientific expertise that may be needed in the system, some in different directions: (i) towards the acquisition of upstream genetic science and the establishment of platforms to relate to global efforts including the private sector; (ii) integrators of NRM research and policy development; (iii) policy and legal affairs – e.g., governing IPR and the use of genetic and other technologies at the System level and amongst NARS; (iv) increased capacity in effecting institutional change; (v) new social science capacities (or linkages) in poverty analysis, and market analysis and global trade; (vi) post-harvest management and linkages to production chain expertise; (vii) research management at the consortium level integrating system skills in ITC. The CGIAR Centers, and the System as a whole, have opportunities for consolidation and

**Figure 3.** Illustration of how Priorities could contribute to cross-cutting research on climate change<sup>a</sup>

Priority area 1	Priority area 2	Priority area 3	Priority area 4	Priority area 5
<b>Sustaining biodiversity</b>	<b>Genetic improvement</b>	<b>Diversification and high-value commodities</b>	<b>INRM</b>	<b>Policies and institutional innovation</b>
1A: Conservation of PGR for food and agriculture	2A: Maintaining enhancing yield of staples	3A: Income increases from fruit and vegetables	4A: Integrated land, water, forest management at landscape level	5A: Science and technology policy and institutions
1B: Promoting conservation/characterization of UPGR for income	2B: Tolerance to abiotic stresses	3B: Income increases from livestock	4B: Sustaining aquatic ecosystems for food and livelihood	5B: Making international and domestic markets work for the poor
1C: Conservation of indigenous livestock	2C: Enhancing nutritional quality and safety	3C: Enhancing incomes through production of fish and aquaculture	4C: Improving water productivity	5C: Rural institutions and their governance
1D: Conservation of aquatic animal genetic resources	2D: Genetic enhancement of high-value species	3D: Sustainable income from forests and trees	4D: Agroecological intensification in low-/high-potential areas	5D: Improving research and development options to reduce rural poverty and vulnerability

<sup>a</sup> Strong color represents major research focus, light color represents contributory research

- 1 Conservation of agrobiodiversity (plant and animal)
- 2B Tolerance to abiotic stresses (drought)
- 2A Breeding for reduced evapotranspiration
- 4A Integrated natural resources landscape management in the face of climate change
- 3A Diversification of farming systems
- 4A Governance of environment and natural resources
- 4C Improving water productivity
- 4D Agroecological intensification to overcome soil degradation
- 5A Future trend analysis and science policy

partnering strategies (e.g., in the case of functional genomics, and the development of other task forces).

### Advocacy

It is clear that the results from CGIAR research may have little impact in adverse policy and institutional environments, so research is therefore proposed to better understand such environments. In addition, it is argued that the CGIAR should do more lobbying and provide the advocacy needed to bring about the appropriate supporting environment – including investments in rural infrastructure, delivery systems, and many other development aspects.

### Regional priorities

In its analysis of the plausible futures for the rural and urban poor in developing

countries, the SC has specifically considered regional differentiation in constraints, endowments, and partnerships. The identification of strong national programs and other regional actors to tackle issues in collaborative partnerships form an important component of determining comparative advantage and in the placement of CGIAR research. Whilst the Priorities identify important global research, it is fully anticipated that there will be different emphases in research approaches across regions constrained by different agroecologies, the distribution of poverty, and development issues. For example, priority issues identified by the different regional organizations highlight tackling water scarcity in WANA, augmenting soil fertility in SSA, avoiding land and water degradation by intensive systems in the face of population growth in Asia, and dealing with the rise of new market realities for

**Figure 4.** Illustrating how Priority research activities support cross-cutting ecoregional programs: the example of the Rice–Wheat Consortium<sup>a</sup>

Priority area 1	Priority area 2	Priority area 3	Priority area 4	Priority area 5
<b>Sustaining biodiversity</b>	<b>Genetic improvement</b>	<b>Diversification and high-value commodities</b>	<b>INRM</b>	<b>Policies and institutional innovation</b>
1A: Conservation of PGR for food and agriculture	2A: Maintaining enhancing yield of staples	3A: Income increases from fruit and vegetables	4A: Integrated land, water, forest management at landscape level	5A: Science and technology policy and institutions
1B: Promoting conservation/characterization of UPGR for income	2B: Tolerance to abiotic stresses	3B: Income increases from livestock	4B: Sustaining aquatic ecosystems for food and livelihood	5B: Making international and domestic markets work for the poor
1C: Conservation of indigenous livestock	2C: Enhancing nutritional quality and safety	3C: Enhancing incomes through production of fish and aquaculture	4C: Improving water productivity	5C: Rural institutions and their governance
1D: Conservation of aquatic animal genetic resources	2D: Genetic enhancement of high-value species	3D: Sustainable income from forests and trees	4D: Agroecological intensification in low-/high-potential areas	5D: Improving research and development options to reduce rural poverty and vulnerability

<sup>a</sup> Strong color represents major research focus, light color represents contributory research

2A Higher yield potential and better performance under aerobic (rice) and no-till conditions  
 2A Looking at rice and wheat diseases and pests plus weeds in new no-till and direct sown rice systems  
 2A Looking at mechanization and labor saving in rice–wheat systems since labor is scarce  
 2B Looking at salinity management – need better germplasm  
 3A In some locations work on vegetables to increase diversity and incomes – bed-planted vegetables  
 4C/4D Water is a major problem in some rice–wheat areas and will be even scarcer in the future. Looking at ways to improve efficiency through tillage, bed and alternative crops and diversification  
 4D Use of conservation agriculture principles in a system basis plus monitoring consequences  
 4A Less work on landscape scale  
 5A, 5B, 5D Work on interacting with the poor – how to gain entry to their confidence and understand needs but also look at ways to improve livelihoods  
 utilize new technologies for better incomes  
 5A National programs are part of the RWC and are looking at some of these policy issues to help improve the livelihoods of the poor  
 5C Work with self-help groups, water user associations, local manufacturers for equipment, input suppliers, seed companies, etc. and links with ARLs for research areas  
 Research supported by the role of the RWC to strengthen the NARS through training, introducing new knowledge and technology, information exchange, regional, and country visits

agricultural produce in LAC. The CGIAR portfolio is well placed to contribute to these priority research efforts and, through System-wide linkages, to provide the benefits of research through spillover to other regions. As above, CGIAR contributions will be limited to the 20 Priorities.

### Gender

It is intended that in the translation of strategic priorities into projects and programs, regional (biophysical and social) factors will

be taken into account. In particular, the gendered nature of agricultural production will influence research in areas with large numbers of women farmers (e.g., SSA) and approaches to defining pro-poor traits for improvement, market chain research, biodiversity conservation, and opportunities for land tenure, amongst others.

### New partnerships

It is expected that the research proposed in this Report will be carried out in strong

**Figure 5.** Illustrating the extent of forestry and tree research in the CGIAR research portfolio<sup>a</sup>

Priority area 1	Priority area 2	Priority area 3	Priority area 4	Priority area 5
<b>Sustaining biodiversity</b>	<b>Genetic improvement</b>	<b>Diversification and high-value commodities</b>	<b>INRM</b>	<b>Policies and institutional innovation</b>
1A: Conservation of PGR for food and agriculture	2A: Maintaining enhancing yield of staples	3A: Income increases from fruit and vegetables	4A: Integrated land, water, forest management at landscape level	5A: Science and technology policy and institutions
1B: Promoting conservation/characterization of UPGR for income	2B: Tolerance to abiotic stresses	3B: Income increases from livestock	4B: Sustaining aquatic ecosystems for food and livelihood	5B: Making international and domestic markets work for the poor
1C: Conservation of indigenous livestock	2C: Enhancing nutritional quality and safety	3C: Enhancing incomes through production of fish and aquaculture	4C: Improving water productivity	5C: Rural institutions and their governance
1D: Conservation of aquatic animal genetic resources	2D: Genetic enhancement of high-value species	3D: Sustainable income from forests and trees	4D: Agroecological intensification in low-/high-potential areas	5D: Improving research and development options to reduce rural poverty and vulnerability

<sup>a</sup> Strong color represents major research focus, light color represents contributory research

1B Potentially includes conservation and characterization of tree and shrub species for income

2D Includes the genetic improvement of tree or shrub species for income, nutrition or health (e.g., medicinal plants)

3A May include enhancement of farming systems for fruit tree species where these are prioritized

3D Includes valuation of the benefits provided by forest and tree species and identifies market opportunities for valuable species

4A Integrated management of land, water, and forest at the landscape level.

4A Research to improve environmental policies includes forestry in cross sectoral approaches

4D Stabilization and rehabilitation of degraded agricultural land includes contribution of agroforestry

4D Includes on-farm trees for diversification and enhancement of farming systems in high potential areas

5C Contributions to conservation and use policies for plant genetic resources will include, or be relevant for, forest and tree species

partnerships with relevant agents. Increasingly these will be national and regional agricultural research systems. However, ARIs and agencies, the private sector, and NGOs have vital roles to play in achieving our common goals. Strategic choices in dealing with the 'other 96 percent' of agricultural research will be required with the nature of the partnerships determined by the particular research.

#### *Working with strong versus weak NARS.*

CGIAR Centers work with selected NARS in their regions, and share information globally with many more. All Center programs will be time-bound and increasingly include exit strategies where the products or the program itself will be taken over by NARS. However, it is difficult to prescribe a uniform interaction given variability in the NARS, and in the biophysical and human capacity of the states concerned. The heterogeneity of NARS in

terms of capacity and rates of development by region increases the complexity of interactions for the CGIAR. The existence of strong NARS accelerates opportunities for transferring aspects of research to partners and raises the requirement that the CGIAR does not duplicate existing capacities. However, the continued existence of weaker NARS in several regions means strategic choices (about the speed and staging of research, capacity building, and ensuring regional spillovers from CGIAR research) must be made according to partner strengths. Involving NARS program partners of different strengths in research consortia can assist opportunities for South–South interactions and regional spillover.

*Private sector.* Among the major strategic opportunities to draw the private sector into assisting the global goals of the CGIAR will be the application of private sector biotech-

nologies in germplasm enhancement. This demands that the CGIAR is fully aware of private-sector progress, able to access relevant technologies through partnerships, and apply them to the requirements of developing countries, particularly the poor. Elements of a successful strategy need to be integrated from Centre to System level, and through active PPP research utilizing proprietary technologies. Means to develop co-operative research on natural resource and environmental issues may be explored.

*New linkages with ARIs.* There are, increasingly, opportunities to source relevant research from non-CGIAR providers. In general, outsourcing of research or for example, capturing food safety, market chain knowledge and post-harvest expertise from others, is to be welcomed as part of the principle of developing new science partnerships.

The SC believes that an innovation systems approach should be pursued where appropriate instead of the traditional linear research through extension to farmer approach. As a minimum, there should be a strong two-way communication between farmers and researchers whether at the national or international level.

Finally, options for collaborative research on each of the priorities identified in this Report should be pursued using three main criteria: (i) low transactions cost; (ii) building on existing structures; and (iii) interaction among those researchers actually doing the research.

### **Catalyzing new solutions**

Following from the above, it is clear that in the accomplishment of the Priority research the role of the CGIAR Centers will vary according to the subject and the expertise required. The CGIAR will expect to lead global research programs in some defined areas, working with existing and new partners. It will continue to convene consortium approaches to research on important challenges with other research providers (including NARS and research institutions in industrial countries concerned with international agricultural research). The implementation of the Priority research will also require that the CGIAR augment its role of catalyst, integrator and disseminator of

knowledge within the overall global agricultural research system (Figure 6). Such approaches help in building common frameworks for all players (CGIAR, NARS and other partners) to conduct research in a cooperative and efficient manner. Finally, the CGIAR's SC has an important role to play in facilitating this overall process by helping CGIAR Centers and the System itself in mobilizing the global agricultural research system around the goals of the CGIAR.

### **Next Steps – Implementing the Priorities**

The CGIAR will need to translate the new Priorities into a coherent set of research programs that effectively bridge and synchronize efforts across CGIAR Centers and their partners. This will involve several important components: (i) translating the priorities into a set of Center and partner research programs; (ii) developing a transparent and well coordinated mechanism for allocating resources to the research programs and the Centers involved; and (iii) identifying a smooth and efficient transition process from the set of activities and programs currently undertaken by the Centers and their partners (and related funding) to the new set.

*Translating priorities into operational programs.* Finding the proper balance between the different CGIAR operating modes, including Center core programs, SWP or Ecoregional Programs, CPs, and Task Forces remains a considerable challenge. Although the rationale and logic behind bringing CPs into the CGIAR agenda has been well documented, the appropriate roles and boundary conditions still need to be developed for each category.<sup>28</sup> Over time, with increasing emphasis on new partnerships, regional approaches to research planning and implementation and delivering

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28 Interim Science Council. 2002. *Identifying Challenge Programs that Enhance and Broaden Support for the CGIAR Research Agenda Working Paper*, CGIAR Interim Science Council, FAO, Rome, Italy. In its evaluation of CP proposals, the interim SC identified a number of conditions under which certain themes and associated program proposals appeared better suited as CPs, *vis-à-vis* core programs or SWPs.

**Figure 6.** General indication of areas in which the CGIAR anticipates being: a lead provider of research (L); a partner in research (P); or a facilitator of international efforts (F)<sup>a</sup>

Priority area 1	Priority area 2	Priority area 3	Priority area 4	Priority area 5
Sustaining biodiversity	Genetic improvement	Diversification and high-value commodities	INRM	Policies and institutional innovation
1A: Conservation of PGR for food and agriculture [F/P]	2A: Maintaining enhancing yield of staples [L/P]	3A: Income increases from fruit and vegetables [F/P]	4A: Integrated land, water, forest management at landscape level [P/F]	5A: Science and technology policy and institutions [P/F]
1B: Promoting conservation/characterization of UPGR for income [F/P]	2B: Tolerance to abiotic stresses [L]	3B: Income increases from livestock [L/P]	4B: Sustaining aquatic ecosystems for food and livelihood [P/F]	5B: Making international and domestic markets work for the poor [L-CG-specific application]
1C: Conservation of indigenous livestock [F/P]	2C: Enhancing nutritional quality and safety [L/P]	3C: Enhancing incomes through production of fish and aquaculture [L/P]	4C: Improving water productivity [L/P]	5C: Rural institutions and their governance [P/F]
1D: Conservation of aquatic animal genetic resources [F/P]	2D: Genetic enhancement of high-value species [P]	3D: Sustainable income from forests and trees [P]	4D: Agroecological intensification in low-/high-potential areas [P/F]	5D: Improving research and development options to reduce rural poverty and vulnerability [P/F]

<sup>a</sup> Virtually all CGIAR research is done in partnership, and so the indicative allocation is relative amongst the three categories.

tangible outputs within defined time periods, the *distinction* between these different modalities may in fact become more blurred. Nevertheless, in the short term, decisions about the appropriate programmatic modality for accomplishing specific objectives derived from the CGIAR Priority areas will need to be made at the same time as research programs are being defined. The SC will continue to work with stakeholders (through a workshop in the first instance) to refine the placement of CGIAR effort in the research to development continuum and pathways to delivery. Similarly, the SC will continue to work to develop an extended practical definition of international public goods research, which will guide the Priority development from strategies to implementation.

In order to provide coherence at the System level, the SC proposes the engagement of CGIAR Centers and other stakeholders in implementing the Priorities for research directly following their endorsement. The elements of the approach will include: (i) establishing a small working group with

representation from CGIAR stakeholder groups to jointly develop the strategy for implementation; (ii) reviewing in detail the current allocation of Centers' efforts and budget to Priority research and conducting a gap analysis between current CGIAR research and Priority research (such as reviewing whether previously developed CP proposals meet Priority research requirements or could be developed to do so); (iii) reviewing the efficacy of research vehicles for addressing Priorities (SWPs, CPs, virtual Task Forces etc.); (iv) developing a CGIAR strategy for gap filling in terms of scientific disciplinary expertise, consortium building, and the mobilization of science; and (v) the implementation of the new System Priorities would be facilitated by a System-level funding mechanism, which would complement current bilateral approaches. The aim should be to enhance the System's efficiency in tackling major strategic objectives, to support the System Priorities through a move towards corporate donorship, to remain focused on international public goods research (rather than development) at Centers and to limit unproductive contract research.

*Resource allocation to the new System Priorities.* As discussed at the CGIAR AGM 2004, the implementation of the new System Priorities would be facilitated by a System-level funding mechanism, which would complement current bilateral approaches. A Task Force to explore the possibility of developing such a mechanism has been set up by the CGIAR.

*Managing the transition.* Centers should make evolutionary not revolutionary changes in their science strategies. The three-year adjustment to the progressive implementation of the Priorities will be monitored by SC oversight of program

objectives in the MTPs of Centers, CPs and SWPs. The SC will undertake a dynamic review of the Priorities, including strategic studies and by extending the consultative processes pioneered in this exercise. Center-driven innovation and progress, as reflected in the MTPs, will also play a major role in the evolution of the System Priorities.

The SC expects to review the System Priorities approximately five years from now, and to carry out a major reconsideration of the Priorities in 10 years' time. In addition, on-going monitoring by the SC will aim to identify new promising opportunities for enhancing the impact of CGIAR research.



## Glossary and Acronyms

Agrobiodiversity	biodiversity of species contributing directly or indirectly to agricultural production
Agroecology	the integrative study of the ecology of the entire food system, encompassing ecological, economic, and social dimensions
Agroecological intensification	(used in this Report to mean) research to augment the overall productivity of food systems
Alliance of CGIAR Centers	Cooperative organization of the CGIAR Centers (formerly Future Harvest Centers)
ARI	advanced research institution
ASTI	Agricultural Science and Technology Indicators
AVRDC	The World Vegetable Center
CBC	Committee of Board Chairs (of the CGIAR)
CDC	Center Directors' Committee (of the CGIAR)
CGIAR	Consultative Group on International Agricultural Research
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CP	Challenge Program (a consortium approach, of CGIAR Centers and other partners, to major research topics)
CSO	civil society organization
Ecoregion	geographic area with generally similar ecological characteristics (and tendency to similar farming systems)
DNA	deoxyribonucleic acid
ExCo	Executive Council of the CGIAR
FAO	Food and Agricultural Organization of the United Nations
GDP	gross domestic product
GMO	genetically modified organism
High-value	a relative term used in this Report to denote species and commodities which command higher unit prices than staple crops, and which could thus be exploited for additional income from agriculture
High-potential environment	areas having inherently high potential for agricultural productivity, by reasons of climate and resource endowment.
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immunodeficiency Disease Syndrome
IFPRI	International Food Policy Research Institute
IPM	integrated pest management
IPR	intellectual property rights
IPGRI	International Plant Genetic Resources Institute, now Bioversity International
INRM	integrated natural resource management
LAC	Latin America and Caribbean region
Low-potential environment	areas with inherently low potential for agricultural productivity, by reasons of climate or resource endowment
MDG	Millennium Development Goal
MTP	Medium-Term Plan
NARI	national agricultural research institution
NARS	national agricultural research system
NEPAD	New Partnerships for Africa's Development
NGO	non-governmental organization

NRM	natural resource management
NTFP	non-timber forest product
PPP	public–private partnerships
QTL	quantitative trait loci
R&D	research and development
RAIS	risk assessment information system
RIL	random inbred lines
RWC	Rice–Wheat Consortium for the Indo-Gangetic Plains
SC	Science Council of the CGIAR
SINGER	the information network of the CGIAR SWP for Genetic Resources
SPS	sanitary and phytosanitary (regulations)
SSA	sub-Saharan Africa
SWP	Systemwide Program
TBT	Technical Barriers to Trade Agreement
TRIPS	Agreement on Trade-related aspects of Intellectual Property Rights
UPGR	under-utilized plant genetic resources
WANA	West Asia/North Africa region
WTO	World Trade Organization



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Science Council Secretariat  
c/o FAO  
Viale delle Terme di Caracalla, 00153 Rome, Italy  
[www.sciencecouncil.cgiar.org](http://www.sciencecouncil.cgiar.org)  
t 39 06 57056782  
f 39 06 57053298  
e [sc-secretariat@fao.org](mailto:sc-secretariat@fao.org)

