CGIAR 40 YEARS

A STRATEGY AND RESULTS FRAMEWORK FOR THE CGIAR

For submission to the CGIAR Fund Council and Funders Forum

February 20, 2011

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FOREWORD

The Funders Forum of July 2010 discussed the Strategy and Results Framework (SRF) presented by the Consortium Board (CB) on behalf of the CGIAR Centers. While the effort of the Centers was recognized, and a number of important components of the CGIAR strategy were considered to have been adequately covered, it was felt that the then current version could only be considered a work in progress, since it failed to properly address a number of essential issues and concerns raised by donors and other stakeholders at that meeting. The Chair of the Consortium Board was requested to take responsibility for producing a revised version of the SRF taking into account these comments. The crucial importance of the SRF as the strategic expression of the reform process was highlighted, and a sense of urgency was conveyed for its finalization and approval.

This document responds to that request and builds on the previous work by the Centers. It sets out the Strategic Results Framework providing the rationale and content that should guide international agricultural research in the CGIAR system in the years to come. The document addresses the gaps and concerns identified by donors and other stakeholders at the last Funders Forum meeting. In particular, the SRF identifies the evolving context of international agricultural research and the role of the CGGIAR over the coming few years on the basis of its comparative advantage. It defines the four strategic system level outcomes (SLOs) that should be pursued in future international agricultural research, namely reduction of rural poverty, increase in food security, improving nutrition and health, and more sustainable management of natural resources; and it identifies thematic areas in which the CGIAR needs to have strong competencies in order to be able to carry out the research needed to achieve the vision of the CGIAR.

The CGIAR Research Program (CRP) is designed as the key instrument to achieve this greater alignment of research outputs with the selected four SLOs. The CRPs will make explicit the execution of CGIAR research within an AR4D framework that allows a clear linkage between investment in the CGIAR research and the potential impact on development outcomes in collaboration with research and development partners. The key role of partnerships to reach concrete impact on the ground through the elaboration of an impact pathway for each CRP is highlighted in the document. Finally, the document addresses a number of important governance, management, and institutional issues, and makes a number of recommendations to be taken into account when looking at the future.

The Consortium Board believes this new version of the SRF satisfies the concerns expressed at the last Funders Forum and provides clear and well articulated arguments on how the CGIAR proposes to address the new challenges. It also produces an easily understood framework to track measurable developmental impact targets. It provides guidance as to how the Centers' research efforts in producing international public goods will interact with the work of other national, regional, and international organizations as

well as other relevant development stakeholders and partners to achieve development impacts. The SRF also constitutes an important guiding tool for the CB policy decision making process, including the setting up of priorities in and among CRPs.

The Consortium Board recognizes that the process of development of the SRF and the portfolio of CRPs did not respond to an appropriate time frame. In an ideal world, there should have been agreement and approval of the SRF first, and then, and only then, the CRPs should have been defined and developed as the operational arm of the SRF to achieve the selected system level outcomes. For a number of reasons which are well known, and whose responsibility is attributable to both Centers and Donors, the process did not materialize as it should have. In fact, fifteen CRPs have been developed before the conclusion of the SRF, and two CRPs have already been approved by the Fund Council, before reaching agreement on the essential components of the SRF. This has certainly created a number of difficulties and complexities in the writing of the SRF which is now presented.

As recognized in the text, it is logical that, in the absence of clear guidelines, the existing CRPs have some inconsistencies with the current SRF framework.. What is significant to highlight, however, is that the current CRP portfolio has a good alignment with the System Wide Outcomes selected in this SRF, and that its successful development and implementation will make a significant contribution to the vision of the CGIAR.

As the best way to continue moving forward in the reform process, the document suggests the adoption of a pragmatic transition period in which the Consortium Board and proponents of CRPs, will endeavor to the maximum extent possible, to better bring into line with the SRF, through certain adjustments and alignments, the areas needing attention in the CRPs. In fact, a number of these inconsistencies have already been addressed by the Consortium Board in its recommendation and guidelines given to the proponents in the process of development of the CRP Portfolio. This will certainly contribute to the achievement of more strategic coherence at the CGIAR system level.

The SRF as well as the CRPs should be considered living documents that will evolve and be adjusted to respond to new developments and opportunities as well as changing realities. The "second generation" of CRPs that will be developed in the future will fully adjust, from the outset, to the principles and criteria set forth in this SRF.

Moreover, a new SRF will have to be developed in the foreseeable future, and in not later than six years in response to the evolving global scenario, the emergence of new challenges, and the evaluation of the success and shortcomings of the implementation of the present SRF. The new document should devote more analysis, and certainly a much greater amount of time, than was possible in this revision of the SRF, to define the best integration between the SLOs and the core competencies of the CGIAR. The SRF should be at the forefront on how the international community should allocate resources for international agricultural research. A clearer definition regarding

boundaries and interactions among a new generation of CRPs will facilitate decision making and priority setting.

In spite of the limitations inherited from a far-from-perfect process for the development of the SRF, we firmly believe that the approval of this document will be a major step forward in the new CGIAR system that is taking shape. It will also enhance the important role of international agricultural research in the fulfillment of the MDGs. It is indisputable that research is part of the solution to the problems of rural poverty, food security, undernutrition, and environmental sustainability. As such, we sincerely hope that this SRF will create a better environment for international agricultural research and contribute to a significant expansion of its funding.

This SRF document was developed by a team of distinguished professionals: Martin Piñeiro (Chair), John Lynam, Jeff Waage, and Eduardo Trigo (who participated on behalf of GFAR), under the overall guidance of the Chair of the CB and with technical support from Daniela Alfaro.

A draft version of the document was submitted to the consideration of the Director Generals, as well as the Board of Trustees of the CGIAR Centers. They responded with submissions consisting of a long list of general comments, and, as requested by the Consortium Board, concrete suggestions on revised drafting in tracked changes. Most of the comments were considered useful and constructive and taken into account in this final version which is submitted to the consideration and approval of the Consortium Board.

Finally, this document also benefited from the advice and substantive contributions from Professors Gordon Conway and M.S Swaminathan, as well as the current and former chairs of the ISPC, Kenneth Cassman and Rudy Rabbinge, who kindly devoted time and effort in support of this important work. The Consortium Board would like to express its gratitude for the dedication and hard work of all of them in a very tight timeframe.

Carlos Pérez del Castillo

Chair of the Consortium Board

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List of Abbreviations and Acronyms

AfricaRice - a CGIAR Research Center
AGRA - Alliance for a Green Revolution in Africa
ARIs - Advanced Research Institutes
AR4 - Fourth Assessment Report
AR4D - Agricultural Research for Development
Biotech - Biotechnology
Bioversity International - a CGIAR Research Center
CAADP - Comprehensive Africa Agriculture Development Program
CB - Consortium Board (of the CGIAR)
CDB - Convention on Biological Diversity
CG - abbreviation of CGIAR
CGIAR - Consultative Group on International Agricultural Research
CIAT - International Center for Tropical Agriculture
CIFOR - Center for International Forestry Research
CIMMYT - International Maize and Wheat Improvement Center
CIP - International Potato Center
CO_2 - Carbon Dioxide
CRP - CGIAR Research Program
CSOs - Civil Society Organizations
FAO - Food and Agriculture Organization
FARA - Forum for Agricultural Research in Africa
GCARD - Global Conference on Agricultural Research for Development
GFAR - Global Forum on Agricultural Research
GMOs - Genetically Modified Food
GXE - Genotype-By-Environment
HYVs - High-Yielding Varieties
ICARDA -International Center for Agricultural Research in the Dry Areas
ICRAF - World Agroforestry Center
ICRISAT - International Crops Research Institute for the Semi-Arid Tropics
ICTs - Information and Communication Technologies
IEA - Independent Evaluation Arrangement
IFPRI - International Food Policy Research Institute
IITA - International Institute on Tropical Agriculture
ILRI - International Livestock Research Institute
IMPACT - Integrated Modeling Platform for Animal and Crop Systems in the Tropics
INRM - Integrated Natural Resource Management
IPCC - Intergovernmental Panel on Climate Change
IP - Intellectual Property
IPG - International Public Goods
IPR - Intellectual Property Protection Issues
IRRI - International Rice Research Institute
ISPC - Independent Science and Partnerships Council

ITPGRFA - International Treaty on Genetic Resources for Food and Agriculture
IWMI - International Water Management Institute
MDGs - Millennium Development Goals
NAROs - National Agricultural Research Organizations
NARS - National Agricultural Research Systems
NGOs - Non-Government Organizations
NRM - Natural Resource Management
OP - Operations Plan
PES - Payments for Environmental Services
PRSP - Poverty Reduction Strategic Planning
R & D - Research & Development
REDD - Reduced Emissions from Deforestation and Forest Degradation
RLC - (FAO) Regional Office for Latin America and the Caribbean
RUPES - Rewards for, Use of and shared investment in Pro-poor Environmental Services
SLOs - System level outcomes
SRF - Strategy and Results Framework
SSA - Sub-Saharan Africa
UN - United Nations
UPOV - International Union for the Protection of New Varieties of Plants
WANA - West Asia and North Africa
WDR - World Development Report
WORLDFISH - a CGIAR Research Center

Executive Summary

1. Overview

Global crises in food supply, the global economy, climate and the environment present well documented and growing threats to the lives and livelihoods of millions of poor people. The CGIAR consortium of international research centers and partners is ideally positioned to help address these challenges by means of coordinated, science-based, technological, and institutional and policy approaches.

The CGIAR's reputation for expertise and innovation in creating and facilitating ground-breaking technologies, exploiting vast germplasm resources, marshaling public and private research through a broad network of partnerships and pointing the way to policy and institutional innovations is strong, global and well-established.

The scale of future challenges, however, requires a redoubling of efforts. For this reason, the CGIAR has set out a new, results-oriented strategic framework: the Strategy and Results Framework (SRF). This document provides an overarching structure for the combined work of its Centers that brings focus and efficiency to its research, steering it clearly towards system level objectives and outcomes.

The result will be measurable enhancements of the CGIAR's contributions to a reduction in poverty, increased global food security, improvement of nutrition and better management of natural resources.

The framework has been devised to effectively channel the comparative strengths and assets of the CGIAR by means of a more integrated organizational structure, while at the same time taking full advantage of the talents and opportunities available within the global agricultural innovation system of which the CGIAR is a part.

This new framework provides strategic direction, ensuring that the work of centers and research programs converges on the shared objectives of the CGIAR, and produces measurable results that enable these objectives to be met. Achieving this will draw upon major core competencies across the Centers and on a broad range of partnerships, not only in the research process, but also in subsequent stages of the impact pathway, to ensure that the research results lead effectively to impact.

The SRF applies to the CGIAR as a whole. It enables all of the CGIAR Centers, partners and donors to see how their work fits in with that of other organizations in the global AR4D system and their efforts contribute to the overall vision adopted by the CGIAR with the Reform process: **To reduce poverty and hunger, improve human health and**

nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership.

2. The Role of the CGIAR in the Global Research System

While the traditional agenda of the CGIAR, linked to food crops, natural resources management and agricultural policy, remains as relevant as ever, new demands need to be confronted. Coincidentally, a number of national agricultural research institutions in the developing world have significantly increased their scientific strength, while private sector investment in research which is relevant to developing countries has grown enormously. The further development of the CGIAR has to take into consideration this evolving international context and by exploiting partnerships and its comparative advantages, it should maximize its potential contributions to agricultural development and the achievement of the MDGs.

As part of this perspective, the CGIAR will endeavor to mobilize all available capacities that are relevant to the fulfillment of the CGIAR Vision and thus fulfill its role as **the only institution with a clear mandate on science and technology development for the eradication of hunger and poverty at the global level.**

To implement its mandate, the CGIAR expects to build on its past success as well as on its core assets and comparative advantages, and strengthen its capacity to fulfill a critical role in the Global AR4D system: **producing, assembling and delivering research outputs, in collaboration with research and development partners. These outputs will be International Public Goods (IPG) and will clearly contribute to the solution of significant development problems that have been identified and prioritized with the collaboration of developing countries.** GFAR and regional FORA and organizations can have a significant role in this process.

3. Towards a strategy and results framework

The new CGIAR is a consortium of fifteen research centers that will now develop a joint agricultural research for development program (AR4D) with activities across Centers tightly aligned with selected development objectives. This represents a fundamental change in strategy and its implementation will increase the probability of achieving larger development impacts, potentially within a more efficient research structure.

For this purpose, following a general trend in international organizations, a management by results framework has been adopted under which a coherent framework for strategic planning, management, and communications based on continuous learning and accountability will be implemented.

The implementation of this framework requires, as a first step, the identification of development outcomes to which research activities will contribute. The CGIAR has derived, from the MDGs and the CGIAR Vision, four system level outcomes that will

serve as the focal point of all CGIAR research activities. The selected four system level outcomes (SLOs) are:

a. **reducing rural poverty.** Agricultural growth through improved productivity, markets and incomes has shown to be a particularly effective contributor to reducing poverty especially in the initial stages of development;

b. **improving food security.** Access to affordable food is a problem for millions of poor people in urban and rural communities and it requires increasing global and regional supply of key staples and containing potential price increases and price volatility;

c. **improving nutrition and health.** Poor populations suffer particularly from diets which are insufficient in micronutrients affecting health and development, particularly in women and children;

d. **sustainable management of natural resources**. Agriculture demands better management of natural resources to ensure both sustainable food production and provision of ecosystem services to the poor, particularly in light of climate change.

There are clear associations between these four system level outcomes, but there are also important differences in the way in which they contribute to broader development goals. In addition, each SLO will require special and different strategies, research competencies and research outputs and outcomes. Therefore these SLOs represent a distinctive set of interactive targets for the contributions of agricultural research to development.

4. Organizing Research to deliver system level outcomes

Achieving the CGIAR Vision and having an effective impact on the four SLOs requires exploiting core competencies across the CGIAR system and improving the alignment of research programs and downstream institutional arrangements around explicit strategies. For this purpose the CGIAR will organize research programs that are designed as an instrument to achieve greater alignment of research outputs with SLOs by leveraging synergies across the Centers' core competencies and developing effective partnerships.

Currently the CGIAR has developed strong research competencies in:

- Improvement of crop and animal production for commodities of importance to the poor;
- natural resource management for sustainable agriculture, including conservation and improved use of water, soils and forests; and
- social sciences and policy research which benefit the poor through improving access to agricultural resources, food and markets.

In order to address emerging challenges for agricultural development and impact on the SLOs, research competencies will be developed or strengthened in:

- improving production systems which integrate commodity, natural resource management and policy research to improve productivity and livelihoods in a sustainable manner at the national and regional level;
- understanding the impact of climate change on agriculture and devising strategies for adaptation and mitigation that will benefit the poor;
- developing agriculture for improved nutrition and health outcomes, particularly for vulnerable groups such as women and children.

In addition to the research areas of special CGIAR competency, there are a few critical areas that cut across the potential Research Programs and affect the ability of the CGIAR to have an impact on the SLOs. In these cross-cutting areas the CGIAR will build institutional capacities, or focal points, capable of providing strategic coherence, greater research efficiency and scientific quality to the overall research effort within the CGIAR. These cross cutting activities will be supported through the Consortium Office. Among them, Gender Inequality in Agriculture and Capacity Strengthening, Learning and Knowledge Sharing are given significant importance as well as specific suggestions for action throughout the document.

Research implementation through the CGIAR Research Programs (CRPs)

The CGIAR Research Programs (CRPs) will be the main organizational mechanism of CGIAR research. They will be the vehicle for better alignment of core competencies (Thematic Areas) as developed across Centers around a more strategic approach of the CGIAR system to impact on SLOs. The CRPs will make explicit the execution of CGIAR research within an AR4D framework that allows a clear linkage between investment in the CGIAR research and its potential impact on development outcomes. **The CRPs involve three core principles, namely: a) a strategic approach to organizing research around impact on the four SLOs, b) integration of research across core competencies and c) clarity on and differentiation of partnerships at the various stages of the R&D process.**

CRPs will be the main research instrument of the CGIAR. As such their development process should be designed to assure that they have a number of characteristics or attributes that define their quality and strength. A set of critical attributes for the design of a CRP are given in this document, which also provide the basis for the criteria to be used in the assessment of CRPs that have been agreed with the ISPC.

Organization and implementation of CRPs

The Consortium Board is responsible for the overall CRP portfolio approval and for its submission to the CGIAR Fund Council. The Board's roles will include ensuring that: a) individual CRPs are aligned with the SRF, responding to the common criteria agreed with the ISCP for the assessment of the CRPs; b) that they are in synergy with each other, reducing overlaps and leveraging complementarities; and c) that milestones

and outputs, which will be specified in a performance contract to be signed between Centers and the Consortium Board for each CRP, are delivered within the agreed timeframes and budget.

The main governance and management arrangements for the CRPs are also identified in the document.

Existing portfolio and convergence with the SRF framework

The CGIAR is developing a complete, strategically coherent and balanced portfolio of CRPs across the four SLOs. The logical phasing of the development of the SRF followed by the development of the CRP portfolio did not materialize as it had been envisaged. A portfolio of fifteen CRPs now exists before the completion of the SRF and consequently, in the absence of clear guidelines, some inconsistencies between the SRF framework and the available CRPs may exist. The document suggests a transitional management period that will have to be taken into account in order to adjust the current CRP portfolio to the SRF guidelines.

It is important to emphasize, however, that the process by which these CRPs have been developed has meant an important step forward. It has led to the identification of a common research strategy for all the Centers and has explored the needed linkages across Centers in order to achieve both greater strategic coherence and improved research efficiency.

Investment Required in relation to the existing portfolio

Investment in agricultural research must increase substantially if it is to have a sizeable impact on poverty and hunger.

To achieve a food-secure world by 2025, an annual increase in agricultural productivity of 0.5 percent across all regions until that year is required. According to IFPRI's estimates, this equates to a massive expansion of investment in agricultural research for development above current levels – from US$ 5.1 billion per year today to US$ 16.4 billion per year by 2025.

This increase includes the investment needed in national as well as international public-sector research. Investment in international public goods research is currently about 10 percent of total public R&D spending (slightly over US$ 500M in 2009). Making the conservative assumption that this will at least be held constant, and extrapolating it to 2025, a CGIAR budget of US$ 1.6 billion (10 percent of US$ 16.4 billion) by 2025 is required if it is to make the appropriate contribution to food security and poverty reduction by that year.

The implicit budget request in the existing portfolio of fifteen CRPs is around US$ 790 million for the first year (2011), with an annual increase of around US$ 100 million for the first three years. A projection of these budget figures to the year 2025, using the

mentioned annual increase, would produce figures similar to, although slightly higher than, the IFPRI estimates.

5. Evolution of the SRF: Looking into the future

This SRF and the existing Portfolio of CRPs is an institutional asset of the CGIAR. The CRP portfolio must be seen as a "living agenda" which evolves in time as new problems and opportunities are identified and implemented CRPs mature and come to an end

The second generation of CRPs will have to fully adjust to the principles and criteria set in this SRF and evolve into a well balanced and efficient portfolio in relation to the four SLOs. The Consortium will have to strengthen its capacities to manage this adjustment and guide the process in the direction of obtaining an increased impact on the four SLOs.

CHAPTER 1. THE GLOBAL FOOD AND AGRICULTURE SYSTEM AND THE CGIAR

1.1 Introduction

1. The Consultative Group on International Agricultural Research (CGIAR) is facing immense challenges and opportunities. Global food insecurity has increased and undernutrition remains stubbornly entrenched among many of the world's poorest people. Global economic and population growth have increased the pressure on food supplies. Natural resources are overstretched. And climate change imposes new stresses on natural resources, agriculture, and health, especially among the poor. Commercial agricultural pressure on land and water resources is increasing and conflicts over these are spreading, with poor communities' rights often going unprotected.

2. The CGIAR is well positioned to help overcome these challenges. After nearly two decades of neglect, the role of agriculture and agricultural research in reducing poverty is once again receiving high-level political recognition. The World Bank *World Development Report 2008*,[1] policy statements from the United Nations, the Groups of Eight and Twenty (G8 and G20), the European Union, the United States, China, and the African Union, among others, and numerous reports from other institutions,[2] are focusing attention on issues close to the heart of the CGIAR. The time is ripe to further develop a truly global agricultural research effort, drawing on existing resources in the CGIAR and its partnerships to build increased support for their mission.

3. As a key component of the international agricultural research system, the CGIAR has contributed mightily to innovations that have led to increased food production and availability and improved natural resources management, with the benefits flowing largely to poor people. But the context, in which it operates, that of R&D in world agriculture, is changing. After a long period of neglect, agriculture is again being considered a key sector for development in the fight against hunger and poverty. The demand for agricultural R&D is becoming more diversified and complex, while science is presenting new opportunities. National agricultural research capacities in many developing countries are still weak, but in some of the larger countries, especially Brazil, China and India, national research systems have made rapid advances which are turning them into significant international players. In other parts of the world, regional organizations have consolidated as resources for supporting national efforts.

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1 World Bank, World Development Report 2008: Agriculture for Development (Washington, DC, 2008).

2 International Assessment of Agricultural Knowledge, Science and Technology for Development, Agriculture at a Crossroads (Washington, DC: Island Press, 2009); Intergovernmental Panel on Climate Change, IPCC Fourth Assessment Report: Climate Change (Cambridge: Cambridge University Press, 2007); Millennium Ecosystem Assessment, in the four volumes in its Ecosystems and Human Well-Being series (Washington, DC: Island Press, 2005); D. Molden, ed., Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture (London: Earthscan, 2007).

Private sector research is playing a growing role, and although its deployment in low income countries is still very uncommon, it holds potential capacities that cannot continue to be ignored. These changes have been in the making for a long time and now require that the CGIAR re-examine its business practices so it can continue to be an effective investment.

4. The CGIAR has thus embarked on a process of reform designed to create a more coherent program, with a new Strategy and Results Framework (SRF) to help it more effectively meet current and emerging research and development challenges. Rising to these challenges will require a sizeable increase in funding, and the SRF sets out a structure that shows how additional resources would be channeled to maximize the returns to investment.

5. The strategy presented here is for the CGIAR as a whole. As far as possible, it has been developed on the basis of evidence. This evidence includes the use of models, which were important in projecting the demand for food and other commodities and so in identifying major research needs, and many sources of information and advice, all of which are made transparent. It was assumed that investors wanted to hear first from the research communities about what and where the strategic R&D investment opportunities are. If need be, this approach will also allow hard choices under budget constraints to be made more rationally.

1.2 The repositioning of agriculture in the fight against hunger and poverty

6. More than a decade ago the Millennium Development Goals (MDG`s) confirmed the global community's preoccupation and firm commitment to working jointly and seriously to improve the living conditions of the poor and hungry. Since then there have been repeated commitments to eradicating global poverty and hunger, most recently in response to the food crisis of 2007–2008 but also predating this. In 2008, the United Nations assembled a High-Level Task Force on the Global Food Crisis, which developed a *Comprehensive Framework for Action* that represents the consensus view of the UN system on how to respond to the food crisis. Promotion of smallholder food production plays an important role in this framework.[3] The G8 along with other countries issued a statement in July 2009 to the effect that "there is an urgent need for decisive action to free humankind from hunger and poverty ... We therefore agree to act with the scale and urgency needed to achieve sustainable global food security. To this end, we will partner with vulnerable countries and regions to help them develop and implement their own food security strategies, and together substantially increase sustained commitments of financial and technical assistance to invest in those strategies."[4] This statement, which specifically supports reform of the CGIAR, was later affirmed by the G20 and signed by 36 nations and UN agencies.

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3 United Nations, High-Level Task Force on the Global Food Security Crisis, "Comprehensive Framework for Action" (New York, 2008).

4 Group of Eight, "L'Aquila Joint Statement on Global Food Security," July 10, 2009.

African leaders have made a new commitment to investing in agriculture and pursuing agricultural growth through the Comprehensive Africa Agriculture Development Program (CAADP). Agricultural R&D is an important pillar of CAADP and will be strongly promoted by the Forum for Agricultural Research in Africa (FARA) and the Alliance for a Green Revolution in Africa (AGRA). In at least some donor countries, foreign aid has been ring-fenced by governments mindful of the public outcry against poverty and hunger in the mid-2000s and the ongoing campaign to "make poverty history".

7. It is in this context that the role of agriculture - broadly defined to include the livestock, fisheries, forestry and agro forestry sectors alongside crop production, and urban production alongside rural - is being reconsidered. The livelihoods of millions of smallholders and rural people depend directly on their ability to grow, harvest, process, market, and utilize crops, livestock, fish and tree and forest products. The indirect effects of agricultural growth and ecosystems services on incomes and jobs, on consumers' food security, nutrition and health, on educational prospects, on social and cultural development, and on the environment, are even larger (Valdes and Foster 2010). In focusing on this issue the World Bank has emphasized the need to differentiate countries in terms of agricultural development strategies, suggesting the need to recognize three distinct "rural worlds": ***Agriculture-based countries*** **(**where agriculture is a large share of GDP, a major source of growth and most of the poor are in rural areas); ***Transforming countries*** (where agriculture is no longer a major share of GDP or growth, but poverty remains overwhelmingly rural); and ***Urbanized countries*** (where agriculture is a relatively small share of GDP and poverty is mostly urban) (WDR 2008). In all cases agricultural growth remains fundamental for poverty reduction and food security and the targets associated with the first of the Millennium Development Goals (MDGs) of halving poverty and hunger by 2015 will not be reached without major changes in agricultural and food production patterns. But doing so will require the design of different agricultural strategies to reflect the different needs and opportunities implied in each context. In working towards the achievement of the MDG, the priority in the short run is in working primarily with the agriculture-based and transforming countries of South Asia and Sub-Saharan Africa where most of the poor and undernourished people live (reference to IFPRI maps). However, it should be emphasized that this is an evolving picture and in the longer terms, as economic development trends and the geography of poverty change and countries "migrate" in their rural realities, research strategies should also be revised to maintain their alignment to development goals taking into consideration the increasing importance of urban population and urban poverty.

8. If poverty and hunger are to be eradicated, substantial investments must be made in agricultural research and innovation as well as in agricultural development. The SRF reflects the opportunities that agriculture presents for pro-poor economic development and the contribution that a well-functioning food and ecological system can make to human wellbeing and security. Improved agriculture and natural resource management have crucial roles to play with regard to other development goals in addition to halving hunger and poverty (MDG1), including

the MDGs related to achieving greater environmental sustainability (MDG7), improving access to water (MDG7c), overcoming land degradation (MDG7a), promoting gender equality (MDG3), reducing child mortality (MDG4) and improving maternal health (MDG5).

9. Meeting these development challenges requires a focus on empowering women to grasp opportunities for improving their livelihoods and those of their families. Women play an increasingly significant role in agriculture, as they are responsible for approximately 50% of all production. The CGIAR recognizes this role and is committed to increasing its efforts to orient research and to change farming practices and systems so that women can play an important part in enhancing agriculture productivity and improving their livelihoods. It is also committed to influencing governance systems to include women in decision-making.

1.3 Looking into the future: more diversified and complex demands for the global AR4D system

10. When looking into the future, it becomes necessary to reflect about what is expected from the AR4D system and as we do, it is clear that while the initial focus on food availability, production and productivity as key elements for future food security will remain as strong as ever, there is also the need to consider the broader issues of hunger and poverty, environmental sustainability and natural resource issues, together with a greater awareness of the policy and institutional aspects. These latter dimensions are required in order to accelerate the adoption of new technology and, ultimately, food safety and adaptation to climate change as urgent concerns.

11. **The challenge of increasing agricultural productivity and defining more efficient food production strategies.** Challenges to overcoming poverty and food insecurity and achieving sustainable management of natural resources arise on several fronts. Decades of underinvestment in agricultural research and innovation have slowed productivity growth. Annual growth in cereal yields worldwide has declined from about 3 percent in the 1960s and 1970s to less than 1 percent since 2000. In 2007 and 2008, high prices and favorable weather encouraged agricultural expansion in developed countries, but production in developing countries failed to take off. Cereal output grew by 11 percent in developed countries between 2007 and 2008 but by only 0.9 percent in developing countries. If Brazil, China and India are excluded, cereal production in the rest of the developing world actually fell by 1.6 percent.

12. The recent food and financial crises have serious implications for food and nutrition security in developing countries. Since 2007 / 2008, the prices of nearly every agricultural commodity have risen sharply, in a process which does not seem to have peaked yet. Several factors contributed to these price increases: increasing frequency and severity of droughts, rising energy prices and subsidized bio-fuel production, income and population growth, and market and trade policies that had a distorting effect. Increased volatility and risk will remain as lasting features of the world food system, requiring urgent attention from

planners and policy makers in addition to researchers. Poor people spend 50–70 percent of their income on food. Because wages for unskilled labor tend not to rise in line with food inflation, the poor have little capacity to adapt as prices rise. Moreover, even before the recent food crisis, the poorest of the poor were being left behind. Programs are needed to address production and productivity through policy and institutional innovations, improved markets and market linkages for smallholder agriculture.

13. In the long run, urbanization and the rapid increase of food demand in regions with scarce agricultural resources like Southeast Asia will shift the food insecurity problems into urban areas increasing the pressure on the need for trade and efficient use of scarce agricultural natural resources

14. **The need for more sustainable natural resource use patterns**. At the same time, the natural resources on which agriculture depends are under severe stress. Global economic and population growth have combined to increase demands of water, arable land and forest products, including wood fuel for cooking. Deforestation and land use change are undermining the provision of environmental goods and services, reducing resilience and options for the future through loss of biological diversity. Climate variability and change will further threaten agricultural productivity and production by increasing the risk of droughts and floods, affecting temperatures and crop growing seasons, altering the distribution of pests and diseases, and triggering rises in sea levels as well as changes in the ability of the oceans to support life. Many of the world's fisheries are already near collapse. Genetic erosion undermines efforts to improve crops and livestock. It is no exaggeration to say that natural resources depletion and degradation threaten the very future of civilization beyond their impacts on global food security and the global economy. Different regions face different challenges: in Sub-Saharan Africa, poverty and food insecurity persist and are even worsening in some countries; much of Asia and Latin America have benefited from rapid economic growth in recent decades, but inequality remains a serious problem, with gaps between rich and poor widening; the dry areas of North Africa and South, West and Central Asia confront particularly serious water scarcity issues, likely to be exacerbated by climate change. Competition for access to productive resources has been recognized as an increasing source of conflicts. To combat these problems, better adaptation of crops and livestock to drought, heat and other stresses is needed, but this alone will not suffice. Broader land management changes also need to be promoted and new policies and institutions must be put in place that recognize the importance of agro forests and forests in minimizing soil erosion and soil fertility decline and in protecting water quality while assuring a stable water supply.

15. **Climate change as a new challenge.** Although not new, climate change is now universally recognized as a major problem for development in general and agricultural development in particular. The Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) provides in-depth analysis of recent scientific understanding on climate change (IPCC, 2007). It brings together evidence that confirms that human-induced temperature

increases are taking place, with measurable and increasing effects on other parts of the Earth System. Many scenarios are available of how the global climate might change over the next century (IPCC, 2007). Although there are many uncertainties, it is becoming increasingly evident that regardless of mitigation efforts (undertaken today and in the future) temperatures will continue to rise over at least the next five decades because of earlier emissions of greenhouse gases. The magnitude and frequency of extreme events are also likely to increase. Adaptation is therefore a necessary response to climate change. At the same time, mitigation of further climate change is an urgent challenge if future changes are to be limited.

16. Climate change will have far-reaching consequences for agriculture[5] that will disproportionately affect poor and marginalized groups who depend on agriculture for their livelihoods and have a lower capacity to adapt (World Bank, 2007). Climate-related crop failures, fishery collapses and livestock deaths already cause economic losses and undermine food security, and these are likely to become more severe as global warming continues. Agriculture and related activities also contribute to global warming, with around 80% of agricultural emissions, including deforestation, occurring in developing countries (World Bank, 2007). There remains much untapped technical potential to reduce agricultural emissions and increase agricultural mitigation of emissions from other sectors, notably through reduced deforestation via changes in land use and agricultural practices.

17. Sustainable food security in a world of growing population and changing diets is a major challenge under climate change and resource degradation. Although estimates of food insecurity vary (Barrett, 2010), the number of undernourished people already exceeds 1 billion and feeding this many people will require more than incremental changes (Federoff et al., 2010). Food production may need to increase by as much as 70% by 2050 when the global population will number 9 billion (World Bank, 2007; Royal Society of London, 2009). Food security depends not only on gross production of staples, but also on agriculture's ability to provide a diverse and balanced food basket, and on the socio-economic factors that determine whether poor people, particularly women, are able to purchase, store, prepare and consume sufficient food.

18. The AR4 report notes that climate change is already having an impact, for instance, through changes in patterns of variability and associated changes in rainfall distribution (IPCC, 2007). It anticipates with high confidence that projected changes in the frequency and severity of extreme climate events, together with increases in outbreaks of pests and diseases, will have significant consequences for food security. It identifies smallholder and subsistence farmers, pastoralists and fishers as those most vulnerable to these impacts. It also finds that Africa is highly vulnerable to climate change, because of multiple stresses and low adaptive capacity. Projections indicate an increase in arid and

5 The term agriculture is used inclusively to capture the wide range of productive uses of extensive and intensive farmland, rangelands and fisheries and their wider landscapes.

semi-arid land in some countries, while others will get wetter but with changes in seasonal patterns. In Asia, potential changes in the monsoon and in glacier and snowmelt are perhaps the greatest threats. Sea-level rise is also of great concern as coastal and deltaic areas are often heavily populated and intensively cultivated. The natural and managed habitats of fish will be greatly influenced, with declining productivity in fisheries very likely. The report recognizes that, with only a decade of research on climate change adaptation, considerable knowledge gaps remain concerning the adaptive capacity of agriculture.

19. Climate variability and risk has always been a part of agriculture, and farmers and researchers have developed many ways of coping with and managing risk, through different coping and adaptation strategies, including the development of drought-resistant and other abiotic stress-tolerant crop varieties, and soil and water management practices for marginal areas. Climate change introduces a new dimension to the problem. The unprecedented rate and magnitude of climate change presents great challenges to farmers, researchers and policy makers alike.

20. **The growing importance of policy and institutions as instruments for agricultural development.** It is now evident that the success of the "green revolution" in increasing production and productivity in some areas of the developing world like, for example, the Punjab region in India, was highly influenced by the existence of institutional capacities for effective technological diffusion and an appropriate policy context (Hazel 2009). Recent studies show that this and other worldwide agricultural research success stories have taken place in situations where policy and institutional frameworks where conducive to agricultural development (Spielman et al., 2010). This evidence supports new worldwide awareness about the importance of policies and institutions in the aftermath of the world economic crisis of 2008.

21. As several recently launched high-profile reports and programs have reiterated (Zeigler and Mohanty 2010; Bruinsma 2009; Spielman and Pandya-Lorch 2009), the key to stopping the double-edged sword of poverty and hunger in an increasingly resource-strained world is rapid agricultural sector growth that manages to thrive under, rather than lose out against, global drivers of change. Shown to reduced poverty by twice the rate of the nonagricultural sectors, agriculture growth –especially smallholder agricultural growth- remains a frustratingly underexploited means to promote development, reduce poverty and bolster food security. Thus policies and strategies to sustainably increase land, labor and water productivity; promote technology adoption; and promote the marketing of agricultural inputs and outputs will be most crucial to the slowing or reversing of these recent trends (Rosegrant et al. 2009). Implementation needs to be fostered by equitable and effective institutions to deliver on these policies, promote technology adoption and provide services, as well as to ensure that benefits are translated into long-term asset building (e.g. Birner, Quisumbing and Ahmed 2010; World Bank and IFPRI 2010). Improving smallholder productivity, food security and livelihoods is also critical to achieving most of the targets specified under the Millennium Development Goals (Rosegrant et al., 2006).

22. Systematic data collection, analysis and modeling of applications are critical for fostering the positive change in policies, governance arrangement and market systems to allow agriculture to fully contribute to poverty reduction and development. Furthermore, today's constantly changing and interconnected world requires continuous reconsideration of formerly proven principles. Just as climate change shifts the parameters for crop yield improvement, different socio-political dynamics beg for policies, institutions and markets that promote greater equity and environmental protection, while still increasing productivity to meet the needs of rising populations.

1.4 A scientific environment offering new opportunities and challenges

23. Advances in biological sciences – genomics, transgenic and non-transgenic breeding methods, cloning, plant tissue culture, apomixis, somatic embryogenesis – and their interfaces with information and communication technologies (ICTs), ecological science –functional diversity – and even nanotechnology are transforming both the processes and the products of agricultural research, as well as the institutional and economic environment of agricultural technology development and innovation systems. There are quantum leaps in our knowledge about the way plants and animals grow and synthesize useful products, as well as the scientists' ability to transform them. Gene maps of major species are now already available or under advanced stages of development and functional genomics has started to yield a continuing flow of critical information about the role of genes, as well as markers for many of them, and breakthroughs have also taken place in the area of genetic engineering, greatly expanding the possibilities to handle and transform microorganisms, plants and animals. These advances are starting to show up in the efficiency and effectiveness of research processes, by helping detect previously hidden genetic variability and better understanding gene functions, improved plant breeding methods, safer and more effective pest control strategies and plants with improved agronomic traits and nutritional characteristics. At this stage, biotechnological approaches, although they do not represent an alternative to conventional agricultural research technologies, should be anticipated to eventually become the standard for the trade and a key component of agricultural innovation processes to help break present yield barriers, and a source of important social, economic and environmental benefits (Phillips, R., 2010).

24. On a related, but independent front, remote sensing, information and communication technologies are also expanding the above-mentioned potential in distinct directions. While biology is breaking old barriers about what is possible, ICTs are scaling up those possibilities by dramatically enlarging the capacities of using new knowledge and putting people in touch, as well as redefining the basis for strategies for communicating with end users and, actually, defining a whole new space for innovation at the farm level (Ballantyne, P. et al., 2010).

25. These evolutions clearly offer significant new opportunities in terms of opening up previously denied territories and increasing the efficiency and efficacy of

research efforts, and also new alternatives for empowering rural population. However, they also bring about a number of important changes in related science and technology institutional systems, which need to be internalized if those opportunities are to be exploited to their fullest.

26. ***A closer relation to basic science***. Biotech applications development is closely linked to the basic scientific disciplines of biology, genetics, biochemistry and chemistry, among other areas of science and they are applicable across a broad range of subject matters in the areas of health, environment, manufacturing industry and agriculture. Biotechnology capacities are of a generic nature and its natural institutional environment is that of the basic sciences, which usually have no operational links to existing agricultural technology delivery systems, although it is true that once the new genetic constructs are available, for them to be of any economic value, there is the need to backcross them into the broad germplasm basis of existing commercial varieties and undertake the large scale field evaluations to adapt the new products to local ecological conditions and cultural practices. These characteristics have direct implications both in terms of the diversity of the institutional actors involved, as well as with the structure of interactions between basic and applied research organizations. Exploiting the opportunities of the "new" biology requires an interdisciplinary approach and capacities that, in most cases, are to be found outside the traditional agricultural institutions (Phillips, R. 2010).These characteristics reinforce the already existent push towards a more multidisciplinary, multi-institutional (public and private sector and other stakeholders) emerging from the impact of globalization on how research is conducted, where research capacities are increasingly flexibly rearranged and organized responding to the nature of what needs to be researched rather than following traditional institutional lines and mandates (Ekboir and Sette, 2010).

27. ***The growing importance of intellectual property rights*** The emergence of biotechnology brings about a noticeable displacement of the "technological space" in the direction of the private sector. While public goods tend to dominate the traditional agricultural technology research and development policy and organizational systems, in biotechnology, proprietary technologies are the norm rather than the exception; a fact that is showing in the structure and investment trends of the industry, as well as in increasingly more complex management requirements for R&D processes. Intellectual property protection issues (IPR) go beyond the conventional plant variety protection frameworks into patent legislation and its coverage of biological materials and processes. IPRs pose a new and distinct management challenge for existing research institutions, since, in general, they are not well equipped to deal with proprietary knowledge. There is not only the lack of negotiating skills; more important are the administrative and bureaucratic limitations they have to deal with in the acquisition, negotiation and protection of IPRs. These put public institutions at a clear disadvantage with respect to private sector entities, and will, almost certainly, become tangible barriers for accessing certain strategic technologies.

28. ***Investment requirements and potential spillover effects***. In spite of increasing evidence that the costs of doing biotechnology research have been steadily going down, the endemic situation of underinvestment in agricultural research in the developing world represents a major hurdle for the future use of the new technologies, particularly in what can be expected in terms of the capacities of partner institutions at the national level. However, available evidence shows that the products of upstream research activities (genomic information, genes, markers, gene constructs, transformation methodologies) are usually applicable across a wide range of crops and agro-ecological environments, while downstream products (genetically modified crops and varieties) are more location specific, pointing to the fact that to benefit from the new technologies it does not seem to be essential that all stages are fully integrated within an institution –or a country for that matter. Actually, the experience to date is that the biotechnology and the plant breeding research steps for GMOs grown commercially today have only occasionally taken place in the same institution, or even in the same country. This will greatly facilitate the exploitation of spillover effects, and should be an important criterion for the development of up-stream partnerships with the advanced research institutes as well as the integrations of capacities and activities across centers and partnerships.

29. ***A renewed strategic importance for genetic resources.*** Various international agreements protect the access to and use of the genetic resources that must underpin the renewed commitments to end hunger and poverty. The International Treaty on Plant Genetic Resources for Food and Agriculture, which came into force in June 2004, creates a legal and administrative framework for an international pool of plant genetic resources in support of breeding, research, and sustainable use. Ongoing negotiations under the Convention on Biological Diversity and the Commission on Genetic Resources for Food and Agriculture present similar opportunities for animal, microbial and tree genetic resources.

30. Capturing the opportunities implicit in these international undertakings will not only require sustained political will in support of agricultural development, but also a significant reinforcement of research capacities to inventory and valorize available resources, as well as for designing and implementing new agricultural systems for the poor and vulnerable, which include crops, trees, livestock and fisheries, including wild as well as domesticated resources. These capacities together with appropriate policy and institutional research will need to be centerpieces of the CGIAR's new strategy.

1.5 A more diverse and demanding institutional landscape

31. The AR4D landscape around the world has changed significantly since the 1950s, when international cooperation in agricultural research started out of the conventional wisdom that it was necessary to increase agricultural production in the developing world – the issue identified as the overriding objective at the time. The problem was not lack of knowledge or technology, but how to mobilize what was already available at the international level and creating the capacities

needed at the national level to adapt it to local conditions. Out of this relatively simple concept significant efforts were put in place to create and strengthen national agricultural research capacities and international cooperation evolved into what today is known as the CGIAR.

32. The main operational model was a relatively linear approach to innovation evolving around germplasm development, top-down, and supply driven. Germplasm was collected, improved and tested at the international centers, passed on to the national research institutes for multi-location tests, and then promoted by national extension services and – whether private or public – seed firms through demonstration plots. This approach generated both success – "the green revolution" – and a formidable structure aimed at applying science to development issues, where the CGIAR continues to be at centre stage, but also new challenges that are key variables when strategizing for the future. These touch almost every aspect of the system from its conceptual approach to the *modus operandi* of the aid institutions and the roles of different actors and capacities at the national level.

33. ***The emergence of innovation systems as a conceptual framework and partnerships as operational instruments.*** New knowledge and technologies continue to be recognized as the essential output of research activities both at the national and international level. However, research organizations are also increasingly seen as key actors in new knowledge / technology uptake processes, as the linear view of the innovation process has been replaced with an innovation system view of the world, where a much more diversified and complex universe of public and private actors come into play and affect the final outcomes of research investments. This is significantly expanding the demands that national and international institutions need to confront, taking them into fields where, in many cases, they lack capacities and comparative advantages, thus highlighting the role of collective action and partnerships at all levels. These are increasingly recognized as strategic approaches to pool complementary assets such as intellectual property, genetic resources and research tools; facilitate the exploitation of economies of scale and scope; ease and improve technology transfer through arrangements with private input distributors; promote better integrated value chains; and foster mechanisms to express consumer and farmer demands for technology and product traits. In this context the range of partners for the CGIAR in the future will be much more varied than in the past, and will include not only traditional partners such as national research programs, advanced research institutes (ARIs), international agencies and the UN, but also newer ones such as private-sector companies, other ARIs, development agencies, non-government organizations (NGOs), civil society organizations (CSOs) and producer organizations, both in developing and developed countries (WDR, 2009, CGIAR, 2008). Working within an innovation systems perspective, the centers will need to reach beyond the traditional research partnership in establishing broader associations with these other actors in such a way that they fully participate in the design of the research effort and are able to anticipate what will be required to scale up research outputs and develop the appropriate

institutional and policy environments for the successful uptake of the new knowledge and technologies being generated at the research level.

34. **Changing aid architecture.** The nature of aid supply has been dramatically transformed over the past decade, in terms of the levels, the plurality of funding sources, and donor coordination and alignment mechanisms, reflecting the broadly shared view that today's global challenges are too wide ranging and complex for single actors to address alone, as well as the need for better alignment between international and national priorities and plans, along with clear indications about how research efforts will eventually achieve the expected impacts (Pingaly, 2009, Lele, 2005). Although many of these changes open new opportunities as there is the expectation of significant increases in the levels of aid availability, they also require adjustments in international agricultural research program development and implementation.

35. Reflecting the above-mentioned move towards an innovation systems framework and these new perspectives, the donor community has moved to a result / impact *modus operandi,* extending into AR4D support the same performance or results based management approach that they started to use during the 1990s in other development aid areas.

36. ***Underinvestment and increasing differentiation of capacities among NARS.*** A second critical dimension of the institutional landscape the CGIAR is facing is what has been happening with its immediate partner institutions, the national agricultural research organizations. Public sector institutions constitute the backbone of the world AR4D system. Whether in the form of national agricultural research institutes, or as agricultural research councils acting as coordinating bodies of specialized, regional or local research institutions, government organizations make up the bulk of research capacities in every region of the world, and have been the most important strategic partners of the CGIAR throughout the last fifty years (Lele et al., 2010). Some of today's institutions go back as far as the early 20th century; however, most of them in their present form have a similar origin as the CG institutions, since international cooperation played a substantive role in setting them up as decentralized or semi-autonomous institutions. They were originally conceived to be non-bureaucratic and somewhat protected from short-term political pressures, and to receive significant political and financial support both from national sources and from international donors, development assistance agencies and multilateral organizations, in a process that lasted until well into the 1980s (Pardey et al., 2006). Since then, national agricultural research has continued to develop but in the context of an evident overall situation of underinvestment and increasing differentiation among countries, which has led to the appearance of a clear divide between the "haves" and the "have-nots" in terms of science capacities for supporting agricultural development, a phenomenon with clear implications with respect to the capacity to be effective partners for international research effort (Lele et al., 2010).

37. While agriculture has shown relatively healthy rates of growth, investments in research have lost priority both at the national and international levels, a trend that should raise a question about the way political leaderships are valuing

agricultural research as a strategic instrument for development (Pardey et al. 2006, Lele et al. 2010). In this context, Asia and the Pacific and Latin America have performed relatively better than other regions, while Sub-Saharan Africa showed a deterioration of already very modest investment levels (Beintema, 2010).

38. Within this global investment context, there is also a well set trend to a greater concentration of investments and capacities in a small number of countries – China, India, Brazil, Indonesia, Mexico, South Africa and Argentina – which in some cases – China, India, Brazil – have rapidly increased agricultural science output to establish themselves among the world's largest providers of agricultural research knowledge. On the other extreme, there are a large number of countries which in relative – and even absolute terms – exhibit weaker capacities than they had a couple of decades ago. Usually this is the case in the smaller and poorer countries, particularly in Sub-Saharan Africa and Central America, which typically have but one grossly understaffed and under-resourced research organization. In Sub-Saharan Africa in 2000, 93% of the region's agricultural R&D agencies employed fewer than 50 researchers, and 40% of them employed fewer than five full time-equivalent researchers (Beintema and Stads, 2004).

39. ***The consolidation of regional and sub regional organizations.*** Along with the above-mentioned process, the last decades have seen a significant move to establish and consolidate regional and sub-regional bodies directed to complement and support national research efforts and promote regional collective action in order to benefit from economies of scope and scale. These initiatives respond to many different sources and have different capacities and although very few have succeeded in achieving political and long term financial sustainability, most are well integrated with existing local and national capacities and there is no doubt that they are an integral feature of the AR4D institutional landscape. They do not replace national capacities, but they do represent a significant opportunity, not only for productive interaction in terms of priority setting and program development, but also as potential partners for implementation, particularly with respect to lower income countries in regions such as SSA and Central America and other parts of the world. In many of these cases, where the weaknesses of national research systems have become a significant limitation for effective links with international programs, regional and sub-regional organizations offer a good platform for working on aligning priorities with relevant problems, creating ownership and setting up relevant partnerships.

40. ***The growing role of private sector providers.*** The increasing role of the private sector in agricultural research in the developing world is another trend that deserves attention, as it has evolved rapidly from its initial involvement in a few export crops during the post world war period. Today, the private sector is already a key player in the supply of genetic technologies and seeds, agrochemicals, veterinary products, agricultural machinery and implements, and even human nutrition. This role will continue to grow as the cost of biotechnology applications continues to fall, intellectual protection instruments become more standard and input and service markets consolidate. In most cases, efforts by both multinational and national input supply firms are mostly concentrated in the commercial

agriculture sector where the market and institutional conditions are present to ensure suitable rates of return for their investments, and this will continue to be so for quite some time. But it is clear that their up-stream platforms will have an increasingly wider application scope and this will open up important partnering opportunities with public entities –both national and international – that have downstream capacities across different crops and agro-ecological environments.

41. ***The Global Conference on Agricultural Research for Development, GCARD.*** All the trends mentioned above are, in practice, creating a new context for agricultural research for development and a clear need for improving the ways in which the different stakeholders work together to put in place the investments and capacities that will enable research to be effectively embedded in the wider development agenda and operationally linked to national and local innovation processes. It was this recognition that led to the initial drive for a reformed CGIAR and the setting up of the Global Conference for Agricultural Research for Development, GCARD, as the natural institutional space for developing the collective action needed to transform the global AR4D system from its current fragmented status to a more coherent and cohesive effort, where agricultural knowledge, science and technology can contribute their fullest possible roles *vis à vis* the internationally agreed development goals (Maputo Declaration).

42. To this extent, the GCARD I process set in motion a widely inclusive discussion involving all interested parties and stakeholders to analyze priorities, opportunities and limitations and, eventually, to agree on a common road map proposing six major areas of work which provide the common principles and mutual accountability among all stakeholders for an improved and more effective global AR4D system. This six-point plan includes the following: (i) current and future research agendas and priority setting at national, regional and global levels will result from an inclusive process for all AR4D stakeholders, anticipating future needs through coordinated foresight studies, (ii) inclusive innovation pathways based on equitable partnership principles are adopted as the basic operational strategies for addressing development challenges, (iii) a program of increased, integrated and better planned investments is set in place to address the enormous investment backlog existing today, (iv) increased AR4D capacities to meet national needs are recognized as a key systemic priority, (v) an improvement in the coordination and effectiveness of the linkages between research and development, and (vi) increased effectiveness in the monitoring, evaluation and reporting of AR4D investments and results to highlight its value to society (GCARD Road Map, 2010.)

1.6 The role of the CGIAR in the global research system

43. Since the 1960s, CGIAR Centers have contributed to increased agricultural production in developing countries through innovative research that was beyond the capabilities of national agricultural research systems and unlikely to be undertaken by advanced country research institutions (ARI`s) or the private sector. Today, as has been described in previous sections, the situation has changed substantially, and so has the CGIAR (see Box 1.1).

Box 1.1: The CGIAR over the years

A focus on food security and poverty reduction and an evolving research model based on partnerships are the common threads connecting the system's evolution over the last four decades.

The first CGIAR emerged from a coalition of donors supporting a network of plant breeders in international agricultural research centers and national agricultural research organizations (NAROs) working in the development of high-yielding varieties (HYVs) of wheat and rice that constituted the basis of what became to be known as the "green revolution". The main focus was on plant breeding and there was little or no interaction with other actors of the agricultural innovation system, beyond the links with public extension agents who were responsible for diffusing the new varieties. Eventually as new problems (e.g., pests, weeds and soil erosion) were identified as barriers to the diffusion of HYVs, new activities (e.g., agronomy and entomology) were incorporated; later social scientist were brought on board to help adapt the research-adoption-diffusion strategies outside South Asia, where the initial activities were focused.

During a second phase, the generalized conviction of the success of the initial model led to the creation of new centers to research and develop technologies for new products (potatoes, livestock, fish), specific regions (the humid tropics, dry and semi-arid areas), resources (water, forests and trees) and policy organization and management. The focus continued to be on food security and poverty, with an increasing emphasis on natural resources and sustainability issues. Efforts were essentially aimed at producing research outputs and partnerships expanded beyond plant breeding into other areas and involved not only NAROs but also advanced research institutions (ARIs). These networks, however important, remained complementary to the center-based scientific model prevalent in the system.

Towards 1990 and beyond, the CGIAR agenda continued to grow in response to demands for greater evidence of the impact of research investments. Many centers became involved in impact assessment activities and in research on patterns of technology diffusion, natural resources management and the livelihood strategies of poor households, while also getting involved in the exploration of novel approaches to poverty alleviation and the sustainable use of natural resources. This expansion took place in a context of declining international assistance for agriculture and agricultural research where the CGIAR was not sparred, meaning that the system had to address a much broader portfolio with fewer resources, forcing centers to seek special project funding to supplement the shrinking levels of core funding, which further dispersed their agenda.

The above created a growing sense of lost direction, duplication of efforts and decaying impact, which interacted with a number of other factors, including the growing complexity of modern science, reduced investments in agriculture and agricultural R&D in many developing countries, and the greater role of the private sector and other civil society organizations as knowledge providers. The resulting situation led in more recent times to a process of re-evaluation of its research and partnerships approach in favor of a more systemic and development-outcome oriented approach. Later, this process gave rise to System-wide and Ecoregional Programs, followed by the "Challenge Program" concept to address complex issues of global and regional significance in a focused way, by integrating capacities across centers and achieving formal partnerships with a broad array of institutions. The new initiatives produced significant improvements in some areas, but remained a somewhat parallel structure to the centers' activities and an extension of a more traditional perspective of science. Finally, in 2008, the system undertook a broad review of its structure and activities, which identified the proliferation of CGIAR structures and programs, as well as dispersal of focus, as primary impediments to effectiveness. As a result, a far reaching reform effort was set in motion, which addressed not only the review of its vision and objectives, but also its institutional strategy, thus initiating a process to formally integrate its activities at the system level, which highlights the role of partnerships as an integral component of its efforts.

Source: The authors on the basis Ekboir and Sette, 2010; CGIAR, 2008, and other institutional documents.

44. While the traditional agenda linked to food crop yields and productivity increases remains as relevant as ever, new demands need to be confronted, related to more sustainable patterns of natural resource use and effective responses to the effects of climate change, including attention to deforestation and other land cover change. On the institutional front, a number of national agricultural research institutions in developing countries have become real scientific power-houses and regional fora, and research organizations play key roles in research and technological diffusion, while private sector investment in research of relevance to developing country agriculture has grown enormously. In addition, a number of research institutions in advanced countries (ARI`s) have consolidated and expanded their work in researching issues of relevance for the developing countries' problems and needs.

45. The above-mentioned institutional developments make up a formidable set of new capacities to confront the challenges identified. However, neither national research institutions nor private sector entities can reasonably be expected to provide international and global public goods in the areas of agricultural research and environmental sustainability – goods that have the ultimate goal of eradicating poverty and hunger worldwide. National institutions by necessity respond to national needs and priorities and private investment is inevitably guided by market constrains. Yet meeting international targets for poverty and food security require mobilizing all available capacities, including the extraordinary advances made by the ARIs and the private sector in science producing knowledge and technologies of relevance for the poor farmers and consumers in the developing world. **This is the critical continuing role of the CGIAR, as the only institution in the system with a clear mandate for scientific research that provides international public goods for eradicating poverty and hunger at the global level.**

46. To effectively respond to the challenge of this unique role, the CGIAR is adopting a research for development perspective, as the organizing concept of its scientific effort. By relying on the identification of clearly bound development challenges identified jointly with other stakeholders where science and technology can play a significant role, as the "entry point" of its program development process, the CGIAR expects to brings to its activities the focus and accountability that the international community is demanding. **In practice, the CGIAR will work to organize the activities needed to utilize existing knowledge, generate knowledge not readily available and integrate the technological and social processes that are needed to produce significant development impacts, and it will do so through a responsive mode of operations with partnerships and collaboration as its key guiding principles.**

47. In response to these trends, demands, opportunities and conceptual definitions, as well as to the imperative need to focus its activities to ensure an adequate level of impact for its investments, the CGIAR undertook a reform process.[6]

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6 CGIAR Working group on Visioning, "Visioning the Future of the CGIAR", Report to the Executive Council (Washington, DC, CGIAR, 2008)

48. This restructuring process was started by defining a new vision for the CGIAR: ***To reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership and leadership.***[7]

49. This vision is developed from the CGIAR's experience showing that sustainable agricultural development requires research outputs across agricultural science, natural resource management and policy, and it reflects the breadth of research capacity that the CGIAR has built across its Centers for this purpose. It addresses the key development research challenges for which the CGIAR has a comparative advantage, and can be achieved only with the help of partners in the public and private sectors and through supportive government action.

50. Additionally, this process also makes explicit recognition of the CGIAR's specific role in strengthening weaker national partners so that they can participate effectively in global agricultural research and innovation systems, in building and supporting international research networks, and in developing effective partnership models with civil society and private sector investors. The CGIAR's enduring value as a catalyst, facilitator and leader of international public goods research in agriculture continues, but in order to deliver outcomes effectively and efficiently it must now build even stronger partnerships with the other actors in the changing global food and agriculture research system.

51. To achieve this vision at the organizational level, the CGIAR will develop structures and processes to provide the performance and incentive systems that encourage interdisciplinary teamwork, partnerships with other stakeholders and emphasis on mutual learning, and effective knowledge management that promotes change. In this way agricultural research will fulfill its responsibility to support development and become an effective contributor to national and global development objectives.

52. At the implementation level, the CGIAR expects to build on its past success in key areas, in addition to its core assets and comparative advantages, which include:

    - A group of 64 member countries and organizations committed to addressing global development challenges through international agricultural research
    - A critical mass of scientists with multidisciplinary knowledge of key agro-ecosystems
    - An extensive global research infrastructure, including research stations representing many agro-ecosystems

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7 In order to implement this vision, the CGIAR committed itself to work with partners, stakeholders, and potential beneficiaries towards three strategic objectives: i) Create and accelerate sustainable increases in the productivity and production of healthy food by and for the poor (Food for People), ii) Conserve, enhance and sustainably use natural resources, including biodiversity, to improve the livelihoods of the poor in response to climate change and other factors (Environments for People), and iii) Promote policy and institutional change that will stimulate agricultural growth and equity to benefit the poor, especially rural women and other disadvantaged groups (Policies for People) (CGIAR Working group on Visioning, "Visioning the Future of the CGIAR", Report to the Executive Council, Washington, DC, CGIAR, 2008)

- Global and regional research networks with strong links to national agricultural research and innovation systems
- Global collections of genetic resources held in trust for the world
- A Global mandate that emphasizes research for development and a reputation for being an "honest broker," acting in the interests of the world's poor in the global science and policy-making communities.
- Scale and scope comparative advantages to deal with global agricultural research problems and issues.

53. Looking towards the future, these core assets are instrumental in defining and implementing the CGIAR's critical role within the emerging global agriculture for development system: **that of producing, assembling and delivering, in collaboration with research and development partners, research outputs that are international public goods which will contribute to the solution of significant development problems that have been identified and prioritized with the collaboration of developing countries.** This role will be played through the following seven strategic core functions:

    i. Identify and prioritize, together with developing countries and development partners, significant global development problems, associated to the four system-wide outcomes that have been selected by the CGIAR, where science can make significant contributions to its resolution

    ii. Bring together and systematically organize existing knowledge which is relevant to the solution of the identified and prioritized development problems

    iii. Develop, in collaboration with appropriate partners, the necessary research activities to complement existing knowledge, fill identified knowledge gaps and produce the research outputs that are necessary for the solution of the identified development problems

    iv. Play a catalytic and leadership role in organizing, with the appropriate partners, the impact pathways, the technological delivery systems and the policy and institutional frameworks that are needed and relevant, in relation to each particular case, in order to achieve the desired development outcomes. This role may include advocacy and backstopping functions in relation to partners in their fund raising activities

    v. Play a leading role in the monitoring and evaluation of all the activities in which it participates to extract the relevant lessons learned and best practice technologies

    vi. Conserve, evaluate and make available the genetic diversity of the world's major crops and related knowledge

    vii. Play a catalytic role in capacity building in the area of AR4D

54. These core functions define a specific role for the CGIAR: that of focusing on AR4D activities that contribute to desired development outcomes, through providing a

platform to mobilize and organize the needed scientific and technology delivery capacities, and by doing so, increasing the efficiency and effectiveness of the whole. In some cases this will require just to mobilize and provide focus for the activities of others; in other cases it will also contribute by filling the capacities and knowledge gaps that may exist for available resources to be fully exploited; and in a few cases it will require to go beyond and create the new competencies needed to effectively address the identified problems.

1.7 Towards a new strategy for the CGIAR

55. The above-mentioned challenges and trends call for an in-depth review of the CGIAR business model and strategy. Although successful, the approach followed over the last fifty years seems to fall short of addressing the magnitude of the challenges and fully exploiting the opportunities implicit in the institutional complexities found today. There is a need to focus and embed research in the wider development agenda, so that its results can effectively be linked to innovation and in turn be transformed into development impacts on the lives of millions poor farmers and consumers worldwide. This cannot be done piece by piece, or by one institution alone; it needs the collective action of a wide diversity of public and private actors to affect the final outcomes of research investments. In this context and following the principles put forward by the Reform Process, the new CGIAR strategy is based on (i) defining its research priorities within an AR4D framework, so that the generation of new knowledge and technologies is more responsive to development needs and research outputs are more relevant and accessible to those in need, (ii) integrating its capacities across existing centers, so that the scale and scope of its efforts become commensurate to the magnitude of the challenges, and (iii) reviewing its partnering approaches so that it can work more effectively to involve all relevant stakeholders in their best possible roles, not only in research, but also in translating research into innovations and development outcomes.

56. The practical implementation of this strategy implies organizing research activities around large initiatives that respond to well identified development problems, with the participation of two or more Centers as well as outside partners. These Programs will be identified as CGIAR Research Programs or CRPs.

57. The following chapters elaborate these strategic principles into the strategic results framework for the system for the next six years.

CHAPTER 2. TOWARDS A STRATEGY AND RESULTS FRAMEWORK

2.1 How research contributes to delivering development outcomes

58. The development of the CGIAR was based on autonomous research institutes organized around specific research mandates, essentially in the areas of Natural Resource Management (NRM), commodities and ecoregions. Each Center was accountable for impact in the scope of the research outputs produced within its research mandate, and as was described above, the Centers have had impact on these development outcomes. However, given the complexity of achieving impact in areas still unreached by Center research, the SRF will argue that development outcomes can better be achieved at the CGIAR system level with a tighter alignment of activities across the Centers around these development outcomes. This idea is also central to the evolving framework of agricultural research for development (AR4D), within which the current reform process is cast. However, while impact of CGIAR research has been demonstrated ex-post, as seen in Chapter 1, it is a different question to articulate an ex-ante vision of how research should best be organized at the CGIAR system level in order to achieve a significantly broad range of quite different development outcomes and at the same time be evaluated in terms of progress toward achieving these objectives. The notional framework for doing this has been developed within the evaluation field as "managing for results" and the analytical device is the strategic results framework.

59. Managing for results is a business concept that has been taken up by the public sector in a number of realms, including international development.[8] The Independent Review of the CGIAR System,[9] completed in 2008, highlighted the advantages of this approach for the CGIAR. The idea is to manage and implement investments in a way that focuses on the results desired and uses information on progress towards these results to improve decision-making. According to the review, managing for results is "a coherent framework for strategic planning, management, and communications based on continuous learning and accountability." Such an approach requires:

    - a results-oriented strategy that sets directions and outcomes;
    - management decisions and resource allocations that align with strategic outcomes;
    - program performance indicators that target clients and beneficiaries and measure impro vements in the livelihoods of beneficiaries; and

8 The Paris Declaration on Aid Effectiveness, for example, has established managing for results as one of five mutually reinforcing pillars. Results-based management emerged from initiatives of CIDA and others.

9 CGIAR Independent Review Panel, "Bringing Together the Best of Science and the Best of Development," Independent Review of the CGIAR System, Report to the Executive Council (Washington, DC, 2008).

- indicators that are used as signals to motivate staff and provide a base for learning and improving.

60. For the SRF, research will be directed at results which are defined as System Level Outcomes (SLOs). These represent a set of international development outcomes which can be enhanced by improvements in agriculture and which constitute the targets of CGIAR research at the system level through the concerted action of CGIAR centers and their partners. The ability of the agricultural sector to contribute to such broad range of development outcomes is unique and exemplifies as the multi-functionality of the agricultural sector in the development process, especially in the early stages of development.

61. System Level Outcomes will be critical to the design of the research which the CGIAR system will undertake, but research will not itself deliver development outcomes. Rather, research will make a specific contribution to achieving these outcomes, as illustrated in Table 2.1, and described below.

TABLE 2.1. RELATIONSHIP BETWEEN SYSTEM LEVEL OUTCOMES AND RESEARCH

Level of activity	What may be achieved at that level	Role of CGIAR with appropriate partners
Development impact	Changes in well-being, improved livelihoods, availability of ecosystem services, opportunities, choices, reduced risks	
System Level Outcomes	Change in action/behavior of potential beneficiaries Change in productivity Change in equity/ empowerment Change in market condition Change in investments Change in security of assets/ habitats	CGIAR researchers are engaged with institutions which are scaling up research outcomes to contribute to System Level Outcomes
Research Outcomes	Recognition/appreciation of research knowledge Use of knowledge by partners Mobilization of new capacity and resources Extension of technology/ materials Change in policy environment	CGIAR researchers are co-responsible with partners for generating Research Outcomes
Research Outputs	Change in knowledge Change in capacity Change in technology Change in materials Change in policy options Change in awareness/ understanding	CGIAR researchers are accountable for generating Research Outputs

62. Research by CGIAR centers will generate Research Outputs, i.e., international public goods, for instance in the form of new understanding or technology. The CGIAR will be accountable, with its research partners, for the delivery and quality of these Research Outputs, both in relation to scientific standards and their potential for contributing to SLOs. These outputs, most often in some combination of technological, management and institutional innovations, will then be applied with partners who may include potential users. Research Outcomes will include the performance of these outputs when applied locally and their degree of uptake. The CGIAR will be jointly responsible with its

partners for delivering these outcomes. For positive Research Outcomes to have a developmental impact, they then need to be scaled up and applied widely across beneficiary communities. This process will generate the intended System Level Outcomes. CGIAR researchers may not be directly involved in any research at this level, but they will be engaged with the development partners, public or private, who are responsible for this scaling up. This means, specifically, that they will have involved these partners in the design of the research and the processes that have led through Research Outputs and Research Outcomes, so as to ensure that results are suitable for upscaling and have the best chance of delivering System Level Outcomes. These different components or stages in the R&D process will be identified and described in the rest of Chapter 2 and in Chapter 3. Table 2.2 illustrates how the different elements described in the SRF will contribute to the results framework.

TABLE 2.2. ELEMENTS OF THE SRF

Results Framework	CGIAR R&D continuum	Partnerships
Research outputs	Strategic and applied research	Advanced Research Institutions and strong NARS
Research outcomes	Piloting and innovation platforms	Regional, national research and development institutions
System Level Outcomes	Scaling up and out	Development partners

2.2 System Level Outcomes for agricultural research

63. The Millennium Development Goals represent a unique international consensus on priorities for investment in international development for poverty reduction. They reveal the range of areas where agriculture makes a critical contribution to development. The fact that agricultural development is not presented as an explicit MDG goal or target reflects to some extent the low priority given by governments to agriculture at the time of the MDGs formulation, a situation that has now changed dramatically, as described in Chapter 1. However, it also reflects the way in which agriculture is relatively unique in being able to impact on a range of very different development outcomes.

64. The MDGs provide a framework for identifying this multi-functionality and the set of development outcomes to which agricultural improvement can contribute. They have been the basis on which the CGIAR vision, presented in Chapter 1, was developed. MDG1 provides a target for poverty reduction, an important component of which, for many poor communities, will be growth in income from agriculture. It also presents a target on hunger reduction which will be strongly related to the achievement of food security, both at the household

and global level. The MDG1 hunger target is also closely related to health and the provision of nutritious food and reduction of agriculturally-related disease at critical stages of maternal and child development. In this way, healthy diets contribute to other MDG targets on education, maternal and child health and infectious disease. MDG7 targets environmentally sustainable policies, many of which will be directed at agriculture in its broadest sense, which involves the potential threat to the conservation of forests, water resources, fisheries and biodiversity and its role as a major cause of greenhouse gas emissions, but also as the potential for innovation leading to the sustainable intensification of food production and climate change mitigation. Finally, with its targets on liberalizing trade for development and focus on least developed and landlocked states, most of which will be agrarian, MDG8 will be particularly influenced by agricultural development.

65. These agricultural links to international development goals, as defined by the MDGs, can be developed into four distinctly targeted but closely interacting System Level Outcomes (SLOs) for international agricultural research as carried out by the CGIAR.

66. The contribution of agriculture to poverty reduction depends on a country's economic structure, or what the WDR 2008 termed the three worlds of agriculture, namely agrarian economies; transitional economies, where overall economic growth is increasingly dependent on manufacturing and services; and urbanized economies. This contribution requires different strategies across these three worlds, namely smallholder led growth in agrarian economies , integration of lagging rural areas into expanding urban markets in transitional countries, and safety nets in urbanized economies

67. Within the poverty focus of CGIAR research, there is a particular need to address agrarian economies, where agricultural growth will be a key contributor to reducing rural poverty. But there is also a need to address agricultural growth in transitional and even urbanized economies where poverty persists, and where there are also the greatest current opportunities to increase food production through sustainable intensification of lagging agricultural areas, and thereby to contribute to reducing food prices and increasing food security for both the urban and rural poor worldwide. For this reason, reducing rural poverty and increasing food security are defined as distinct, but related, development outcomes for agricultural research. Reducing hunger, as the other target of MDG1, is closely related to reducing rural poverty and increasing food security, but improving access to affordable food does not fully address this challenge. Improving the nutritional value of food and reducing levels of disease are also critical to reducing hunger, and they identify a distinct development outcome for agricultural research. Finally, agricultural growth will draw on natural resources which are increasingly degraded, such as water and soils. Agricultural research must make a contribution to environmental sustainability, so that ecosystem services are sufficient to meet both agricultural and other human needs, and this identifies our fourth System Level Outcome for agricultural research. Each of these four System Level Outcomes is described in more detail below.

Reducing rural poverty

68. Approximately 1.4 billion people continue to live in extreme poverty, surviving on less than US$1.25 a day. About 70% of these live in rural areas and 80% of these rural households depend to some extent on agriculture for their livelihoods; the poorest households tend to be the most dependent on farming. While rural poverty is a complex problem, investment in agricultural growth has been shown to be a particularly effective contributor to reducing rural poverty rates, particularly in the early stages of rural development (WDR 2008, IFAD 2011)[10]. However, this recognition comes after a couple of decades of underinvestment in agriculture and a poverty reduction strategic planning (PRSP) process where rural development was closer aligned with rural investments in education and health, rather than clear strategies for generating equitable agricultural growth.

69. As a System Level Outcome, reducing rural poverty will therefore require research to develop and validate specific agricultural investments appropriate to different agrarian economies. This research will probably involve a range of integrated components, including improving varieties of crops and livestock, restoration of degraded natural resources and improved value chains and markets. Research outcomes will be a capacity for sustainable intensification of production with improved stability of yield and resilience to shocks. Measurable elements of this system level outcome will include improved household food security, increased stability of production and resilience to shocks and increased income from farm and non-farm activities, permitting investment in health, education and other poverty-reducing activities.

Increasing food security

70. Food price increases in recent years have shown that access by the poor to affordable food is increasingly linked to global food supply. The food price spike of 2007-2008 is estimated to have pushed an additional 100 million people into food insecurity, increasing the total to an estimated 1,020 million by 2009 (FAO/RLC, 2009). This, along with population growth, slows achievement of MDG targets on poverty and hunger, with the number of under-nourished people worldwide actually increasing over the tenure of the MDGs to date.

71. Improving food security for the urban and rural poor on a global scale will require steady growth in productivity of agricultural systems, particularly for staple cereals, and a special focus on sustainable intensification of existing agricultural land in potential "breadbasket" areas of the tropics and subtropics. This increase in global food security must be achieved in these regions in spite of threats to water supplies, declining soil fertility, recent and probably continuing climatic shocks to production, and declining growth rates in cereal yields.

72. As a System Level Outcome, increasing food security will therefore require research to develop and validate agricultural investments appropriate to high

10 For references: IFAD (2010). Rural Poverty Report. New Realities, New Challenges: New Opportunities for Tomorrow's Generation. International Fund for Agricultural Development, Rome, Italy

potential areas, including research on improvement of crop productivity, a sustainable provision of natural resources which anticipates climate change, and improvements in policies on markets and trade which help to reduce and stabilize prices. Measurable elements of this System Level Outcome will include changing levels of production, price and access to affordable food by the urban and rural poor.

Improving nutrition and health

73. Agriculture, nutrition and health are closely linked. While food security, at the household and national level, provides a foundation for agriculture's contribution to health, it is not alone sufficient. Achieving MDG1's target "To halve the proportion of people who suffer from hunger by 2015" will depend not only on calorie sufficiency but also on dietary quality. Two billion people suffer from a diet insufficient in micronutrients essential for healthy growth. Good nutrition and health is also linked to food safety and the prevention of agriculturally associated zoonotic, water- and food-borne diseases. Improving nutrition and reducing food contamination and disease will not only address MDG1's hunger target, but will also contribute to the achievement of other MDGs, by improving maternal health, reducing child mortality and the impact of infectious diseases[11], and improving educational attainment[12], making an overall contribution to improved economic productivity.

74. The immediate causes of undernutrition, by which we mean the lack of food energy and nutrients, including essential micronutrients, include inadequate dietary intake and disease. Adequate household dietary intake including key micronutrients is particularly important for women and children and will be influenced by gender relationships in the control of food production and consumption as well as opportunities for local agricultural diversification.

75. As a System Level Outcome, therefore, improving nutrition and health for the poor will require research to develop a portfolio of agricultural interventions for increasing the availability and affordability of a range of nutritious foods, by exploiting local biodiversity, improving the nutritional quality of staples and increasing access to animal products, vegetables and fruit. It will also require, more broadly, the collaboration of agriculture, nutrition and health specialist and development of policies which achieve agriculture and health synergies. Measurement of these outcomes will involve not only metrics associated with healthy growth, particularly in children, but also evaluation of dietary intake, nutrient uptake and consequent health effects.

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11 Black, R. E., Allen, L. H., Bhutta, Z. A., Caulfield, L. E., de Onis, M., Ezzati, M., Mathers, C. and Rivera, J. 2008 Maternal and child undernutrition: global and regional exposures and health consequences. Lancet 371, 243-260.

12 Pridmore, P, 2007. The impact of health on education access and achievement: a cross-national review of the research evidence. CREATE Pathways to Access Research Monograph, Number 2 London, Falmer: CREATE 2007

Sustainable management of natural resources

76. Ensuring environmental sustainability is a key element of international consensus around Millennium Development Goals, reflected in MDG7's target to integrate sustainability principles into national policies and programs related to reversing decline in forests, fisheries and biodiversity, and reducing growth in water usage and CO_2 emissions. Indeed, this international consensus has grown stronger in the decade since the formulation of the MDGs as a result of our growing understanding of the likely environmental impacts of anthropogenic climate change.

77. More than any other human activity, agriculture has impacted on environmental sustainability and ecosystem services, particularly through deforestation, loss of biodiversity, water scarcity and degradation of soils from unsustainable farming and grazing. Further, we now understand that the agricultural sector is a significant contributor to greenhouse gas production, and that agriculture will be the human activity most affected by climate change, with those effects concentrated on poorer regions of the world. Therefore, as a global environmental priority, and to secure and protect the specific role of agriculture in addressing MDGs on poverty and hunger, there is a need to make agricultural production more environmentally sustainable.

78. Specific action is needed for increasing use efficiency of water and synthetic fertilizers without decreasing agricultural productivity, and to improve the quality of degraded landscapes suitable for agriculture. This involves both changes in agricultural production methods and conservation of natural resources, like trees, forests and fisheries, which provide important ecosystem goods and services. Agriculture's contribution to climate change involves different actions focused on reducing greenhouse gas production and carbon capture.

79. As a System Level Outcome, sustainable management of natural resources will therefore require research to develop and validate investments in more efficient and sustainable use of specific natural resources for agriculture, as well as investments in reducing the contribution of agriculture to climate change. Research on climate change as it affects and is affected by agriculture and forests will be important to understanding how these investments need to be made. Research outcomes will include effective methods integrated into productive farming systems which exploit opportunities for climate change adaptation and mitigation, and measurable elements of the System Level Outcome may be related to changes in resource use per unit of production, restoration and conservation of ecosystem services or reduced impacts of climatic change and shocks.

80. There are clear associations between these four system level outcomes. For instance, improved food security, as reflected in lower global food prices will contribute to a reduction in rural poverty and improved nutrition. But there are also important differences in the way in which these four outcomes contribute to the broader development agenda influenced by agriculture, which reflects differences in agricultural systems and economies. For instance, a strategic focus on national food security is usually not congruent with strategies to reduce

rural poverty, given that the bulk of the rural poor reside outside the principal bread basket areas and large parts of the rice bowls have moved to small scale mechanization. More importantly the portfolio of research outputs and outcomes that contribute to these different System Level Outcomes are quite different, and this is reflected in the different ways by which their effectiveness will be measured. Therefore, these System Level Outcomes represent a set of distinctive, yet interacting, targets for the contribution of agricultural research.

81. Furthermore there is a broad body of evidence that scientific research, including research in areas of natural and social science, can make substantial contributions to international development, and specifically to achieving the targets of the MDGs (Conway and Waage, 2010). For agricultural research, supporting evidence has been generated through ex-post evaluation of the impact of research to generate international public goods[13]. The CGIAR has played a major role both in the research evaluated and in its evaluation. Some of this evidence is presented in Annex I.

13 International Public Goods may be defined as "scientific and technical knowledge, agricultural research products and services or research capacities to respond to and anticipate demand, that are essential to improving agricultural productivity and environmental sustainability in the poor regions of the world" (CGIAR synthesis report page 16). These goods may find global application, contributing to outcomes in many countries, as can arise through commodity-focused research to improve crop or livestock varieties. Alternatively, they may contribute to more local outcomes, adapted with research partners to specific agricultural systems, as can often arise through participatory breeding programs or with research on policy options or natural resource management.

CHAPTER 3. ORGANIZING RESEARCH TO DELIVER SYSTEM LEVEL OUTCOMES

82. The main objective of the new CGIAR is that of aligning the research of its 15 autonomous Centers to achieve an impact on the four CGIAR system level outcomes (SLOs) of reduction of rural poverty, food security increase, improvement of nutrition and health, and sustainable management of natural resources. Achieving this vision requires exploiting core competencies across the CGIAR system and better aligning research programs and downstream institutional arrangements around explicit strategies designed to impact on the four system level outcomes. This marks a fundamental shift from individual Centers being responsible for impact—arising essentially from the research outputs developed around particular mandates—to the CG system itself being responsible for impact. The CGIAR Research Program (CRP) concept has been designed as an instrument to achieve this greater alignment of research outputs with system level outcomes by exploiting synergies across center core competencies.

83. The logic of how research produces an impact on development outcomes is deeply rooted in the AR4D perspective. **CRPs organized around development objectives start from the development outcome and organize backwards through the impact pathway, rather than identifying research outputs produced within particular mandates and specifying illustrative impact pathways that potentially contribute to all of the system level outcomes**. The SRF recognizes that there is an inherent complexity in having impact on outcomes like rural poverty and that this requires a greater scope in research outputs and tighter coupling of these outputs into research outcomes targeted on SLOs. This will require, at least, effective targeting, often within regional strategies, appropriate technology design, and innovative institutional arrangements. This chapter will firstly illustrate, without being prescriptive, how a strategic approach to achieving system level outcomes sets key parameters on the organization and design of research across the system. Secondly, the chapter will outline how the core competencies across the CGIAR system will be more effectively organized to contribute to those SLOs and what additional core competencies and support functions are needed to meet them. Finally, the chapter will set out the role, function, and design attributes of the CRPs as the principal mechanism for achieving this alignment between core competencies and SLOs. As such, this chapter will provide the conceptual core to the design and implementation of the SRF.

3.1 A Strategic Approach to Impact on the System Level Outcomes

84. Aligning research around impacts on SLOs requires a strategy on how that will be done. In particular, a strategic approach to have impacts on the SLOs at the level of the CGIAR will set parameters on what research is done at each stage in the R&D continuum and how research outputs are translated into research outcomes. In

doing so, it recognizes that there are often complementarities and trade-offs in achieving eventual impact on the four SLOs - for example, between rural poverty and national food security as described in Chapter 2 - but it also recognizes that all four require inherently different strategies given that the CGIAR utilizes only science, research and new knowledge as the key driver of change in these SLOs. At the same time there is an inherent unpredictability in matching research investments with impact. Scientific discovery is itself a stochastic process (Social Science Stripe Review, p. 32) and the translation of research outputs into longer term impacts is significantly unpredictable. Strategic planning around SLOs is designed to reduce that uncertainty, but not eliminate it. Moreover, evaluation focuses on near term, direct impacts, realizing that these "do not measure the indirect impacts and will mismeasure distribution effects" (Social Science Stripe Review, p. 34). Introducing trade-offs between SLOs into research design adds greater complexity and unpredictability.

85. This chapter provides a skeleton structure for strategies that would align research design, integration of research outputs, targets for application of research and institutional partnerships around specific SLOs. In particular, this more strategic approach to achieving SLOs focuses on how research derived from quite different core competencies is linked, what new areas of research and associated competencies are needed to better address SLOs, and the need for better definition of partnerships and differentiation of those partnerships along the R&D continuum, especially in the areas of co-responsibility in producing research outcomes and engagement with development partners.

3.1.1 Reducing Rural Poverty

86. *a. Problem* Structure: In many respects the central objective of research for agricultural development is its impact on rural poverty. On the one hand, the evidence is clear that investment in agriculture has the greatest potential for reducing rural poverty (World Bank, 2007). These macro-level impacts are attributable to growth in the agricultural sector and the income and employment opportunities that are produced. In turn, although growth pathways vary, a significant part of that growth can be attributed to investment in agricultural research. However, as Lele et al. (2010) point out, this understanding of agricultural growth and poverty reduction does not match the understanding of the micro-foundations of lifting poor households out of poverty, i.e., the type of direct investments and programs that underlie rural development strategies

87. At the same time, it is recognized that new technologies by themselves are a very blunt instrument for reducing rural poverty. The factors that constrain widespread adoption of new technology are exactly those that are closely associated with rural poverty, namely poor education, limited land resources, lack of access to input and output markets, and marginal agroclimatic conditions. Moreover, poor households must devote a significant part of their labor to casual rural employment just to meet minimal food and health requirements. Single technologies, assuming they are accessible to poor households, will have

some impact but often are not sufficient to lift them out of poverty. Multiple and interacting constraints imply the need for multiple interventions with the objective that a subset of critical interventions release further investment by poor households as a pathway out of poverty. Such complementary interventions to productivity enhancing technologies include organizational innovations for access to input and output markets, insurance, microcredit, enhanced property rights, especially for women, and safety nets.

88. *b. Target Areas:* Approaches to reducing rural poverty must be contextualized and targeted to those areas where there will be maximum impact. For the CGIAR, the locus of rural poverty is principally in Sub-Saharan Africa and South Asia. In South Asia, rural poverty tends to be concentrated in semi-arid areas, in tribal areas, and in lagging economic areas such as eastern India. The spatial distribution of poverty in turn defines the context and options that might be pursued to reduce poverty levels and rates. In Sub-Saharan Africa, the locus of poverty is in rural areas and poverty is a more widely distributed or generalized phenomenon with higher rates than in South Asia. Yet, poverty rates tend to be higher in arid and semi-arid areas, with pastoral areas having particularly high rates. A rural poverty gradient has been posited across the agro ecological zones of West Africa from the Sahel to the humid coastal zone, where large urban areas and associated market opportunities also tend to cluster. In East and southern Africa, the density of rural poor is highest in the high population density, high potential areas with poor market access, such as exist in the Great Lakes region or the southern part of Malawi. This depth and distribution of rural poverty often leads to arguments that agricultural growth based on commercializing smallholder production is essential to alleviate poverty and that such growth must start in the bread-basket areas, build on market-based approaches and focus initially on those smallholders that are better resourced. The approach to rural poverty would then be to focus on mechanisms to include poor households in smallholder-based growth strategies through institutional innovations such as farmer associations or marketing cooperatives.

89. *c. Strategic Approach:* The CGIAR's core competency is agricultural research, and its principal outputs are focused on increasing agricultural productivity. However, a productivity focus is not sufficient to achieve large impacts on rural poverty, unless progress can also be made on the contextual determinants of rural poverty, particularly access to output and input markets, credit and insurance, and other areas of service delivery; that is, the necessary and sufficient conditions for smallholder-led agricultural growth which in turn provide opportunities for poor households to emerge from poverty. Understanding how to increase agricultural production and productivity in areas of high rural poverty, with all of their market, institutional and agro climatic constraints is the initial priority, which can be augmented by organizational and methodological innovations that ensure sufficient participation by the poor, particularly women, in that growth process. In such contexts root crops, dryland cereals, grain legumes, agroforestry, and ruminant livestock are important components of diversified farming systems. Crop and soil management become essential to increasing productivity and exploiting any yield gains in improved varieties. At

the same time, innovations that compensate for incomplete or non-integrated markets will be critical to providing the incentives for farmer adoption. A more strategic approach by the CGIAR to rural poverty could involve the following elements: (1) setting the approach within a regional strategy; (2) understanding the interaction between innovations in productivity, NRM, market access and policy on rural poverty; (3) piloting novel methodologies that will improve inclusiveness of gender and ethnicity, often through farmer associations or novel service delivery programs; and (4) a comparative research program on the micro-foundations of rural poverty.

90. *d. Institutional Arrangements:* The institutional arrangements have two principal dimensions. Firstly, research partnerships will primarily involve national agricultural research institutes, most often with significant constraints. In the context of Sub-Saharan Africa, sub-regional research organizations, which used to be the focal point for the research networks of Centers, have been changing their program structures and Center interaction has declined. There is a potential for better program alignment between the CGIAR as a system and the sub regional organizations, certainly with lower transaction costs as compared to working with a host of individual centers. Secondly, research on organizational innovations to achieve impact on rural poverty will involve working with a cross-section of government agencies, service provides, and farmer associations. Programs combining work on institutional innovations with development of improved production systems will often involve innovation platforms, as is being tested within the Sub-Saharan Africa challenge program.

91. *e. Impact Targets and Measures:* The logic of the CGIAR's monitoring of impacts on rural poverty shifts from a focus on understanding the impact of a particular technology on the incomes of the rural poor to understanding the complex of factors required to significantly reduce rural poverty rates on some level. Because women in Sub-Saharan Africa and South Asia are disproportionately below the poverty line and at the same time are central to decision making in agricultural households, understanding how women can improve control over income streams arising from technological innovations will be a significant component of the impact monitoring. The focus shifts from ex-post impact assessment to understanding the pathways out of poverty, most often through well-constructed panel surveys, but done within the context of methodological approaches that facilitate agrarian change. The intent is thus not just to document impacts on rural poverty but to understand the processes by which these occur. Accountability for rural poverty outcomes would thus be defined at a benchmark site or pilot scale. In the case of rural poverty outcomes, it is particularly important to specify impact pathways and the articulation of research outputs within pilot sites that test the potential for impact on poverty outcomes

3.1.2 Improving Food Security

92. *a. Problem Structure:* There is increasing evidence of a fundamental structural change in the global balance between the demand for and the supply of food, and this is increasingly reflected in rising world food prices, as demonstrated by the spike in world prices in 2008 and the fact that world prices have just passed that level again (FAOs Price Index). Over the past five decades growth in world food production has been dependent primarily on increasing crop yields, firstly in the developed world and then with the Green Revolution in the developing world. Much of this increase has been due to expanding irrigation and fertilizer use complemented by improved genetic potential (Fischer, et al, 2010) as well as expansion of double and triple cropping in irrigated rice production systems. Over the last decade there has been evidence of a clear slowing in cereal yield growth, particularly of rice and wheat, a leveling in fertilizer use, and constraints on expansion in water use. Given these trends, prices of wheat, rice and maize are expected to rise by 91%, 60%, and 97% respectively by 2050 (Rosegrant, et al, 2008). Stability in world food prices and the unfettered ability to secure food imports are increasingly important policy objectives, especially for importing countries like China and India. Moreover, given globalization in agricultural markets, stable prices in this sector are also critical for the welfare of the growing ranks of the urban poor as well as to reduce pressure on tropical deforestation in countries like Brazil. Sustaining yield growth of the three principal cereals under increasing resource constraints will be essential to meeting growing world food demand over the next four decades.

93. At the same time, there are regions where meeting national and regional food security is becoming increasingly vulnerable due to increasing competition for resources, greater weather variability, and rising domestic demand, particularly Sub-Saharan Africa, West Asia and North Africa, and the non-irrigated areas of South Asia. Herrero, et al. (2010) argue that extensive crop-livestock systems in these regions have been neglected in the past and at the same time offer the most potential for increasing agricultural production and, in turn, meeting national and regional food security. More diversified systems and staple food sectors, such as the root and cereal crop systems of coastal West Africa have cushioned these economies from the impacts of rising world prices. Specialized intensification in the irrigated areas and diversified system intensification in rainfed dependent regions suggest two necessary paths to achieving global and regional food security.

94. *b. Target Areas:* Ensuring global food security has a different target area focus than food security in vulnerable regions. Cassman (1999) has noted that meeting world food needs by 2050 will depend on continued intensification in four critical production systems, "(*i*) irrigated annual double- and triple-crop continuous rice systems in the tropical and subtropical lowlands of Asia, which account for about 25% of global rice production, (*ii*) irrigated annual rice-wheat double-crop system, which is the primary cereal production system in northern India, Pakistan, Nepal, and southern China, (*iii*) temperate maize-based, rain-fed cropping systems of the North American plains, which contribute more than 40% of global maize

supply, and (*iv*) the favorable rain-fed wheat systems of northwest and central Europe, which account for more than 20% of global wheat supply;" to that can be added the increasing importance of Latin American maize production from the "cerrados" and pampas regions. Two of these are of particular importance to the CGIAR. Production trends in these regions will have major implications on the ability to meet growth in global food demand. At the same time, the irrigated areas of Asia, which are diversifying into higher value commodities like horticulture produce, and major river deltas of South, East, and Southeast Asia, which form the principal rice bowls for the globe, are increasingly susceptible to rising sea levels from climate change. Sustainable intensification of cereal production in the principal breadbaskets of the world will be critical to balancing world food supplies.

95. Regional food security in Sub-Saharan Africa, WANA, and the rainfed areas of South Asia is important because of its close link to both nutrition and rural poverty. However, while national food security is an important determinant of these two SLOs, it is not sufficient and does not guarantee impact on either rural poverty or undernutrition. Thus, in East and Southern Africa 50% of maize supplies are accounted for by only 1 to 3% of the total rural farm population, while the bottom 15-20% of small-scale farm households are approaching landlessness, with less than 0.5 hectares and reliance on net purchases of maize (Jayne, et al, 2006). For organizations like the Alliance for a Green Revolution in Africa, a focus on breadbasket areas in each country is seen as both a key to national food security and to igniting agricultural growth.

96. *c. Strategic Approach:* Methods for meeting the challenge of sustainably increasing cereal yields in the world's breadbaskets will vary by crop and production system. Fisher, et al. (2010) argue that there is still opportunity for exploiting the gap between current farm yields and potential yields on experimental stations in most regions, including continued maintenance research on disease and pest resistance and greater precision in matching agronomic practices and varieties to specific farmer conditions. However, most of the irrigated food grain breadbasket areas are already intensively farmed, and sustainable intensification is a critical issue in these areas due to increasing competition for water to fuel productivity gains, particularly with urban water usage (or depletion of groundwater); soil quality has also been degraded and there is often declining nutrient use efficiency, which in turn results in nutrient fluxes into aquatic ecosystems. Genetic improvement will be a larger source of yield improvement than in the past but complemented by maintenance of soil quality and increased precision in the supply and use of water and nutrient resources. Molecular breeding will allow more effective combining of key traits and targeting to specific production ecologies, including greater resilience to yield limiting factors like drought and heat stress. The possibilities for increasing the yield potential of the crop, through genetic engineering such as the C_4 pathway in rice, deserve investment, but the probabilities of success remain largely undefined. Sustainable intensification within the irrigated breadbasket areas will combine greater precision in genetic improvement with greater

resource use efficiencies, particularly the more effective management of soil quality and water use.

97. The breadbaskets of sub-Saharan Africa rely on rainfed agriculture and particularly crop-livestock-tree systems. Sustainable intensification in these systems requires quite different strategies, with more of a focus on synergies between system components, improved management of the natural resource base, and crop and animal breeding with focus on dual purpose varieties. Biomass is becoming an increasingly valuable and therefore scarce resource in these systems, with trade-offs between its use in ruminant production, ecosystem services, particularly soil health, and potentially second generation biofuels. Meeting national and regional food security in these regions will require more diversified approaches, including improved access to input and output markets.

98. *d. Institutional Arrangements:* The institutional context within which this research is done is rapidly changing, due in part to the large investments in research capacity by China, India and Brazil and in part to the increasing research capacity of the private sector, especially in hybrid maize, rice and horticulture. Since private sector companies are the principal delivery mechanism for hybrid varieties in Asia and Latin America, there will be a need to continually define both institutional arrangements between seed companies and the CGIAR, with IPR and contractual arrangements being critical issues. Some of the CGIAR's genetic research will move significantly upstream, especially in ensuring a broad base of germplasm and incorporating traits that address other SLOs like improved nutrition and natural resource use. The CGIAR will continue to breed for crops where hybrid production is limited, particularly wheat and rice outside irrigated ecologies. At the same time, Brazil, China and India invest far more in these research areas than the CGIAR and the role of the CGIAR in linking this capacity through networks to small and medium sized countries will remain essential. These two areas of institutional arrangements are very different from the more traditional research partnerships with NARS in small and medium sized developing countries, which is more typical of regions such as Sub-Saharan Africa and WANA. Region, size of country, and research strategy as defined by intensification pathway will result in an increasing differentiation of institutional partnerships.

99. *e. Impact Targets and Measures:* Although the problem structure is framed in terms of regional and global grain supplies and prices, the impact targets are defined in terms of sustainable intensification in breadbasket regions, with quite different pathways between irrigated and rainfed systems. Yield increases will be an important indicator but changes in total factor productivity, including changes in resource use efficiency, will give a clearer indication of yield gains in relation to resource use. Changes in resource quality, particularly as to soil and water, would in turn be better sustainability indicators. Cost-effective monitoring of sustainable intensification at scale is a research area in itself, which may involve potential trade-offs between components such as nutrient pollution of water supplies. Development of methodologies for measuring

and monitoring sustainable intensification would be a part of tracking progress toward this strategic outcome.

3.1.3 Improving nutrition and health

100. *a. Problem Structure:* Hunger and poor nutrition, with their profound impacts on health status over the lifetime, are closely linked to poverty and the many factors that may contribute to insufficient access to high quality and safe food. Because the poor spend the major portion of their income on food, the price of and access to the principal food staples—the cheapest source of calories—is a major determinant of insufficient calorie consumption. Hence, there is also close link between national food security, staple food prices, and calorie undernutrition. But insufficient calorie intake is only a part of the undernutrition problem, as food staples may lack key micronutrients which are needed by vulnerable groups like women, infants and children, and which are usually supplied in diverse diets through foods like vegetables, fruits and animal products. Insufficient consumption of micronutrient-rich foods by poor and vulnerable groups is a problem of access and affordability, but also one of behavior and education. Besides its potential to influence nutrition, agriculture has other effects on the health of the poor, through water- and food-borne and zoonotic disease, the effect of which is likely to be particularly severe on the rural poor.

101. *b. Target Areas:* The locus of child undernutrition is in Sub-Saharan Africa and South Asia, with rates declining in South Asia with economic growth but with absolute numbers still the highest. In these areas, undernutrition is concentrated in rural areas and closely correlated with low levels of women's education. The particular nutrient deficiency can vary with agro-ecology and certainly with food sources in the local farming system. Identification of critical vulnerable populations is dependent on household surveys and close links to the nutrition community. Over coming decades, the focus on undernutrition will shift to the urban poor, and the very different problem of calorie-rich but nutrient-poor diets which contribute to chronic cardiovascular and other diseases. While this problem is currently less relevant to the CGIAR's agricultural approach to undernutrition, new research should be developed with a mind to the potential to improve urban as well as rural diets.

102. *c. Strategic Approach:* The strategy is built around designing effective means of delivering nutrient-rich foods to vulnerable groups, particularly those nutrients essential to growth and development of children. Defining those populations and nutrients is critical to cost-effective targeting of research interventions. These may range from increasing the nutritional value and safety of relatively more available, staple foods, e.g., through plant breeding and biofortification, to increasing production and consumption of foods rich in micronutrients, particularly animal products, vegetables and fruit, through local agricultural diversification, school feeding programs and improved market chains. There is a need for more evidence on where and how local improvements in agriculture lead to reduced undernutrition. Local programs of food supplementation and

fortification have a good record of addressing undernutrition, but are rarely linked to local agricultural production which could present opportunities for agricultural improvement and sustained access to nutritional foods. Because of the critical importance of women in child nutrition, understanding and enhancing their role in the production and distribution of food at the household level must be an essential part of any strategy to reduce undernutrition.

103. A strategic approach to improving nutrition could therefore involve commodity and farming system research, integrated with innovations in delivery systems which favor vulnerable groups. There would be a particular need to include research skills and methods from nutrition and health disciplines.

104. With respect to broader interactions between agriculture and the health of the poor, health risks such as zoonotic pathogens and plant-associated aflatoxins can be reduced by improved methods of food production, storage and processing. Investments are needed in development of food value chains that ensure food safety for the poor.

105. *d. Institutional Arrangements:* The institutional links between agricultural research, nutrition and health, whether at the national level or within the CGIAR, have always been tenuous, insofar as they cross different sectors and responsible institutions. Yet they are central to agricultural strategies designed to improve nutrition and health. This applies to links at both the research level and in terms of designing delivery systems, especially in the area of food-based approaches within the nutrition community. The institutional arrangements are made more complex by the differences in capacities between South Asia and Sub-Saharan Africa and in the latter case where international NGO's have often supplemented capacity for program delivery in the nutritional area. Nutritional delivery systems have primarily been implemented through health delivery infrastructure, but the shift to food-based nutritional improvement involves delivery systems closely linked to traditional extension (or community health delivery) but with quite different skills. Whether such programs would be specific to achieving nutritional objectives or could be integrated into larger rural poverty programs is yet to be determined. With respect to diseases associated with agricultural production, there will need to be close cooperation with health researchers. Because nutrition, infection and chronic disease research represent relatively isolated disciplines within the broader health community, agricultural researchers may need to make separate institutional arrangements with these health research communities in order to achieve the necessary collaboration.

106. *e. Impact Targets and Measures:* The measurement of changes in health that derive from changes in agricultural production is complex, involving not simply changes in household access to food, but also changes in patterns of consumption and the demonstration of health effects arising from that consumption. Measurement of changes in nutritional status and establishment of nutritional outcomes require specialized methodologies that may not integrate easily with conventional evaluation of agricultural interventions, and will involve close collaboration with nutritionists. Further, measuring health effects may necessitate a long time scale and may require longitudinal tracking and sophisticated household

surveys. The costs of impact evaluation in this particular area are large and need to be factored into research work on improving undernutrition.

3.1.4 Sustainable Management of Natural Resources

107. *a. Problem Structure*: Sustainable management of natural resources has been a central objective of the CGIAR since the expansion in the number of Centers in the late 1980s. Research within the CGIAR has essentially been organized by Centers working on particular natural resources, namely water, forestry, fish, agroforestry and biodiversity, and with two Centers working on soils and savannas as part of their mandate. The objectives of NRM research within the CGIAR have evolved and broadened over time. The initial rationale for the expansion was built around the development of sustainable production systems, where research on productivity was integrated with research on NRM. This nexus between research on productivity and enhancing the provision of ecosystem services was considered to be a particular comparative advantage of the CGIAR. However, the development of an organizational framework to integrate this research proved difficult. The ecoregional programs in the late 1990's were one such initiative, especially the rice-wheat consortium in the Indo-Gangetic Plain and the Alternatives to Slash and Burn, which were the most successful platforms, but in general, the INRM framework developed in the early part of the last decade did not gain traction elsewhere in the CGIAR system.

108. Moreover, the problem structure of NRM is usually framed in terms of operation at different scales from production systems to communities to landscapes/watersheds to national policy frameworks and to global conventions. Sustainable management of natural resources such as water, forestry, grasslands, capture fisheries, and biodiversity has been framed within this hierarchy of interacting scales. This has facilitated the transition of NRM research into the areas of mitigation of climate change and the provision of ecosystem services. These are quite different objectives, and this difference hinders the specification of a clear development outcome around which to align NRM research within the CG system, which would possibly be most clearly defined in terms of the intersection between productivity and ecosystem services. However, different objectives require quite different alignment of research activities and imply different accountability frameworks, as, for example, with the interacting roles of tropical forests, livestock, and land degradation in climate change mitigation.

109. Defining boundaries and points of integration across the breadth of NRM research gives rise to a range of arguments. On the one hand, there are particular disciplines which define research in the areas of water, forestry, fisheries, rangelands, and soils. Each has a particular knowledge base, quantitative methods, and a research agenda. Also, at least for water, forestry and fisheries, there are often separate ministries in charge of management of these resources and river basin institutions that arbitrate on cross boundary issues in managing water resources in the basin. Moreover, international conventions also tend to focus on particular sectors, as, for example, the focus on forestry in the REDD

convention. All of this tends to reinforce sectoral boundaries in how NRM research is carried out, as is reflected in the mandates of the NRM Centers. There were a range of initiatives in the early part of this decade toward defining a framework for integrated natural resource management (INRM) (Science Council, 2004). However, the principal focus was on sustainable production systems. INRM was quickly displaced by a focus on landscapes as the appropriate research and management unit, partly driven by the increasing interest in provision of and payment for ecosystem services, especially the development of carbon markets. However, it remains to be seen whether managing carbon, hydrology, nutrient flows, and biodiversity within critical landscapes is possible and generates potential benefits. As with INRM, there have not been mechanisms within the CG to systematically test the approach.

110. *b. Target Areas:* Natural resources virtually by definition are universally distributed, whether water, soils, or trees. Nevertheless, effective management of these resources is conditioned by local context. This has made it difficult to target NRM research as well as to demonstrate impact at the local level. Rather, each of the NRM Centers has tended to define for a particular natural resource target areas where the resource quality is degrading, utilization rates are outstripping sustainable supply, or conversion rates of the natural ecosystem represent significant loss of ecosystem services. The comparison of the map for tropical rainforests and agroforestry demonstrates how little potential overlap there is for different domains in managing these two resources. On the other hand, there are apparent criteria that would define priority locations for more integrated approaches to improvement of ecosystem services and other higher objectives might be applied. For example, the upland areas that provide the water sheds for the Asian river deltas or the East African highlands that provide water, agricultural production, and pockets of critical biodiversity are possible examples of target areas where the interaction between ecosystem services affect the future livelihoods of the region.

111. *c. Strategic Approach:* The strategic outcome encapsulated in sustainable management of natural resources encompasses significant diversity in objectives, in problem structure, and in targeting. Is there an approach to integrated natural resource management within the CGIAR at scales higher than production systems and does this involve integrated management of ecosystem services. Currently, the dominant axis of integration is vertically across scales by natural resource. This particularly reinforces the links between policy formulation at national and global level and adaptive resource management at local levels, which in turn recognizes the sectoral focus of the policy formulation process, whether water, forests, or fisheries. This says little about relative priorities across natural resource domains, which will have a regional focus, e.g. the primacy of water in WANA and southern Africa, and could be framed in terms of the relative valuation of ecosystem services deriving from management of that particular resource.

112. A second potential axis is at the production system level. The intent of the INRM agenda of 2004 was to integrate productivity and NRM research at that

level but this did not gather any momentum over the rest of the decade. To address System Level Outcomes this work needs to proceed along two different tracks. The first is the search for increased resource use efficiency, or eco-efficient agriculture, at the intensive margin primarily in breadbasket areas, as fundamental to the work on the food security SLO. The other would focus on reversing the cycle of land degradation in areas of high rural poverty, especially in Sub-Saharan Africa, i.e., work at the more extensive margin, under conditions where input and output markets are not well developed. The trajectories for sustainable intensification and the research strategies designed around those trajectories would be quite different.

113. Finally, the growing significance of climate change reveals a need to ensure that new natural resource management strategies anticipate changes in the quality and variability of natural resources at the landscape and regional level. This, in turn, could imply a third axis of research at this higher level into climate change effects on agriculture and the adaptive response required, and *conversely* on the contributions that agriculture could make in mitigating climate change. Although carbon is the focus of much of this work at the moment, integration of water, soil, and biodiversity is critical for adaptation at the level of the agricultural sector.

114. *d. Institutional Arrangements:* Institutional arrangements in the area of NRM are as diverse as the subject matter, operate at different scales with a particular differentiation between policy and implementation, and are often such that the CGIAR is not a central actor. At the same time realization of development outcomes in sustainable management of natural resources occurs primarily at the local level. The CGIAR is one of the few institutions that can provide a bridge between the local and the global levels. Most of the NRM Centers exploit this bridging function between global, regional and sub-regional policy fora and systematically test new approaches across different local contexts, as for example ICRAF's RUPES project on payment for ecosystem services or the Alternatives to Slash and Burn program. However, this bridging function between levels tends to be specific to the particular NRM sector. An area that is more cross-sectoral is that of climate change, particularly when considering both mitigation and adaptation. CGIAR work on climate change needs to integrate the CGIAR's NRM work and link it to the evolving policy framework for both mitigation and adaptation. Here, collaboration with environmental institutions working on climate change prediction, adaptation and mitigation will be essential.

115. *e. Impact Targets and Measures:* Impact assessment within the CGIAR for NRM research is still evolving (Science Council, 2006; Waibel and Zilberman, 2007) and has primarily focused on impacts at the production system level, where the impact is measured primarily through the productivity effect and there are various attempts to value positive or negative externalities. Impacts at higher levels, for example in terms of reducing rates of deforestation, are rarely evaluated beyond adoption, e.g. adoption of CIFOR's timber certification scheme. Impacts at this level are specific to each sector and would generally be based on an evaluation of changes in the provision of ecosystem services.

Specifying targets and impacts in terms of ecosystem services, however, requires a methodology for measuring baselines and changes due to the respective intervention, which is one of the critical implementation issues in development of carbon markets. To do this will generally require a monitoring system usually linked to a modeling capability, e.g. hydrological models, and a valuation system for the ecosystem service. This is methodologically demanding and a potential area of work for the CGIAR. What will probably emerge is a dual approach, i.e. at the production system level and at the landscape scale or other higher scales of evaluating changes in ecosystem services.

3.2 Organizing Core Competencies in support of System Level Outcomes

116. Aligning research competencies at a CGIAR system level in order to achieve greater impact on SLOs in turn raises the questions of which current core competencies are necessary for this range of SLOs, what new capacities are required and how are these best organized across the CGIAR? New core competencies, increased management and governance structures within the CRPs, and improved management and support functions at the CGIAR system level introduce additional costs, which in turn raises the issue of whether these can be compensated for by improvements in research efficiency across the system.[14] The discussion of core competencies will also introduce only a highly qualitative assessment of areas of potential gain in research efficiency.

3.2.1 Current core competencies and their organization within the CGIAR

117. Currently research within the CGIAR is organized by research theme or mandate and these are of three principal types, namely commodity, NRM, or ecoregion and with one strictly policy research institute. However, there are mainly two dominant axes along which research is organized in the system, namely commodity and NRM, and the ecoregional centers essentially have had research programs divided along these two lines (see figure 3.2.1). Some, such as the World Bank's meta-evaluation (World Bank, 2003), have argued that this has been something

14 Efficiency in the agricultural research process is an elusive concept, partly because of the difficulty in defining any rigorous input-output relationship and partly because of the multidimensional nature of agricultural research that in turn influences the efficient organization of research systems. These dimensions include disciplines, agro climatic and socioeconomic variability, multiple crop, livestock and resource components, and the continuum of adaptive to basic research processes. In general the organization of agricultural research has a thematic dimension and a spatial dimension and in turn has been governed by a set of principles such as multidisciplinarity, demand driven, centralized/decentralized, and external institutional linkages. There are a range of organizational models at a national level that emphasize different elements of this multidimensional decision problem but little to guide the efficient organization of agricultural research at an international level and this lack of a dominant conceptual model should be recognized as a significant gap in undertaking any reform process.

of a fault line in the system, pulling it in two separate directions.[15] Certainly NRM and commodities represent two very different models of organizing research. The commodity programs are primarily organized around global breeding programs whose impact pathways are defined through commodity specific value chains, which in turn assume some level of development of input and output markets. NRM programs, on the other hand, focus on a particular resource, are multi-scalar linking across production systems, landscapes and national and global policy—although research at each of these scales is usually discrete and not functionally integrated—and have impact pathways primarily defined as applying adaptive management methodologies at the local level across a wide variety of contexts. Both types of research undertake policy research relevant to either the value chain or the natural resource. [16]

118. Figure 3.1 depicts the existing vertical organization of research within the CGIAR, with relatively limited interaction between research programs. That is, there are, at present, crop commodity programs, as well as livestock and fish programs, and quite different NRM programs organized around water, biodiversity, forestry, rangelands, and natural fisheries.[17] This organization raises the question of how areas of core competency are to be integrated in order to achieve an impact on the SLOs and whether there are any research efficiency gains from such integration. Neither of these organizational models offers much scope for either inter-commodity or inter-resource research integration. Moreover, impact pathways are defined independently by either value chain or management of the natural resource. The three central areas of core competency, i.e., commodities/productivity, natural resource management and policy, are explored briefly, particularly in relation to how organizational efficiency may be gained within each of these three areas.

119. *a. Productivity/Commodities:* The global scope of the CGIAR's plant breeding capacity is unmatched, although multi-national private firms will have deeper capacity in a few crops, particularly hybrid maize and increasingly hybrid rice. The CGIAR works across a range of staple food crops on which world food supply depends, and especially staple crops important in the food economies of poorer nations. The CGIAR maintains a world germplasm collection in each of these crops, which is becoming more valuable with molecular characterization. Population development is possibly the critical activity and is usually targeted

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15 The World Bank's meta-evaluation of the CGIAR put the issue as follows: "The (CGIAR) System is being pulled in two opposite directions. On the one hand, the CGIAR Centers are not conducting sufficiently coordinated research on the highly decentralized nature of NRM research, which calls for effective partnerships with NARS to produce regional and national public goods in NRM. On the other hand, the System is not sufficiently centralized to deal with advances in the biological sciences and IPRs, which call for a more unified approach to research strategies and policies."

16 In the past couple decades many if not most commodity and ecoregional centers developed NRM research programs, including watershed management, conservation agriculture, long-term research on paddy soils and paddy ecology, and integrated soil and fertility management. These research areas primarily contributed to research on important production systems.

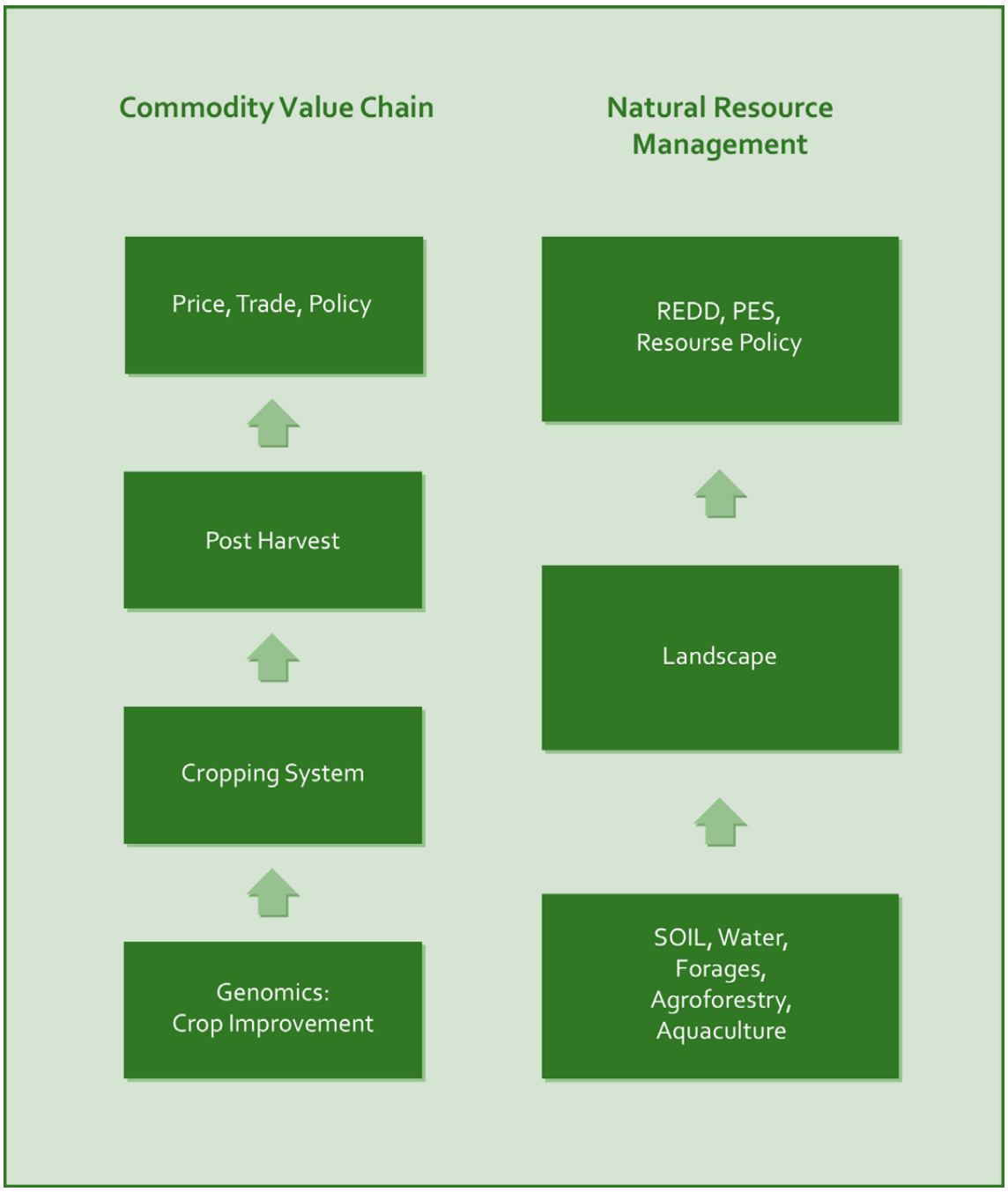
17 The exception to this general trend is that of livestock and fish which attempt to integrate commodity value chains with sustainable management of key natural resources, i.e., rangelands and wild fish stocks.

to particular regions or agroecologies and also is becoming more effective in terms of combining multiple traits through molecular breeding. Breeding of fixed varieties will depend on the capacity of national programs and will often be done collectively through breeding networks. Capacity in post-harvest research varies by crop and is particularly important for roots and tubers, although quality traits have assumed increasing importance, including nutritional traits, such as quality protein maize. Crop management research is primarily focused on areas where genetic progress is more difficult, primarily in rainfed areas and especially in Sub-Saharan Africa.

120. The organizational model for agricultural research in the post-Green Revolution period was the multi-disciplinary crop research program in which various disciplines in what would become integrated crop management were arrayed around a central breeding program. This organizational model was a reaction to the disciplinary organization found in academic institutions. One source of efficiency gains within the CGIAR reform is the integration of research in a particular commodity across different Centers, for example in rice, wheat, maize and cassava, in essence the most important food crops globally. The sources of efficiency gains would come from: a) optimization and integration of selection and testing sites; b) prioritization of research in entomology, pathology and physiology; and c) centralization of seed system and post-harvest research. Priority setting within commodity research programs is well developed, and such a framework could guide resource allocation within these critical commodities across the CGIAR system. All of these activities imply some form of coordinated management of capacities existing in different centers across the CGIAR system.

121. The organization of animal research within the CGIAR has evolved even more radically over the last four decades. In the early periods there was a range of animal research programs within the ecoregional centers and in the two livestock centers in Africa. At the same time there was a classic separation between animal disease and veterinary research, and research on animal production systems, including separate activities in forage germplasm collection and evaluation. The 1990's was a period of consolidation of livestock research into an integrated systems program including the addition of research capacity in aquatic systems with the expansion of centers. In most respects there are few additional efficiency gains to be achieved in the area of animal research in the CGIAR.

Figure 3.1: Schematic of Current Organization of Research within the CGIAR



122. The research efficiency gains from grouping different commodities into root and tuber crops, grain legumes, and dry land cereals are not as apparent. In particular, breeding remains a separate activity with usually little overlap in terms of crossing, selection, and varietal testing sites. There are probably some gains from partitioning research on integrated crop management across crops. Perhaps most importantly there are critical research areas within the commodity group which could build on a common and often specialized capacity. As examples, this would include nitrogen fixation in grain legumes, management

of vegetative propagules and post-harvest processing in root and tuber crops, and integrated research on drought and low soil fertility or on striga –in dry land cereals. The arguments for efficiency gains through grouping are based mostly on considerations of economies of scope, as well as economies of size in areas like nitrogen fixation, and more effective priority setting in allocating resources within the group.

123. Other research efficiency gains occur in research areas that are common across the commodity research programs and where coordinated management can produce such gains. Four areas stand out, namely methods for management of genetic resources, effective application of genomics and molecular tools to genetic improvement, management of intellectual property rights, and effective management and integration of data at the molecular, genotype and genotype-by-environment (GXE) levels. The latter could also be linked to a centralized capacity in weather and soils databases, as exemplified by the African Soil Information Service. These areas take advantage of significant economies of scale and require a significant level of centralization. These areas have been particularly exploited within the evolving global organization of the large crop-breeding multi-nationals. Within the current reform structure these areas may be thought of as cross-cutting platforms within the productivity/commodity theme. Thus, research efficiency gains can be achieved within particular commodity research programs, within commodity groups, and across the whole range of genetic improvement work undertaken within the CGIAR. To fully exploit the potential of the CGIAR reform within the area of genetic improvement requires improvement in management and organization at different levels where priority setting frameworks could guide investments at all other levels. The CRPs are not designed to deal with such cross-cutting issues within a particular area of competence; thus, additional mechanisms are required.

124. *b. Natural Resource Management:* Agriculture occupies almost a quarter of the terrestrial land area of the globe and consumes about 70% of water withdrawals for irrigation. Agriculture has the largest impact on the global provision of ecosystem services, either directly through its use of land and water resources or indirectly through its impacts on land use change, biodiversity, savannas and grasslands, and water quality. The CGIAR is unrivaled in having research capacity across a range of natural resource sectors, including land, water, forestry, rangelands, aquatic systems, and biodiversity, and in being able to connect research on natural resource management at the production system level with research at the landscape and national and global policy level. The world faces major trade-offs concerning how to feed itself to the middle of this century while maintaining and enhancing the provision of ecosystem services. Meanwhile the CGIAR can offer its unrivaled research capacity in the tropics and subtropics, which can be directed at the challenge of achieving sustainable intensification of agriculture, jointly with the effective management of the natural resource base in that portion of the globe where agricultural and land use change is most dynamic.

125. NRM Centers tend to be smaller in size and budget than commodity or ecoregional Centers. Institutional linkages to the larger community working on a resource are critical, defining the Center's niche in that community. Translating research and methodology development into action is the hallmark of Center strategies. Each one of them is primarily organized around and draws on the disciplinary depth of particular resource sectors. In this regard, NRM research is already quite efficiently organized within the CGIAR system. Since the inclusion of the NRM centers into the CGIAR, there have been three major initiatives attempting to achieve greater integration of agricultural and NRM research. The first was the series of workshops at the beginning of the last decade defining Integrated Natural Resource Management with its focus on integrating productivity and NRM research at the production system level (more on this below). The second initiative was the Alternatives to Slash and Burn program which focused on land use change at the forest margin, and particularly on stabilizing the rates of conversion and ensuring sustainability of agricultural systems in these areas. The third initiative is the Challenge Program on Water and Food which focuses on land and water management at basin scale in six target river basins. The latter two reflect the benefits to undertaking research at multiple scales within a research framework of comparative sites. There was more project-based work on managing the interface between agriculture and rangelands, e.g. in South American savannas, and in sustainable land and water use management in lake basins, such as Lake Victoria. All of this work reflected movement towards integrated land and water management at different scales within the context of either dynamic land use change or natural resource degradation. Such evolution would provide one possible pathway for further integration of sustainable production systems with natural resource management at higher scales.

126. The four areas where there may be further gains from joint management across Centers are in those of climate change, payment for ecosystem services, eco-efficient production systems, and a continued consolidation of a network of comparative or sentinel research sites. Climate change and production systems are considered elsewhere in this report. Payment for ecosystem services has primarily been motivated by the development of carbon markets and the potential of different land uses for carbon sequestration. However, they can equally be applied to water and to reducing nutrient fluxes into aquatic ecosystems, which in turn motivate farmer investment in land management practices where there is a lag between investment and farmer return. PES would cut across most of the NRM Centers and would require methods for measuring ecosystem services as the basis for constructing contracts for ecosystem services. In conclusion, there are multiple pathways to achieving the SLO of sustainable natural resource management, but at the moment there is little framework for effectively choosing between these pathways.

127. This last point raises the succeeding question of whether there would be gains through more effective priority setting in the NRM area. Priority setting is essentially an aggregated model of ex-ante impact assessment and has rarely, if ever, been applied in the NRM area across sectors. Methodology development in the area of ex-post impact assessment in the NRM area is noted for both its

complexity and the need to adapt the methods to the particular problem or resource. A comparative methodology across different resource sectors does not exist, much less to disaggregate and prioritize investments by different research components or problem areas. Development of such a priority setting capacity would require significant investment and would only be justified if budgets for the NRM research portfolio were especially constrained and some type of priority setting framework were deemed to aid in defining a fair allocation of resources.

128. *c. Social Science and Policy Research:* The CGIAR brings together within one institution the largest capacity in social science research on agricultural development, primarily arrayed around the topics of technological change, natural resource management, and policy. In the two former fields the CGIAR's multi-disciplinary approach to problem solving and the ability to develop long-term field research sites (often in a comparative framework across sites) has particularly defined the CGIAR's comparative advantage in this research area -see the Social Science Stripe Review-. Social science largely leads research on rural poverty within the system, and it also carries out research on undernutrition, outlook studies on global food supplies, particularly IFPRI's IMPACT model, markets and trade research, and policies supporting natural resource management. In turn, social science is also responsible for carrying out most of the research on adoption and impact, as well as for framing the strategic role of gender in the work of the CGIAR. Social science will therefore play a critical role in defining strategies to impact on system level outcomes

129. Social sciences and policy research within the CGIAR has been carried out through a combination of a specialized policy research institute and the incorporation of social science into the research programs of all the Centers. The latter is in large part a reflection of the fact that agriculture is inherently the human management of biological systems and agricultural research is inherently an interdisciplinary pursuit. At the same time the study of markets, institutions, organizational arrangements, and governance is the realm of social science and requires a range of quantitative techniques and areas of disciplinary specialization. Nevertheless, how best to organize social science research within the CGIAR has always been an area of debate, around various alternatives involving operation from a centralized location or through regional offices, distributed links between Centers around specific research areas such as NRM policy, and/or policy research networks. All of these options are relevant in considering how social science and policy research can best be organized within the CGIAR system and whether there are sources of research efficiency gains through a better organization of that research. Moreover, these issues can be addressed against the conclusions of a recent Stripe review of social science in the CGIAR system, which found a significant loss of social science capacity across the system and a declining ability to pursue cutting edge research in the area of agricultural development.

130. The CGIAR reform and the SRF process will argue that social science and policy research should be better aligned around system level outcomes, which in turn would redefine portions of the research agenda for social science in the CGIAR.

Certainly research on the micro-foundations of moving poor households out of poverty, the integration of productivity, NRM, and market interventions, institutional strengthening as well as defining regional strategies for rural poverty alleviation are relatively new research areas that require a more coordinated approach across the system, especially the development of a more systematic approach to collection of socio-economic data and panel surveys—see the section below on a support function for research methods and data comparability

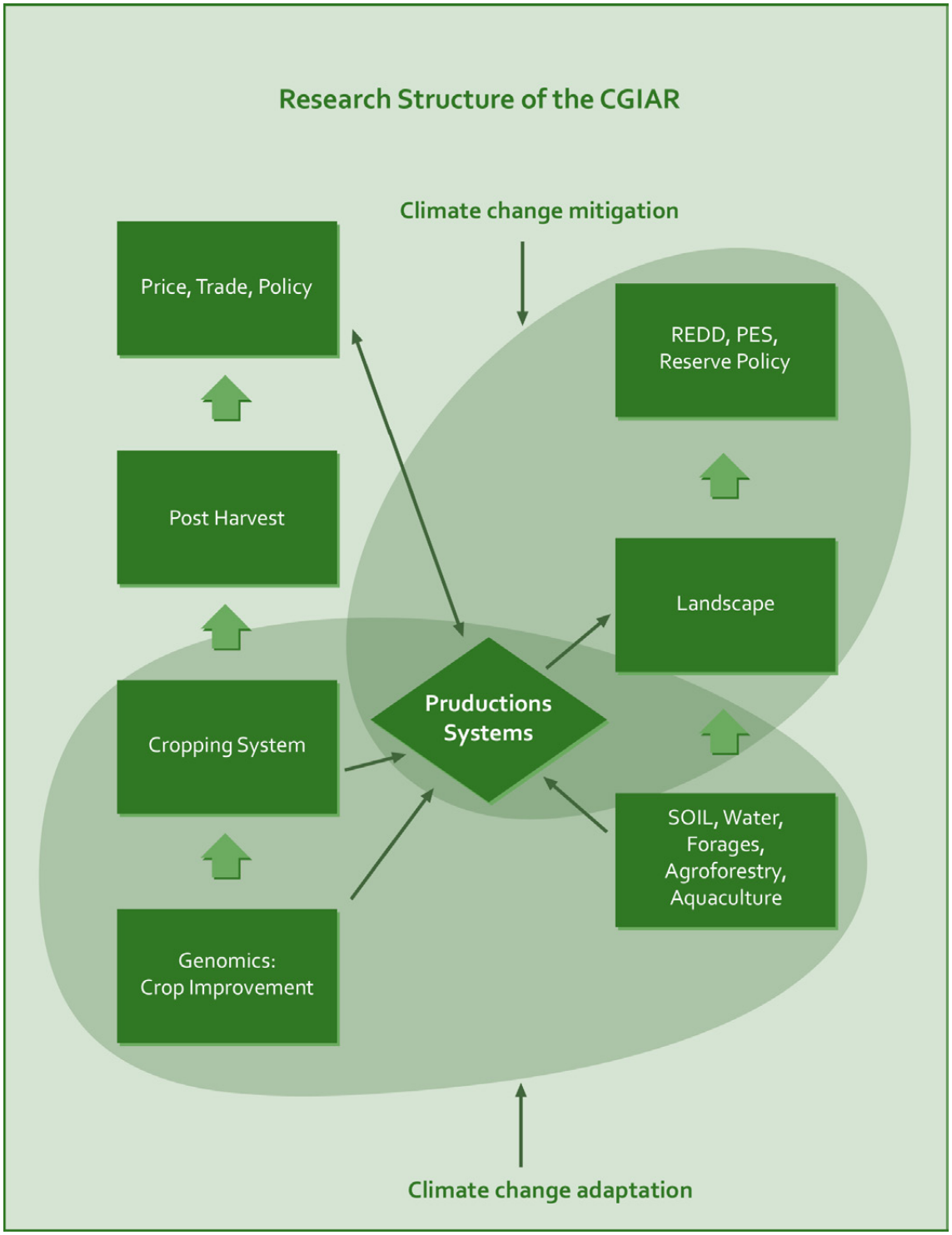
3.2.2 New areas of core competency

131. The SRF will advocate for three additional areas of core competency needed to accomplish impact on the four strategic outcomes and to respond to the principal drivers of change in agricultural systems, namely climate change. These are briefly discussed below in terms of production systems, climate change, and nutrition and health. As presented in Figure 3.2, these new areas of competency depend critically on some level of integration with both the commodity/productivity and NRM core competencies.

132. *Production Systems:* The CGIAR's research on production systems has been episodic, has rarely extended beyond research on mandate cropping systems, and has lacked the methodologies for research at a production system level.[18] Research on production systems has recently been given major impetus through what has been termed ecoefficient agriculture (Keating, et al, 2010) and in terms of understanding sustainable trajectories of farming system intensification.

18 In the late 1970's IRRI developed a rice cropping systems program that did research on different rice production systems, often in farmers' fields. This work became the basis in the 1980's for the development of farming systems research within the CGIAR, but FSR evolved very quickly into a methodology for adaptive research, which was extended further into farmer participatory research, and most often with a singular focus on mandate crops. Although both CIAT and IITA were originally set up as Centers to work on the development of integrated systems for the lowland tropics, they both quickly evolved into crop breeding programs with research on other sub-components, such as hedge row intercropping in IITA. It was rare within the CGIAR system to find research organized at the level of the production system. ILCA did a lot in terms of characterizing livestock production systems in Sub-Saharan Africa, but little in terms of research at the production system level beyond characterization and ILRI's work on modeling of livestock-based systems. CIAT probably came closest in their work on livestock production systems in the savannas of Latin America. The expansion of the CGIAR system in the 1990's brought in more concerted work on agroforestry and aquaculture systems, as well as CIMMYT's work on conservation agriculture. These were in essence new system technologies, where a significant part of the research program was in understanding how to integrate them into existing farming systems. Research framed at the level of the production system was episodic within the CGIAR, was driven by Center mandate, and raised real questions of how system research would be extended to farmers.

Figure 3.2: Integration of New Core Competencies into the Existing



133. Resource use efficiency (and its trade-offs with productivity), especially in terms of water and nutrients, optimizing biomass flows within the system, exploiting synergies in crop, livestock and resource components within the system, and reducing negative externalities are all sub-objectives within this research agenda. Moreover, system constraints and dynamics are very different between, for example, the intensive production systems in the Asian rice bowl and the degrading farming systems in much of Sub-Saharan Africa. The SRF offers the potential to develop this agenda as an explicit inter-Center activity which exploits the crop, livestock and resource component research capacity across the system, on the one hand, and the regional deployment of Centers, on the other hand. The efficiency gains in an integrative approach are obvious, as no Center has the scope of research capacity to undertake it alone, which is partly why the CGIAR has had such difficulty over the decades in developing research capacity in the area of production systems.

134. Development of core competency in the area of production systems will test the ability of the system to undertake inter-center research, building on the experience of the rice-wheat consortium in the Indo-Gangetic Plain. Core aspects of this work will include (1) strategic selection of benchmark sites around core research questions, for example around trajectories of sustainable intensification, (2) developing appropriate and linked data standards at cropping system, production system, household, and market levels to ensure comparability across sites, (3) balancing local system specificity with the ability to generate cross-site system principles, (4)developing effective methods for measuring ecosystem services, and (5) effective iteration between system modeling and component experimental trials. Efficient research design, agreement on research methods, and data management will be critical features of this work. How Centers, in turn, learn from this work and embed results from the production system research within their own research on production system components will test the flows of information and communication strategies of this initiative and the ability to generate added value to inter-Center research.

135. *b. Climate Change*: Climate change will have the greatest impact on agrarian economies with high rates of rural poverty, namely target areas of high priority for the CGIAR, and will introduce higher variability in world food supplies, during a period when balancing world food supply and demand is becoming more precarious. Not only is climate change important to the CGIAR's realization of its four SLOs but the CGIAR is well placed to contribute to research on climate change and to the development of strategies to lessen the impacts of climate change on some of the most vulnerable areas in the world. The CGIAR's comparative advantage in adaptation is relatively clear. However, given the broad array of research areas on the mitigation side of the climate change equation, the strategy will be determined by where the CGIAR can contribute most to carbon sequestration or reduced greenhouse gas emissions and by the potential for agriculture to participate in carbon market development.

136. The development of core competency in production systems as described above will be central to adaptation of agricultural systems to climatic shocks,

increasing temperature, and other effects of climate change such as changes in pest and disease pressure. Carbon becomes an additional metric in this work. Forecasting and modeling capacity will be necessary to inform both the genetic and soil and water research on key research targets, and as a potential tool in risk management at the level of both farming systems and national food security. This in turn provides further demand for more systematic data collection and archiving across the CGIAR system. Possibly, increased competency will be more on the institutional and policy side, involving areas such as risk management and insurance, carbon trading and payment for ecosystem services, and adaptive policy support such as buffer stock management.

137. *c. Nutrition and Health*: More strategic targeting of agricultural research towards nutritional and health outcomes will require deeper competency in these two areas, primarily in terms of a bridging capacity to external research resources. The CGIAR will thus need to focus on developing competencies that allow it to work effectively in partnership with nutrition and health research communities. For instance, the increased work on bio fortification requires more analytical capacity, particularly as work extends into the area of bioavailability. A capacity to measure the population health impacts of improved crops or interventions against agriculturally associated diseases will be critical to setting research priorities and to evaluating alternative delivery methodologies or performance relative to, or in conjunction with, other health interventions, like food supplementation or deworming in children. This is a relatively specialized competency that has in the past been difficult to justify within purely commodity research programs, but which has assumed more importance as the health and economic significance of micronutrients and a reduced disease burden to vulnerable populations has become clearer.

3.2.3 Cross-Cutting support functions

138. There are a few critical areas that cut across potential CRPs at the level of the CGIAR system. These areas directly affect the ability of the CRP to achieve impact on SLOs and reveal the need for a focal point which would bring either more strategic coherence (such as for gender), greater research efficiency and scientific quality (such as for research methods and data standards), or enhanced learning across the CGIAR system (such as for different approaches to capacity strengthening). The organizational arrangements to implement these functions would vary depending on the function and these areas would need to be supported outside the CRP process. Three cross-cutting functions are outlined in this section.

Gender Inequality

139. Gender inequality and its ramifications in terms of lower female education, women's lack of land rights, inequitable access to both income and agricultural inputs within the household, associated lack of control over investment decisions in the farm household, and the larger labor burden borne by women, all fundamentally constrain the ability to meet the four different SLOs.

This is particularly true in regions with high rates of rural poverty and child undernutrition, namely Sub-Saharan Africa and South Asia, where gender inequality is most pervasive. It is in this regard that gender is cross-cutting within an AR4D framework, as it is central to all four SLO strategies, and thus the interventions that address the underlying attributes of gender inequality become strategic components of the ability of the CRPs to attain impact on SLOs. Consequently, streamlining gender issues in the CRPs implementation is a major element of the overall strategy.

140. There are three potential and interrelated approaches that the CGIAR will utilize to addressing gender. They are: a) a strategic approach within the framework of achieving impact on the SLOs; b) a mainstreaming approach across the research programs of the CGIAR specifically incorporating gender analysis; and c) a capacity building approach focused on regions like Sub-Saharan Africa and South Asia, where greater female equality within key institutions will translate into more effective focus on gender inequality at the household level. At a strategic level, the question is with regard to the intervention point where reducing gender inequality will have the most impact on the particular SLO. Thus, as an illustration, it could be hypothesized that: a) women's land rights have the greatest impact on sustainable natural resource management; b) women's nutritional education and access to home gardens have the greatest impact on undernutrition; c) women's inclusion in service delivery, including extension, credit, input distribution and farmers' associations, have the greatest impact on rural poverty; and c) women's ability to participate in input and output markets have the greatest impact on food security. In other words, across the CRPs there is a clear strategic approach to gender in realizing impact on SLOs. This strategic approach is in turn supported by the mainstreaming of gender analysis and gender as a dominate dimension in capacity-building.

141. Earlier versions of the SRF had suggested the establishment of a Platform within the CGIAR to address gender issues in Agriculture. The CB decided not to establish *a priori* such a Platform and instead requested a scoping study to recommend the best ways to integrate gender into all CRPs, which is the essential objective of the reform process. The scoping study highlighted the need for a CGIAR system-wide policy on gender research and concluded that the CRPs should be the main vector for the incorporation of gender into this process. It further suggested recommendations and guidelines on how CRPs should address this issue. The CB in its meeting in Hyderabad endorsed the scoping study and decided that a transitional period of 6 (six) months from the moment of the approval of the SRF, should be given to the proponents of all CRPs to revisit the gender component of the current proposals and adjust them fully to reflect this decision. The CRPs should incorporate in their strengthened proposals a description of the activities pertaining to gender at each stage in the life-cycle of the CRPs from planning to M & E. Each CRP proposal should clearly identify in their request a separate section of the budget that addresses gender issues. The CB will exert the needed leadership in the system in order to ensure the implementation of this issue.

Capacity Strengthening, Learning and Knowledge Sharing

142. Aligning research within the CGIAR around the SLOs involves integration across a range of very different research areas, integrating research outputs into research outcomes, usually within an innovation systems framework, and greatly expands field-based, in situ research activities, often within longer term benchmark sites. The range of partner institutions expands significantly with quite different roles and relationships and includes public, private and civil society partners. Partner capacity is critical to the development of agricultural research for development agenda and yet capacity constraints will vary depending on the institution and the overall socio-economic context. However, the time frame within which the partnership will remain operational will vary significantly. The result is that the locus for capacity development within the CGIAR moves within the CRPs as a support function to the different types of research partnerships. The nature of the capacity strengthening will expand from imparting research skills to include more learning-by-doing, testing of new methodologies and participatory approaches, often building on a base of new knowledge. This implies more innovative approaches to capacity strengthening, often tied to more effective knowledge management, and much more differentiated approaches, depending on immediate need within the implementation of the CRP.

143. A dedicated informal network to promote Capacity Strengthening may work at the system level to link CRPs, centers and partners in these areas. It will support capacity-strengthening and other relevant activities that will be built into each CRP. The system-wide network will share the latest research findings and results on capacity strengthening and it will provide CRPs with fora to share capacity strengthening experiences.

144. This informal network will help the CRPs and their partners to develop and use advanced ICTs for capacity strengthening, so that CGIAR research outputs reach target users and beneficiaries. This effort will include providing CRP partners with access to applications and resources such as databases.

145. The network should be developed by drawing on the capacity-building expertise of the CGIAR Centers, and of other educational institutions. Given the growing role of the private sector in outreach and capacity strengthening along agricultural value chains, this informal network should also seek to harness company contributions to the capacity-building effort.

Research Methods and Comparable Data as an International Public Good:

146. The CGIAR is unique in having the capacity to collect experimental, monitoring, and survey data on agricultural systems throughout the developing world. Such data is costly to generate and is at the same time the basic building block upon which agricultural science depends. Nevertheless, most data is project dependent, has relatively specific objectives, and usually leaves with the implementing scientist or disappears at the end of a funded project. With no incentives to make such data publically available, much of that data is not systematically archived. Further a lack of comparability limits the ability to link data sets, to use it in other applications or to evaluate changes over time. Most

data collected by CRPs, whether broad-scale data used to describe and monitor farming system changes, or focused data collected to examine specific processes and hypotheses, should be of such potential value that the cost of archiving and sharing is justified by the value added in terms of expanded research results from the use of that data by a wider research community.

147. The organization of research at a CGIAR system level offers the opportunity to be more strategic in the production of data, in expanding the community analyzing the data, and in more effective use of ICT in the archiving and dissemination of the data. Moreover, greater accountability at the CGIAR system level for impact on SLOs will require more systematic monitoring data and, where possible, will require that it be linked to national statistical surveys. This also provides an opportunity to bring attitudes and standards of CGIAR research more up to date and aligned with both leading research institutes and donor expectations.

148. Evaluating progress in agricultural development has been constrained by the lack of basic statistical capacity in the sector, especially as compared, for example, to the health sector with its Demographic and Health Survey capacity. Agricultural production data has suffered with the decline in capacity in agricultural extension, ability to undertake agricultural censuses has been lost in regions like Sub-Saharan Africa, and agricultural surveys have given over to more broad-based welfare monitoring surveys. At the same time, as the recent social science stripe review has noted, the ability of the CGIAR to produce high quality, longitudinal survey data has declined in the last two decades.

149. The above is only suggestive of the potential gains from a more systematic approach to data collection, archiving, and dissemination across the CGIAR system, with a view to ensuring quality control, comparability, and effective management of IPR and movement of data into the public domain. A principal means of achieving these goals is to make delivery of data to the public domain part of the performance requirements of research carried out in the CGIAR.

150. The area of research methods and data comparability requires coordination of existing capacities, oversight of research protocols, and strategic direction across a range of very different data generation efforts. The Consortium will facilitate the work of groups of specialists within and among the CRPs, supported by outside expertise as required, to develop appropriate standards. The Consortium support unit could be empowered to verify that the norms established by the groups meet international standards and they are routinely adopted by the relevant CRP sections. This unit could also verify that expanded use of the data outside the CGIAR follows international best practices.

3.3 Research Implementation through CGIAR Research Programs

151. The CGIAR Research Programs (CRPs) will be the vehicle for better alignment of core competencies across the 15 Centers around a more strategic approach to achieve impact on system level outcomes (SLOs). The CRPs make more explicit the execution of CGIAR research within an agricultural research for development (AR4D) framework that allows a clearer linkage between investment in CGIAR

research and the potential impact on development outcomes. The CRPs involve three core principles: a) a strategic approach to organizing research around impact on SLOs; b) integration of research across core competencies as fundamental to the strategic approach; and c) clarity on and differentiation of partnerships at the various stages of the R&D process. The CRPs have specific governance and management structures, and are accountable, within certain tolerance levels, for research outputs and research outcomes designed to impact on SLOs. Together they allow the CGIAR system to evaluate progress on the contributions made to achieve SLOs.

3.3.1 CRP Portfolio Development

152. The CRP portfolio represents the way in which core competencies of the CGIAR are organized and aligned to achieve the four System Level Objectives. The CGIAR is defining this portfolio for the first time, which creates opportunities in terms of innovation in program design, but also challenges in terms of how to assess the whole CRP portfolio in relation to alternative funding scenarios. Besides using the CRPs as a basis for linking research across Centers in pursuit of larger research objectives organized around SLOs, the CRPs are also being used as the principal vehicle for organizing and funding core competencies, for achieving improvements in research efficiency, for defining investment priorities, and consequently for measuring accountability for impacts on SLOs. There is currently no framework which the SRF can utilize to define such an "optimum" CRP portfolio, given the requirements being imposed on the development and definition of the CRP portfolio. At one level this is a necessary limitation of this SRF, but at another level, it is an opportunity for the CGIAR to produce such a framework that would guide research investment in global agricultural research, not just within the CGIAR, into the medium-term future. This section will briefly describe three actions that would be necessary to establish this framework, namely reconcile boundaries, achieve strategic alignment, and set priorities.

153. Reconciling boundaries is effectively about optimizing research efficiency. Historical research boundaries in the CGIAR have been related to Center "mandates" and geography, which has led to both gaps and overlaps. Some of these have been reconciled in the SRF process, through Centers coming together around CRPs, e.g., across regions, for particular commodities or farming systems. However, the CRPs have residual boundary issues, such as how precisely work on drought resistant crops will be undertaken across CRPs on dryland systems, specific commodities and NRM-related CRPs, in order to be efficient. To some extent, these can be resolved through further operational planning of CRPs as they are initiated. Reconciling boundaries should achieve demonstrable economies of scale, scope and size in the research process, as well as optimal spatial allocation, given the strong conditionality characteristic of agricultural and NRM research.

154. Given that the boundaries can be defined, the succeeding issue is how research is strategically aligned around SLOs. This requires some specification of the

necessary and sufficient conditions to achieve outcomes and impact and of how core competencies will be aligned to meet these conditions. Some CRPs have begun to address this challenge. This is the case of CRP4 on nutrition and health, and CRP7 on climate change strategic level outcomes by combining crop breeding, production system and policy research. An even greater challenge is posed by addressing rural poverty reduction, which will need to integrate all competencies and cut across existing CRPs in production systems, commodities, policy and NRM. Here, spatial alignment becomes critical so that research is integrated around the particular agricultural systems where poverty reduction is most probable. Presently, most CRPs identify their target research sites using criteria related to their particular research focus, but there is the potential to develop shared criteria that better align research in different CRPs around achieving SLOs in particular regions.

155. Reconciling boundaries focuses on efficiently organizing research across core competencies, while improving strategic alignment focuses on effectively linking core competencies across boundaries, in effect a two stage process. How these stages are teased out in the definition of the CRPs will be an issue.

156. Priority setting is then a mechanism for allocating resources across this potentially two-stage structure. The multi-functionality of agriculture, as represented by the CGIAR's four SLOs, introduces the problem of comparing benefits across four very different outcome objectives and the problem of the relative weights given to these four objectives. Traditional priority setting frameworks are usually developed and applied within existing, well defined areas of core competency, rarely across quite different areas of core competency, e.g., commodity research, policy and NRM, and almost never where the overall objective is sustainable agricultural development and the task is to meet multiple objectives. Priority setting frameworks are usually employed for investment decisions at the margin, that is, whether to add or delete a research line within an existing portfolio.

157. The development of a research portfolio *de novo* usually falls back to *Delphi* and consultation approaches, as with the ICSU's reassessment of earth system science (Reid, et al., 2010). The development of a more quantitative framework to assess priorities at a system level would require significant investment. And any consideration of such an approach would require an expert group to assess feasibility and potential cost. The CGIAR has never had a dedicated capacity to undertake planning and priority setting across the system, and these techniques essentially stopped being used with the expansion from commodity research to NRM research. Accordingly, the CGIAR experience has been of considerably more rigorous priority setting at the center level than at the system level (Raitzer and Norton, 2009). The alternative would be to develop standards for individual CRP level ex ante impact assessment and benefit estimates could be compared across CRPs (although this would primarily be done only on the basis of total economic benefits). The difficulty would be in terms of overcoming potential double counting of benefits and developing a "best evidence" integrative framework to compare the CRP-generated evidence of impact potential across

the CRPs, that is, some of the same issues inherent in developing a more integrated, quantitative framework.

3.3.2 Necessary attributes in the development of individual CRPs

158. Aligning research for better impact on SLOs requires significantly more specificity in the design of research through the R&D continuum and extends the research process into a better understanding of the necessary, and possibly sufficient, conditions to achieve impact on development outcomes. At the same time, research for development is not an engineering process. There is a significant degree of indeterminacy in both the knowledge development process as well as in the effective application of that knowledge to development problems. Scientific progress often involves taking risks and extending enquiry into areas outside the original research plan and this often runs counter to the purposes of a tightly specified results framework. This is especially true where there is a natural phasing to the R&D process, where research outputs across very different research competencies must be integrated, and where each phase is conditional on the results of the previous phase, as is the case with the type of research being called for in this SRF. The following will set out the critical attributes employed in the design of a CRP that will also provide the basis for the criteria to be used in the assessment of CRPs.

159. *CRP objectives are defined in relation to a strategic approach to achieving impact on an SLO*. The research objectives, which in turn define the programmatic components of the CRP, should follow from a strategic approach to the SLO. The CRP objectives should be clearly defined and there should be a conceptual link between the objectives and programmatic components that build toward a clear definition of impact on the SLO. The scope of the CRP may involve a regional approach to attaining impact on an SLO, a determination of critical entry points to achieving such impact, or a particularly innovative approach to impacting the SLO. The CRP may derive from an overall strategy for that SLO defined and developed at the level of the CGIAR and this may precede the development of one or several CRPs arising from that strategy.

160. *b. A research plan clearly indicating phasing and articulation of program components:* Derived from the research objectives, the research plan should lay out the inputs and research outputs, and show how the Research Outputs are integrated to produce and test Research Outcomes. Research methodologies should be described for each research component with explicit indications of: (1) how the research relates to or draws on research done elsewhere (2) how it draws on relevant core capacities from different Centers and across different core competencies (3) the role that main partner institutions play in the development of research as well as the capacities they contribute and (4) a clear specification of the implied accountability or responsibility of the research, which should clearly specify the implied accountability or responsibility for each research component undertaken by each Center or research partner institution. The phasing of the

different research components should be clear, particularly where one or more components depend on outputs from other components.

161. *c. Specify target population and/or region:* Impact on SLOs is affected by a range of spatially explicit factors, including structure of the economy, distribution of target population, agro-ecology, and pressure on resources. Target regions and populations will follow from the strategy and will provide a planning framework for strategic selection of benchmark sites, testing networks, and pilots, as well as definition of target populations for development of baseline and panel surveys. This would allow a more systematic long-term collection of data with comparability across sites or populations within CRPs focused on a particular SLO and would provide a rigorous basis for monitoring and evaluation of program impact.

162. *d. Define a clear approach to gender within the research program:* Enhancing the long term status of women and girls through agricultural R&D requires that women be involved as active participants, at all levels. Ensuring that women have a voice, opens up more options for high quality research by bringing different experiences and values to the R&D process. Gender analysis will be important in the diagnostic, hypothesis development, implementation and monitoring phases of the research—that is, understanding women's role within the management of new technologies or natural resources—but improving women's livelihoods will require a clearer definition of strategic entry points that could be tested. Identifying such entry points may be a research area in itself or the CRP may already have identified options that require testing. The CRP will need to present a clear summary of the current state of knowledge on the key role of women within the CRP research, followed by a plan either to increase that knowledge base or to test options for improving women's livelihoods within the CRP impact pathway.

163. *e. Specify clearly defined impact pathways:* The impact pathway defines both the causal relationship from research outputs to impacts and the nature of the partnerships at each stage in the pathway. Impact pathway should provide a basis for the design of the monitoring and evaluation system, the specification of targets or milestones at each stage along the pathway, and the identification of the group of partners at each stage and their respective roles. A CRP will entail a more explicit role for Centers in generating research outcomes, particularly in rural poverty and improved nutrition and health pathways, where institutional innovations are critical to delivery of potential impact. Market-driven impact pathways, particularly in food security, will involve different institutional arrangements in generating research outcomes, especially with the private sector. The prospective time frame within which each phase will produce measurable results should be made explicit, as that will define the results against which the CRP will be evaluated for each CRP project period.

164. *f. Explicitly establish partnership roles and capacity strengthening strategies:* At each stage in the impact pathway the type of partner institution and the respective roles in the CRP will vary, as indicated in Chapter 2. At the science end of the R&D spectrum, external scientific partners will bring expertise not

available within the CGIAR and these institutions will be directly accountable for Research Outputs defined within the CRP, in many respects no different from a Center's role within the CRP. In the crop improvement area this will often involve drawing on capacity from the large, developing countries or private sector companies. IPR, legal liability, and respective control over product development will be particular issues that will have to be negotiated in these types of public-private research partnerships. Generating and testing Research Outcomes will frequently involve a spectrum of research and development institutions, often organized within innovation platforms. The respective roles of research and development partners should be clear and development partners should understand the implications of undertaking their field activities within a trial or piloting framework. Organizational and methodological innovations at this stage will often require a range of capacity strengthening activities which should be specified. Should the CRP get to the stage of scaling up and out research outcomes, the locus of management and program control would shift to financing and implementation agencies, but often with a range of subsidiary research questions on how to cost-effectively scale out successful pilot projects which would involve continued engagement of CGIAR researchers with these development partners.

165. *g. Bring together science of the highest quality:* CRPs must be designed to ensure that the best quality of science, required by each stage of research, is brought together in an operationally effective way, irrespective of whether the resources are part of the CGIAR competencies or they are contributed by research partners. Ensuring science quality presents particular challenges. Each stage of the research employs quite different disciplines and research methodologies. Data standards are not as well defined beyond the level of the plant and genetic sub-system and are quite different in the area of social, organizational, and economic experimentation. Given the complexities of research done within a CRP, clear procedures for assessing science quality should be established. In particular, plans for documenting and archiving data should be clearly specified.

166. *h. An appropriate governance structure and accountability framework:* Given that CRPs may involve a number of Centers and possibly external agencies, a specific governance and management structure must be defined in each CRP. Fiduciary responsibility and contractual commitments with the Consortium Board will be vested in the lead Center for the CRP. Each CRP will organize its governance and management structures following the guidelines provided in Chapter 4 of this SRF. The theory of change, delineation of the impact pathway, and specification of the outputs and milestones at each stage will provide the basis for developing a monitoring and evaluation framework and for specifying milestones, outputs, and eventually research outcomes within a well developed time line. This will then be aligned with the contractual period(s) of the CRP.

167. The CRPs are an innovative mechanism for reordering, if not reorganizing, research within the CGIAR. Their primary objective is to better align research across the 15 Centers around strategies to impact on the four system level outcomes. At the same time this is to be achieved while improving research

efficiency, developing new areas of core competency, and enhancing the quality of research in its traditional areas of core competency. However, meeting all of these objectives will probably involve trade-offs within an uncertain funding setting and this is the principal risk factor in this ambitious process. Moving forward will require both trust and collective good will, but the extent to which the Centers can be collectively innovative and creative in realizing this vision will depend on each Center being able not only to preserve and enhance its own core research capacity on which the CRPs are built but also to align them with a more strategic vision of their role in the overall system and their contribution to achieving greater impact on system level outcomes. Effective implementation will be critical and the next two chapters provide an overview of the implementation of the CRP process.

CHAPTER 4. ORGANIZATION AND IMPLEMENTATION OF THE RESEARCH PROGRAMMES

4.1 The Overall Framework and its implementation

168. The CGIAR must deliver the System Level Outcomes articulated in the SRF in the most efficient manner. The Consortium Board has the responsibility for guiding the development of the overall research program to be implemented by the existing Centers and their partners. It also has the main responsibility for overseeing the efficiency and impact of the overall activities implemented by the Centers, through the CRPs.

169. While the Thematic Areas help to define and integrate the collective competencies of the CGIAR Centers, the CRPs encourage alignment with the vision and desired system level outcomes, and provide the accountability mechanisms through the arrangements established for their governance and management. These are described below.

170. The CGIAR Consortium Board is responsible for the overall CRP's portfolio approval and for its submission to the CGIAR Fund Council. The Board's role will include ensuring that individual CRPs are aligned with the SRF, respond to the common criteria agreed with the ISPC for the assessment of the CRPs, are in synergy with each other, reducing overlaps and leveraging complementarities. The Board will also need to ensure that the milestones and outputs, which will be specified in a performance contract, are delivered within the agreed timeframes and budget.

171. In the past, the CGIAR has experimented with different management regimes for Challenge Programs, System-Wide Programs, Ecoregional Programs, and other system components. The Centers also have their own systems and processes in place for scrutinizing performance internally and externally. Although these established mechanisms provide a basis for the future governance and management of CRPs, they must be adjusted to better reflect their greater scale and complexity and to provide full accountability.

4.2 Governance and Management of the CRPs

172. The Governance and management arrangements for CRPs will have the following components:

- Each CRP will be managed by one Lead Center which will have fiduciary and operational responsibilities for its implementation. Specific management structures will be defined in the proposal of the CRP to be submitted for approval to the Consortium Board, and subsequently, to the Fund Council
- Once the CRP has been approved by the Fund Council, the Consortium Board will sign with the Fund Council a Performance Contract Agreement

that will govern the general terms under which the approved CRP will be implemented.

- In addition, each CRP will have a Program Implementation Agreement signed between the Consortium and the lead Center that specifies milestones and outputs against funding on a multi-year basis for the proposed life span of the CRP. Rolling annual contracts will adjust future funding, contingent on the CRP's performance of the contract. The Consortium Board will develop the appropriate framework for evaluation of performance
- Once the CRP has been approved by the Fund Council a detailed operations plan will be prepared by the Lead Center in consultation with and collaboration of other Centers participating in the implementation of the CRP and relevant outside partners. The operations plan will form part of the Program Implementation Agreement.
- CRP's operations plans will further elaborate on impacts and impact pathways, more detailed budget distribution, responsibilities of each participating Center and partnership strategies. Operations plans will cover a five year horizon. To cover these and associated human resources, communication, and other CRP delivery costs, CRPs must be designed using full cost recovery principles.
- The Lead Center, in consultation with other participating Centers, will appoint a Director for the CRP who will be responsible for the quality and relevance of the outputs produced under the CRP.
- The Lead Center in consultation with other participating Centers will establish:

  a. a Planning and Management Committee composed of a representative of the Lead Center, a representative of each participating Center, and a representative of other partners that have substantial responsibilities in the implementation of the CRP. This Committee will oversee the planning, management and implementation of the CRP;

  b. a mechanism to ensure that the work in the CRP is of the highest quality; this will usually include a Scientific Advisory Committee composed of individuals who can bring together state-of-the-art scientific expertise and insights on strategy, partners, etc. This Committee will advise, report, and be accountable to the Planning and Management Committee.

- Since the Consortium Board is ultimately accountable for the efficiency of individual CRPs, it will approve the most appropriate governance arrangement in each particular case taking into consideration the characteristics and specificities of individual CRPs.

  - All programmatic funding, whether through the fund or through restricted projects, must be based on full cost recovery.

4.3 Establishing a detailed Operations Plan for each CRP

173. Once the CRP has been approved by the Fund Council, the lead Centers will assume responsibility for the implementation of a CRP, and on the basis of the document approved by the Fund Council, a detailed operations plan will be developed. The operations plans should fully describe:

- The CRPs impact pathway from research outputs to the specific SRF system level outcomes. In most cases, in order to have the appropriate level of detail, each major component of the Program will need to define its own impact pathway leading to the research outputs that contribute to the desired research outcomes and system level outcomes of each component.
- The partnerships that have been established, the role to be played by main partners and the source of their funding. Partnerships will be identified and justified on the basis of comparative advantages.
- The geographical areas and physical research sites where the CRP and its main components will conduct its work, including their justification.
- A timeframe for implementation so that investors in the CRP can see which work will be funded first, the expected results from each level of investment, and activities may remain unaccomplished if sufficient funds are not available to fund an entire Program. The prioritization of different components within a CRP will use the criteria listed below.

4.4 Establishing relative priorities between CRPs

174. The necessary attributes that should be included in the design of CRPs are identified and described in Chapter 3. They are also the basis on which CRPs will be selected and approved by the Consortium Board. These attributes are consistent with the Common Criteria that have been agreed between the Consortium Board and the ISPC for the design and assessment of CRPs and represent a further elaboration of the agreed criteria, which are:

i. Strategic coherence and clarity of Program objectives

ii. Delivery focus and plausibility of impact

iii. Quality of science

iv. Quality of research and development partners and partnership management

v. Appropriateness and efficiency of Program management

vi. Clear accountability and financial soundness, and efficiency of governance

4.5 Establishing relative priorities between CRP components

175. The definition of the relative priority between the different components that integrate any CRP will be decided by the Lead Center in consultation with other participating Centers and main partners, so as to maximize expected impact potential, using the following guiding principles:

    i. The consistency between the research outputs selected in the specific CRP component and the overall research outcomes selected in the CRP

    ii. The quality of science and likelihood of obtaining the planned research outputs

    iii. The strength and likelihood of the contributions that the obtained research outputs will have on the selected development outcomes

    iv. The strength and conceptual solidity of the described impact pathways

    v. The strength of partners and of their commitment and participation

    vi. Complementarities with other research activities being implemented within the CRP and by the Consortium as a whole

4.6 Design and Management of support functions

176. The CO, in collaboration with Centers, will organize the delivery of support functions that cut across all CRPs and will provide the capacity to deal with these issues at the Consortium level.

177. Each function will be fulfilled by facilitation through the Consortium Office focal point, working with small working groups or networks of experts from Centers, CRPs, and, where necessary, Stakeholders and Consultants to develop best practices and to assist CRPs in sharing and implementation of best practices.

4.7 Intellectual Property Rights Management

178. Although the production of public goods continues to be at the core of CGIAR's business, the legal boundaries for access and exchange of germplasm, technologies and research tools have changed considerably over the past few decades Intellectual property rights (IPRs) have been progressively introduced in agriculture with the adoption of plant variety protection and patents over life forms and are increasingly accepted as the standard for the business and are no longer solely a private sector issue. International treaties--International Union for the Protection of New Varieties of Plants (UPOV), International Treaty on Genetic Resources for Food and Agriculture (ITPGRFA), and the Convention on Biological Diversity (CDB) have also significantly evolved to provide a framework for the management of genetic resources and technologies. In this context, the CGIAR is developing clear system-wide IP principles taking into account the evolving situation with regards to the subject, as well as the realities and policies of the various types of partners with which it interacts. These principles will guide the management of intellectual assets, including the release of intellectual

products that are produced by the Consortium and its member Centers as well as the acquisition of third party proprietary rights. These principles will be applied by the Consortium and its member centers across their activities and programs.

4.8 Managing core assets and maintaining Center innovation capacity

179. For centers to be effective in implementing the SRF and in taking on their roles in CRP governance and management, it is essential that they continue to receive their own institutional funding. This funding is narrowly defined to cover core functions for the programmatic work, such as critical research and network infrastructure, databases and other information resources and support, and administrative and financial functions. An agreed formula should be developed, taking into account the budget executed through CRPs and Center capital investment needs, for core funds to be allocated to each Center each year as direct support. This core funding would come from Window 1and it will be assigned to the upkeep of capital investments, laboratories and other costs that are extremely difficult to attribute to a specific CRP. This will encourage Centers to place the largest feasible share of their efforts within the SRF and, in particular SRF-derived CRPs.

180. Collective action under the envisioned CGIAR Consortium of International Agricultural Research Centers requires joint strategy development and CRP design and implementation – as envisaged in this SRF. Such collective action will require Centers to adopt agreed management and implementation arrangements, within which they continue their individual freedom to operate. Together with delivering the outputs and outcomes of the CRPs in which they participate, they are free to pursue other agendas, provided that work is implemented on a full cost-recovery basis.

4.9 Managing Funding for CGIAR Research Programs

181. Planning and implementing the CRPs will challenge CGIAR scientists and managers, as well as investors, to operate in new ways. Priorities must be set in a clear and transparent manner, based on agreed criteria. Given the nature of the research commitments, both by investors and by the CRPs themselves, will need to be long term. Ideally, priorities will be driven not by individual donors' interests but rather by scientific analysis and best judgments on the research activities most likely to contribute to the CGIAR's vision and desired outcomes

4.10 Monitoring and Evaluation

182. At the 2009 Business Meeting a new Monitoring and Evaluation Framework for the CGIAR was approved. It reflects new accountability functions in which the Consortium Board and Fund Council are allocated responsibilities and a new independent evaluation arrangement is established.

183. The Fund Council has commissioned a report from consultants on the future evaluation system and arrangements for the CGIAR which is being prepared in a dialogue which includes the Centers and Consortium Board. This offers an excellent opportunity for the consultants to provide guidance on the most cost-effective way in which the roles of monitoring and evaluation by the different governance structures of the CGIAR system, including the newly created Independent Evaluation Arrangement should be organized for the benefit of the CGIAR System as a whole.

Evaluation

184. The Consortium and its Member Centers will support the development and implementation of a CGIAR evaluation system which is adequately independent; assists the drive for CGIAR system improvement and provides for mutual accountability by the Fund Council, Consortium Board and the Centers. This evaluation system should provide evidence and analysis on relevance, scientific appropriateness, efficiency and effectiveness for CRPs, Centers and cross-cutting issues as they arise. Without prejudice to evaluation independence, the evaluation system must also be responsive to the needs of all.

185. The Consortium will thus, further elaborate its evaluation strategy by December 2011, following consideration by the Consortium Board of the above mentioned consultants' report.

Monitoring (M&E) and Management Information

186. The Consortium and its Member Centers will ensure that all CRPs will be developed[19] to include clear and comprehensive overall, and component specific, input-output-outcome-impact chains; that risks and assumptions are clearly defined; and that targets, indicators and practical means of verification are provided for each of these, together with baselines. A results-based monitoring framework will be developed for each CRP which also provides an important input for CRP evaluation. Although monitoring frameworks will be CRP specific, they will share certain common standards both for coverage and reporting.

187. The CRP monitoring systems will allow the production of periodic performance reports from the lead Centers to the Consortium Board and the Consortium to the Fund Council.

4.11 Communication Strategies

188. Research programs can have no impact without communications. Knowledge, innovations, research results, policy assessments, practical guidance and recommendations for action are not useful unless they are communicated to those who can use them.

19 Although this will generally not be possible in the short-time frame available for the first version.

189. This role of agricultural research must be embraced by all staff involved in the CRPs as well as by the Consortium Office, System Components and key external stakeholders.

190. An "umbrella" communications strategy for the new CGIAR will make clear what the CGIAR's vision means in concrete terms and what the CGIAR will do to achieve its goals.[20]The Consortium Board and Office will facilitate the overall strategic communications design and take the lead in implementing, directly and through Center communications teams, a special communications effort to convey these key messages to stakeholders. The aim will be to give stakeholders confidence that not only structures but also attitudes and mindsets are supportive of the outcomes of the reform process and the new CRPs.

191. Each CRP will need its own communications strategy. In close coordination with the Lead Center communications work, it will outline the key messages to be conveyed, the key target groups and the media and other channels for communicating with these target groups. The communications strategy will be developed at the same time as the CRP's operations plan and will form a part of this plan. To achieve maximum synergy, the CRP's communications strategies will need to be coordinated with the "umbrella" communications strategy, so as to avoid the impression of competing entities.

192. An improved CGIAR communications strategy at these two levels will:

- Link the components of the new CGIAR so that they reinforce each other's identities and activities
- Catalyze the coordination of CGIAR communications and engage support for communications at the highest levels of the system and its partners
- Encourage a focus on major development issues and what is being done about them through the collective effort, not on individual institutions and "their" successes
- Create incentives for collective communications, rewarding communicators for multi-center initiatives focused on issues rather than institutions
- Integrate communications activities within CRPs from the start, making communications a dynamic and interactive part of their work rather than an afterthought
- Tell compelling stories to showcase research impact by describing how the CGIAR's work makes a difference to people's daily lives
- Scale up the use of new ICTs to build capacity in communications for rural development and mainstream knowledge management in the CGIAR

193. As a result of the reform process the CGIAR has an opportunity to re-position itself as a global leader in AR4D and to greatly magnify the development impact

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20 . This section draws on a discussion paper prepared by a group of communications experts in CGIAR Centers: "CGIAR communicators" (2009).

of its collaborative work. Communications will occupy a strategic place in the Consortium Office and figure importantly in the work of the CRPs. Efficiency gains will be achieved by sharing services across Centers and programs. This is not to say that CGIAR communications should be more centralized but, on the contrary, that this work can best be improved through a networking approach, aimed at achieving high-quality communications at all levels.

4.12 Investment required

194. The recent food crisis, the persistence of rural poverty and the documented deterioration of agricultural natural resources worldwide strongly suggest that persistent underinvestment in agriculture has resulted in an enormous global economic and social loss. More investment in agricultural research is needed urgently, at the international, regional and national levels. Funding must increase substantially if the results of research are to be scaled up sufficiently to make a sizeable impact on poverty, hunger and resource sustainability. Preliminary estimates made by IFPRI suggests that to increase agricultural productivity by 0.5 percent annually across all regions until 2025 (a rate of increase that would lead to a food-secure world by that year) a massive expansion of investment in agricultural research for development above current levels–from US$ 5.1 billion per year today to US$ 16.4 billion per year by 2025–would be required. Beyond just spending more, however, two other actions also need to be taken: increase the efficiency of AR4D and target investments more effectively. If all three things can be done, the result will be a substantial impact at a lower total cost (although still a substantial increase over today's spending levels) and poverty, defined as an income per capita below US$ 1.25 per day, can be reduced by 401 million people by 2025, at a cost of US$16.4 billion per year by that year. (See Box 4.1)

195. This funding increase includes the investment needed in national as well as international public-sector research, and should include incentives in funding for partnering with knowledge and innovation providers such as academic institutions and the private sector or developing creative partnerships to create and/or disseminate innovations. The underinvestment in international public goods in general, and in agricultural research in particular, is known to be at least as deficient as national spending. It seems safe to assume that the share of international public goods R&D as a percentage of total public R&D spending (currently about 10 percent) will at least be held constant. If we assume, therefore, that this share can be applied to the total required public R&D investment of US$ 16.4 billion set out above for 2025, it suggests we should aim for a CGIAR budget of US$ 1.6 billion by the same year – in other words, that the CGIAR will triple its current budget by 2025. However, because research is a long term investment, donors should note that the budget will need to increase substantially well before that date, if the outcomes and impacts proposed in this SRF are to be achieved in a timely manner.

196. This increase in the required funding for international AR4D is also the result of four interrelated factors: a) the mandate of the CGIAR system has been

expanded to explicitly include the responsibility to engage development partners and support their work needed to reach development outcomes, which implies additional organizational and managerial complexity; b) the emergence of new challenges and opportunities makes necessary the expansion of CGIAR research competencies to new areas of work like climate change and nutrition; c) the full adoption o an AR4D perspective implies the establishment of extensive partnerships including, in many cases, sharing of available funding; and d) the adopted mode of research organization based on interdisciplinary and interagency CRPs implies more complex management arrangements, which are more effective for delivering development outcomes but may be more costly to operate.

197. At the time of writing this SRF there is available a portfolio of fifteen CRPs out of which two CRPs have already been approved by the Fund Council. The requested budget for 2011 implied in this portfolio is in the order of US$ 790 million, with a gradual increase reaching a budget of around US$ 975 million in 2013. If these figures are projected to the year 2025, the implicit amount of funding for the CGIAR would be within the range, although slightly higher, of the figures estimated by IFPRI as necessary to reach a food-secure world.

198. Requests follow the traditional emphasis of the CGIAR on productivity work (Crop improvement) with relatively lesser requests in relation to newer areas of work, such as Climate Change and Nutrition. Although this is a reasonable balance, it also shows the importance of examining, in the future, the desired balance between the different Thematic Areas on which the CGIAR has decided to develop competencies for AR4D.

Box 4.1. Levels of investment in agricultural R&D needed to achieve specific results

To analyze the effects of scaling up and improving the efficiency of agricultural R&D, IFPRI's multiplier model was used. A business-as-usual scenario was contrasted with three R&D policy scenarios projecting R&D investment, agricultural growth, and the number of poor in each developing region to 2025 (the CGIAR reports its spending for Sub-Saharan Africa, Central, East and South Asia, Latin America, and West Asia and North Africa; we then used the share of national spending to estimate CGIAR spending on each country or sub region):Scenario A: productivity increases (total factor productivity is assumed to increase annually in all regions by 0.5 percent)

- Scenario A: productivity increases (total factor productivity is assumed to increase annually in all regions by 0.5 percent)
- Scenario B: countries and donors become more poverty oriented (that is, total R&D invested in 2008 is allocated among regions in such a way as to minimize poverty)
- Scenario C: increased productivity is combined with increased R&D efficiency.

Under Scenario A, increasing agricultural productivity annually by 0.5 percent across all regions until 2025 would require over US$10 billion more in annual R&D investment above business-as-usual levels (see table). Under Scenario B, more R&D investment would be allocated to Sub-Saharan Africa and South Asia to minimize poverty. Most of the poor earning less than US$1.25 per day live in South Asia (698 million people) and Sub-Saharan Africa (365 million people). Thus, to reduce poverty more sharply, a significant share of R&D investment should be allocated to those regions. Scenario C shows how improving the efficiency of R&D investment would lead to even better results.

Scenarios for R&D investment and impact on poverty and agricultural productivity growth, 2008–25

Scenario	R&D investment (millions of 2005 US$)		Number of poor (millions)	Change in the number of poor (millions)	Agricultural productivity growth rate (%)
	2008	2025	2008	2008–25	2008–25
Scenario A—0.5 percent growth in productivity	5,139	18,643	1,420	-318	0.92
Scenario B—poverty minimization	5,139	15,328	1,420	-348	0.71
Scenario C—0.5 percent growth in productivity with higher R&D efficiency	5,139	16,347	1,420	-401	1.18

Source: IFPRI multiplier model, A. Nin-Pratt and S. Fan for Strategy Team, 2009.

Note: The scenarios in this table assume a poverty line of US$1.25 a day. For details see report by A. Nin-Pratt and S. Fan (2009) on the CGIAR Alliance website. Although the assumptions made in this analysis are broadly consistent with the results and assumptions related to the scenario analyses reported under the IMPACT model, this model is not formally connected with the IMPACT model.

CHAPTER 5. IMPLEMENTATION AND EVOLUTION OF THE SRF

199. The implementation of the SRF by the Consortium Board introduces three fundamental changes in the way research in the CGIAR will be planned, approved and implemented. The first of these changes is that the CGIAR will function as one Institution, guided by the Consortium Board, with Centers operating in coordination and collaboration in pursuit of agreed common goals and objectives. The second change is the full adoption of an AR4D approach where research priorities and activities will be mainly guided by their potential contributions to the four selected system-wide development outcomes. Finally, the third fundamental change is in the organization of research activities in CGIAR Research Programs (CRPs) aimed at integrating the work of several Centers and outside partners in large and ambitious programs, defined around the contributions that agricultural research can make to selected development outcomes. The planning, selection, approval and launching of these CRPs represent the main tasks ahead.

200. The process envisaged for the development of this SRF and the portfolio of CRPs that would be implemented as a consequence of it was originally sound. First, there was to be an agreement and approval of the SRF as the strategic expression of the CGIAR reform process, setting forth the rationale and content for the combined work of its Centers and a framework to fully implement an AR4D perspective oriented towards system level outcomes and impacts. This process would be followed by the identification of a clearly defined research program based on CGIAR Research Programs (CRPs) that would constitute the operational arm of the SRF to achieve the selected System Level Outcomes.

201. For a number of reasons, which are well known and attributable to Centers and Donors, the process did not materialize as it had been designed. In fact fifteen CRPs have been developed before the conclusion of this SRF and two CRPs had already been approved by the Fund Council before full agreement on the essential components of the SRF had been achieved.

202. It is important to note that in spite of the way the process unfolded , the existing portfolio of CRPs draw on the selected six Thematic Areas in which the CGIAR has and will develop strong competencies and have a reasonable alignment with the four System Level Outcomes selected in the this SRF. Table A.3, placed as Annex II to this document, presents the alignments between the fifteen CRPs and the four system level outcomes. Although the relationships that have been identified have some degree of subjectivity the results from the analysis are encouraging highlighting that a successful development of the portfolio of CRPs would make a significant contribution to the selected system level outcomes. They also suggest that in the future more efforts must be made to improve the alignment of research activities with the system level outcomes

through a better design of the impact pathways of the CRPs as a whole and of components within each CRP.

203. In addition, it is also important to emphasize that the process has resulted in a significant step forward on a number of aspects of the reform process:

a. it has led, for the first time, to the identification of a common research strategy for the fifteen existing Centers;

b. it has led to identification of six research areas in which the CGIAR will build strong competencies, all of which are clearly aligned with the regional priorities identified by Regional Organizations;

c. it has moved the CGIAR into a full implementation of a AR4D perspective including the clear alignment of research with four system level outcomes; and

d. it has put in motion a process by which the CGIAR Centers will act collectively to face the challenges ahead.

204. But it has also implied that in the absence of guidelines established in advance for the development of the research agenda, the existing portfolio of CRPs has some inconsistencies that need to be addressed during the transitional period.

5.1 Transitional issues for the implementation of CRPs

205. The following are four perceived major issues that the CGIAR Fund, Consortium, and Centers must confront in the immediate future: a) recognizing the existing commitments of Centers, b) including existing system-wide activities in the new mode of operations, c) phasing in the CRPs that have been be approved by the Fund Council and those that will be approved in the near future, and d) adjustment, as much as possible, of the CRPs to the strategic and management principles that have been delineated in this SRF.

Recognizing Existing Commitments of Centers

206. At present, Centers operate with significant proportions of bilateral funding. This means that, although a significant part of the work funded through bilateral projects fits in with the overall SRF, most Center staff will be committed to delivering outputs on existing contracts over the next two to three years. External partners presumably face the same situation.

207. An orderly transition of funding and research directions must be managed without the need to renege on existing contracts. In addition, the transition must ensure an orderly move from unrestricted funding of Centers to funding of CRPs, in order to avoid financial shocks that could seriously harm individual Centers. In this respect, it is extremely important that donors, through their financial commitments to the Fund, insure a funding envelope that is consistent

with the evolution of CGIAR funding and the new needs that arise from the reform process.

Including Existing System-wide Activities in the New Modes of Operation

208. A second dimension relates to the continuing system-wide and challenge programs. The management models used by system-wide programs generally fit well within the new CGIAR and they can be integrated into the CRPs.

209. On the other hand the existing five challenge programs have all developed different governance and management models which in some cases differ from the anticipated structures for the CRPs. A case-by-case approach to make them convergent with the new CRP objectives and management styles will be used.

210. To continue under a CRP, however, existing programs or other work must demonstrate a clear link to the system-wide outcomes required or defined by this SRF. If this link cannot be shown clearly and explicitly, the work will have to be terminated upon completion of existing contracts, unless the center concerned can fund it independently. Existing work that continues under a CRP must be explicitly included in it and must be subject to the performance contracts.

Adjustment of CRPs to the SRF Guidelines

211. As has already been mentioned, the existing portfolio of CRPs has been formulated before the approval of this SRF. As a consequence, the current drafting of some issues may not be totally compatible with the principles and the conceptual framework defined in the SRF and require examination.

212. These inconsistencies revolve around three main issues:

    i. The link between research outputs and SLOs. The current portfolio of CRPs has been predominantly constructed starting from research outputs and research outcomes rather than from clearly identified development outcomes as proposed in this SRF. Each CRP component should, according to the SRF, be defined in terms of clearly identified development outcomes and clear pathways and partnership arrangements should be described.

    ii. Governance and Management Structures: The SRF gives clear indications as to the governance and management structures that should guide the implementation of CRPs.

    iii. Best Interaction and potential synergies between CRPs

213. All these three issues are currently being addressed in the development of CRPS. With regards to the governance and management structure, the recommendations of the CB to the proponents are for a strict adherence to the prescriptions given in this document. The response has been very positive. On the definition of boundaries among CRPs to ensure the maximum possible interaction, complementarities, and synergies among them, it is acknowledged that the current CRP portfolio developed without the SRF guidelines may have weaknesses. In this respect, the CB has made explicit recommendations

to the various proponents of CRPs aimed at ensuring that related research components in different CRPs will, at the scientific level, complement each other in the implementation phase in order to reach the system-level outcomes desired. The results seen so far have been satisfactory. It is acknowledged that the adjustments with regards to the above-mentioned first issue, are the most difficult ones to address at this late stage of CRPs development.

214. The CB will continue to the best of its ability, with its current efforts of accommodating to the SRF guidelines, the thirteen CRPs that have not been approved to date. This should not, however, in the light of the realities of the far-from-perfect process that has been agreed between Centers and Donors, be a pre-condition for the CB or the Fund Council granting its approval if they conform to the evaluation criteria agreed between the CB and the ISPC. A transition period has been proposed as the most pragmatic approach to continue with this adjustment process after the approval of the Fund Council.

215. The submission of operations plans will also provide an opportunity for the proponents of CRPs, including those of the two fast tracked CRPs that have already been approved by the Fund Council, to introduce adjustments to align to the guidelines provided by this SRF.

Insuring an appropriate funding envelope during the transition period

216. During the transition period, funding will move from the present situation, where all the funding comes from bilateral unrestricted and restricted funding to individual Centers, to collective funding through the Fund for approved CRPs. While CRPs are approved and operationalized, some Centers may suffer funding problems that need to be adequately considered. A smooth process needs to include an effective development and approval of the new agenda and appropriate funding mechanisms to preserve the existing institutional capacities and prepare the CGIAR for its new organizational and funding structure

5.2 Evolution of the SRF: looking into the future

217. The existing portfolio of CRPs is an institutional asset of the CGIAR. They represent a significant effort and show a good understanding, by the Centers, of research problems that may contribute to the wellbeing of the poor. Not all of them will necessarily be approved and implemented but all of them provide a good basis on which the CGIAR can continue to develop, and make more relevant, its research agenda. It is important to stress that the CGIAR portfolio of CRPs must be seen as part of a "living agenda" which evolves as new problems and opportunities are indentified, new CRPs are developed to respond to them, new funding is made available, and existing CRPs mature and come to an end.

218. The "second generation" of CRPs that will be developed in the future will have to fully adjust to the principles and criteria set forth in this SRF, and the Consortium

will have to strengthen its capacities to do so. A number of dimensions need to be consolidated in the process of further CRP development:

a. Research activities and outputs must be aligned with the four system level outcomes

b. The CRPs must be seen as the research instruments of the CGIAR system

c. Research inputs to the CRPs must be designed to include activities across Centers

d. CRPs should cut across Thematic Areas drawing on the capacities and competencies that are available in the Centers and in other outside partners

e. A major proportion of the overall CGIAR research agenda must be integrated into CRPs

f. Agricultural production system research should increase and progressively become the focal point for the integration of commodity and natural resources research

g. CRPs must become the vehicle for the integration of public and private research

219. Furthermore, in the foreseeable future, and not later than within six years, a new SRF will need to be developed. The next SRF will have to examine:

a. the implementation of the present SRF, evaluating success and shortcomings and extracting the appropriate lessons

b. The need for possible institutional changes and adjustments in current Centers' functions to better serve the new CGIAR Vision and contribute to the system level outcomes in an efficient and effective way

c. The need to incorporate new areas of competencies or abandon some of the existing ones in response to the evolving scenario and the emergence of new challenges and opportunities

d. The evolving roles, functions and capacities of main partners in international research

220. In order to be prepared to deal with these new challenges the Consortium Board will work in the development of institutional capacities in a number of areas. Three of them appear as especially important and are described below.

Strengthening the CGIAR's Strategic Capacity

221. Developing a new strategy at the system level has been a big challenge for the CGIAR. This is the first time that this has been done and the analytical basis had to be assembled from scratch.

222. In a rapidly changing world of ever-greater complexity, the CGIAR needs to be able to anticipate and respond to new challenges, harnessing the best of science

to address global food, agricultural and environmental problems. The new CGIAR must have the capacity to look ahead and work with partners to undertake strategic studies so that it can adjust its research portfolio and reinvigorate its SRF at regular intervals.

Consortium Board role in developing the new generation of CRPs

223. In the future, the Consortium Board will assume, in collaboration with Centers and relevant partners, the responsibility for developing agricultural and research scenarios and identifying the main development problems and desired outcomes that would lead to the second generation of CRPs

224. The portfolio of existing CRPs, if they are approved by the Fund Council, will constitute the initial pillars of the work of the CGIAR. However, this portfolio should be seen as a "living agenda" where CRPs will come to an end as they complete their timeline and new CRPs are identified, developed and approved.

225. The Consortium Board, on the basis of scenarios developed and other available information, should lead this process of CRP identification and development. New conceptual frameworks and rules and principles may be developed during the period of implementation of this SRF. One main element of the exercise will be to evaluate the consistency and balance of the existing portfolio of CRPs and to identify the existing gaps.

Integrating GFAR and GCARD in the SRF development and monitoring processes

226. The SRF has evolved in close interaction with the GCARD within GFAR. Earlier versions of the SRF were part of the regional discussions and the research priorities and approaches existing at the time of the GCARD 2010 were subject to extensive discussion at the conference itself. At this time it was found that there was broad congruence between the eight thematic areas then proposed and the priorities and needs identified through the regional consultation process. However, a number of specific comments were made concerning the coverage of the thematic areas as well as their implementation strategies, particularly the best management structures to align them with national and regional research priorities and development policies and regarding partnering strategies.

227. These discussions and concerns have been summarized in the GCARD Road Map for a Transformed Global AR4D System and have been fully considered in the development of the SRF. Their convergence is highlighted at the same strategic objectives level, where they share the calling for a renewed pro-poor collective effort in research through a partnership mode focused on clearly identified development problems. In this sense, the CRPs represent a critical instrument for the implementation of the Road Map objectives as they a) are outcome-focused on themes embedded in the wider development agenda with intent to create large development impacts worldwide, b) address the involved issues from an innovation system perspective, c) work to involve all relevant stakeholders in their best possible roles not only in research but also to transform it into innovations and development outcomes, d) look to put in place the capacities and investments necessary for partners to perform effectively, and e) involve

pertinent stakeholders in the effective monitoring, evaluation and reporting of outputs and outcomes.

228. In the future, the interaction with the GFAR/GCARD is expected with respect to three main aspects. The first is related to the discussion of the future scenarios that will contextualize research priorities in the CGIAR. GCARD 2012 will come at a most appropriate time for an open discussion of the evolution of the main drivers of the context to be addressed as well as of how the different actors of the AR4D global system plan to position themselves to meet the emerging challenges. At a more operational level, GCARD 2012 will offer the opportunity to (i) take, together with partners and other stakeholders, a critical look at the current portfolio of CRPs and identify possible adjustments needed, and (ii) formally undertake a first approach at the monitoring and feedback from the partnering strategies through which they are implemented. The diversity of stakeholders participating in the GCARD process provides an invaluable opportunity to bring about the plurality of views, perspectives and needs that make the essence of the collective action approach implicit in the conception and implementation of the SRF. This collaborative work does not preclude the possibility that individual CRPs use other mechanisms to gather feedback from stakeholders who are relevant to their particular area of work.

ANNEX I - THE CONTRIBUTION OF AGRICULTURAL RESEARCH TO SYSTEM LEVEL OUTCOMES: EVIDENCE AND PREDICTION

Most evidence for the development benefits of agricultural research and its outputs relates to reduction in levels of poverty, usually measured at a local or national level. A case study analysis by the CGIAR of the extent to which agricultural research has led to local or national poverty reduction has, for instance, identified poverty impacts at the national scale with rice and maize variety adoption in Bangladesh, China, India and Zimbabwe and at a local scale with, for instance, new fishpond/vegetable technologies in Bangladesh, and soil fertility replacement due to agro-forestry in Kenya (Atado and Meinzen-Dick 2007). Five of the seven programs evaluated involved CGIAR research.

At a regional level, Hazell (2009) has made a critical review of agricultural investments by the CGIAR and its partners, considering research in the post-Green Revolution period (i.e., since the early 1980s) in South Asia. His analysis concluded that productivity improvements have yielded substantial indirect impacts on food security and poverty alleviation via price effects.

Other analyses of the outcomes of agricultural research for development by the CGIAR (CGIAR 2008) or more generally (Spielman and Pandya-Lorch 2009) provide evidence of improved productivity, improved nutrition and reduced environmental impact of agriculture. While the greatest evidence of impact has been accumulated for investment in plant breeding research, this is the most methodologically straightforward approach and has also been the area of greatest investment over the longest period hence it offers more opportunity for evaluation. Evaluations of more recent investments in natural resource management and policy research have shown promising impacts, generally on a more local, national level.

What is the potential scale of outcomes and impacts likely from future investment in agricultural research for development by the CGIAR and its partners? Some insight on this question has been generated using the Integrated Modeling Platform for Animal and Crop Systems in the Tropics (IMPACT), a modeling tool developed by the International Food Policy Research Institute (IFPRI).[21] The scenarios use several combinations of factors, including investments in agricultural R&D, efficiency of agricultural R&D, investments in irrigation, changes in natural resource management, and changes in agricultural marketing. More specifically:

- Scenario 1a is an increased agricultural research investment scenario that assumes a 60 percent increase in the growth rates of crop yields,

21 Here only an overview is given. IMPACT has 115 countries (or in a few cases country-aggregate regions), within each of which supply, demand and prices for agricultural commodities are determined. Large countries are further divided into major river basins. World agricultural commodity prices are determined annually at levels that clear international markets. Growth in crop production in each country is determined by crop and input prices, exogenous rates of productivity growth and area expansion, investment in irrigation and water availability. Demand is a function of prices, income and population growth and contains four categories of commodity demand – food, feed, biofuel feedstock and other uses. For details of results and model design, see report by Rosegrant et al. (2009) on the Alliance website.

across all crops, and 30 percent increase in the growth rates of livestock production, over a baseline extrapolated from current trends

- Scenario 1b is the same as Scenario 1a, but with added emphasis on investment in agricultural R&D in South Asia and Sub-Saharan Africa
- Scenario 2 combines improved natural resources management with enhanced market efficiency
- Scenario 3 is a comprehensive scenario that combines increased investment with more efficient research, expanded irrigation infrastructure, improved natural resources management and enhanced market efficiency

The model produces projections in the production and prices of various commodities for these scenarios, extending to 2025 and 2050. The alternative policy and investment scenarios overlay a baseline that assumes a continuation of current trends in population and agricultural and economic growth and that postulates moderate climate change through 2050. For each scenario, changes in yield, total production (crops and livestock), world prices, trade and child malnutrition are presented for 2025.[22]

Table A.1 shows changes in production and prices for important crop and animal products under the four scenarios that inform the results focus of the strategy. The different scenarios also have implications for nutrition, as shown in Table A.2.

22 For the results on 2050, see background paper on Alliance website

Table A.1 Production and price changes under various investment and policy scenarios, 2025

Commodity	Scenario 1a	Scenario 1b	Scenario 2	Scenario 3
	(% change in production in developing countries from baseline scenario)			
Rice	3.8	5.0	5.2	10.7
Wheat	5.0	5.2	7.4	13.2
Maize	3.7	2.4	4.8	9.4
Groundnut	6.0	7.7	4.8	12.0
Cassava and other roots and tubers	8.1	11.2	4.8	14.8
Vegetables	9.2	11.2	5.3	17.2
Beef	4.8	5.5	5.0	13.1
Poultry	5.3	6.2	4.1	12.4
	(% change in world prices from baseline scenario)			
Rice	–7	–10	–4	–13
Wheat	–12	–15	–4	–17
Maize	–18	–24	–3	–22
Groundnut	–14	–17	–5	–20
Cassava and other roots and tubers	–21	–28	–2	–24
Vegetables	–10	–12	–1	–14
Beef	–5	–6	–1	–9
Poultry	–7	–8	–1	–10

Source: IFPRI IMPACT, Rosegrant et al. for Strategy Team, 2009. See Alliance website for full report.

Overall, Scenario 3, the comprehensive scenario, achieves the largest yield production increases for farmers and hence the greatest reductions in prices and childhood malnutrition. These figures point towards the scale of investments needed to achieve real progress in alleviating poverty and hunger, and in turn towards the kinds of research needed and the outcomes such research should seek to achieve. (It is acknowledged that an efflux to off-farm or out-of-landscape employment must still play a major part in rural poverty alleviation if overall smallholder farmer incomes are not to decrease, given the drop in market prices.)

An important feature of this modeling exercise is that it allows the study of distinct yet complementary contributions of increased agricultural productivity ("investment in agricultural R&D" and "expanded irrigation infrastructure"), improved policies

("enhanced market efficiency" and "more efficient R&D"), and improved natural resources management. All of these areas are demonstrably improved by agricultural research, and the CGIAR has a strong track record in delivering in all of them.

Table A.2 Child malnutrition under various investment and policy scenarios (millions of children), 2025

Region	2005	2025 baseline	Change from baseline scenario			
			Scenario 1a	Scenario 1b	Scenario 2	Scenario 3
South Asia	75	70	–2	–3	–2	–4
East Asia and the Pacific	23	18	–2	–2	–1	–3
Eastern Europe and Central Asia	4	4	0	0	0	0
Latin America and the Caribbean	8	8	–1	–1	–1	–1
Middle East and North Africa	3	3	0	0	0	–1
Sub-Saharan Africa	39	49	–4	–5	–3	–7
Developing countries	152	152	–9	–12	–7	–17

Source: IFPRI IMPACT, Rosegrant et al. for Strategy Team, 2009.

Note: The 2025 baseline scenario is with climate change.

Although increasing agricultural productivity (Scenario 1) makes the largest contribution in terms of reducing the price of staple crops, the other scenarios also make significant contributions, and the effect of all factors is usually greater than the sum of the parts when it comes to improving rural livelihoods.

Of particular relevance to this SRF are the observations, from this model that:

- Interventions arising from research outcomes in different areas can make substantial individual contributions to indicators of System Level Outcomes
- Combining these interventions can have an additive effect on System Level Outcomes

Focusing interventions, e.g. on key areas of poverty, can enhance this effect. There is an encouraging evidence base for the contribution of agricultural research to development outcomes, much of it generated by CGIAR research, and a strong indication that better integration of the separate areas of successful CGIAR research will have additive effects which will accelerate the achievement of System Level Outcomes. At the same time, CGIAR work has had to incorporate the complexities of rain fed agriculture most often with inadequate service delivery and market failures, and changing policy contexts. The research problems have become more complex, the productivity gains smaller and more costly to achieve and the policy, market and institutional context within which technical innovations are delivered in key regions

such as Sub-Saharan Africa more constrained. What is needed now is a more integrated approach to CGIAR research across the R&D continuum to deliver this accelerated progress, through a program of outcome-led research and the development of more effective partnerships.

ANNEX II - COMPARING SYSTEM LEVEL OUTCOMES WITH ELEMENTS OF CRPs.

In this table, we present a comparison of outcomes identified in draft and approved SRFs with the System Level Outcomes (SLOs) of the SRF. This table has been produced by selecting from each CRP statements about outcomes which correspond to SLOs. This is a subjective judgment and therefore this table is intended as indicative. Furthermore, some CRP outcomes may apply to more than one SLO, particularly because targets related to rural poverty, hunger and food security are often conflated.

For each CRP, some SLO-relevant outcomes represent a very important element of the CRP's intended outcomes, while others are secondary or arise simply as a consequence of addressing another SLO. In the table, cells representing SLOs which appear to be the most important outcomes targeted by the CRPs are shaded. Thus, CRPs 1.1-3 and 3.4-7 are directed particularly to rural poverty, while CRPs 3.1-3, on rice, maize and wheat are directed both at rural poverty and food security, as is CRP2. CRP4 is distinctive in its focus on nutrition, while CRPs 5, 6 and 7 have the most substantial focus on environmental sustainability, although CRP7 is particularly cross-cutting. Across the current CRPs, therefore, there is coverage of all the SRF SLOs.

Table A.3 COMPARING SYSTEM LEVEL OUTCOMES WITH ELEMENTS OF CRPs

OUTCOME	Rural Poverty	Food Security	Improved nutrition	Sustainability
INDICATIVE FEATURES	Improvement in income and household food security for the rural poor	Improvement in sustained access to affordable food by rural and urban poor	Improvement in health of the poor, particularly women and children	Improved sustainability of ecosystem services through reduced degradation
CRP				
1.1 Integrated agricultural production systems for the poor and vulnerable in dry areas	Increased productivity and higher and more stable farmer incomes; improved household assets; number of people living below US$1 and US$2 per day in targeted areas reduced by around 15%; purchasing power of smallholders increased by 10% in target systems, providing more secure access to food supplies	Improved crop and livestock productivity by 20%; variability in productivity reduced in target systems	Improved nutrition, especially amongst women, children and the landless	Productive quality of environmental resources improved and maintained; environmental degradation reduced
1.2 Integrated systems for the humid tropics	Improved economic returns to farmers and farm-related industries; increased productivity, profitability and household incomes (by at least 25%)	Increased productivity, access to markets and consumer demand	Improved household welfare; increased diversity of food consumption	Maintain long term biological and ecological integrity of resources
1.3 Harnessing the development potential of aquatic agricultural systems for the poor and vulnerable	Increased benefits for producers; strengthened resilience of poor and vulnerable households arising from increased production and new products	Sustainable increases in productivity from aquatic agricultural systems; more products for consumers	Health and nutritional benefits	Improved land and water management
2. Policies, institutions and markets to strengthen assets and agricultural incomes for the poor	Reduction of 7-10% in poverty due to improvements on market access, thereby reducing marketing margins, increasing farm-gate prices, and boosting the production incomes of rural households; more secure environment for uptake of new technologies increases efficiency of production by 1-3%; diversification of non-farm income and reduced risks	Global crop, livestock and fish production increased by 10-15%; 4-6% increase in calorie consumption by the poor due to lower prices and higher farm incomes	Reduced child malnutrition by 3-5%	Reduction in crop area by 3-4%, thereby freeing land for conservation

3.1 WHEAT: Global alliance for improving food security and livelihoods of resource poor in the developing world	Reduced vulnerability, increased productivity and household food security in wheat-growing low income countries; increased productivity adds an annual value of US$ 1.3 billion (by 2020) to US$ 10 billion (by 2030), and these benefits reach 30 million farmer members	Increase in productivity by about 50% helps to address growing global consumer demand; increase in production in the target domain by 28% by 2030 provides enough wheat grain to meet the annual food demand of an additional 57 million (in 2020) to 420 million (in 2030) consumers; climatic tolerance stabilizes prices	Breeding for enhanced micronutrient quantity and quality and improved food safety by reducing mycotoxins	Increased land, fertilizer and water use efficiency; reduced need for farmers to expand wheat area into grass lands
3.2 MAIZE: Global alliance for improving food security and livelihoods of resource poor in the developing world	Sustainable intensification and income opportunities for the poor in maize-based systems; increased productivity adds an annual value of US$ 2-8.8 billion, and these benefits reach 40-175 million smallholder farm family members	Doubling productivity helps to address growing global consumer demand; drought tolerance decreases price fluctuations; increased productivity in the target domain by 7-33% by 2020/2030 provides enough maize grain to meet the annual food demand of an additional 135-600 million consumers	Improved health through nutritional enrichment (quality protein, vitamin A and other micronutrients); improved food safety by reducing mycotoxins	Increased land, fertilizer and water use efficiency
3.3 GRiSP: A global rice science partnership	Rice becomes a better engine for rural economic growth and employment; reductions in food prices lift 133 million Asian people above the US$ 1.25 PPP poverty line, reducing the number of poor by 15%	Increased global rice yields and grain availability reduces rice prices for urban poor, which may allow 107 million undernourished Asians to reach caloric sufficiency, reducing hunger by 20%	Improved health through nutritional enhancement	Sustainable cropping systems resilient to climatic extremes and climate change; water and nitrogen efficiency; increased global rice yield leads to 3 million hectares less land used for rice, thereby saving natural ecosystems
3.4 Roots, tubers and bananas (RTB) for food security and income	More resilient farming systems with increased productivity, food security and income for poor farmers, potentially benefiting at least 180 million poor - 84 million in Africa, 81 million in Asia, and about 16 million in Latin America and the Caribbean	Improved value chains and markets for RTB products	Improved nutritional quality of new cultivars and production and postharvest improvements to reduced risk of nutritional shortfalls	RTB cultivars respond well to simple cultivation methods, with minimal soil preparation and low external input use

3.5 Grain legumes: enhanced food and feed security, nutritional balance, economic growth and soil health for smallholder farmers	Farmers increase income from sales of surplus grain and fodders	Reduction in cost of legumes to consumers due to grain yield gains	Rural households and urban consumers increasing consumption of nutritious grain legumes	Reduced nitrogen depletion and improved soil fertility
3.6 Dryland cereals: food security and growth for the world's most vulnerable poor	Farmers reduce risks and increase net income	Improved value chain, surplus sales and demand for dryland cereals due to grain yield gains	Increased consumer acceptance and demand for highly nutritious dryland cereals	More sustainable and efficient livestock production due to surplus of feed stocks
3.7 Sustainable staple food productivity increase for global food security: livestock and fish	Improved income to farmers through eight improved value chains and secured household and community assets	Increased supply of livestock and fish products	Improved access to animal source foods to improve nutrition, especially of women and children	
4. Agriculture for improved nutrition and health	Improved household nutrition and health from greater production and consumption of nutritious foods, thereby reducing estimated annual costs of US$ 20-30 billion to economic development	Improved value chains creating increased choice of nutritious foods for the poor	Reduced disease risks and improved nutrition, improving health especially for women and children at vulnerable life stages; reduction in agriculture-associated diseases responsible for annual losses of 12 million disability-adjusted life years annually, being- 1/12 of the total disease burden and 1/4 of the total infectious disease burden worldwide	Reduced disease risk from improvement of degraded environments
5. Durable solutions for water scarcity and land and ecosystem degradation	Improved and safeguarded access to land and water resources; benefit to 135 million of poor smallholders in Sub-Saharan Africa and India from improved small scale water management practices; in India, low cost water technologies could lead to an aggregated agricultural income increase of US$ 83 billion	Greater land and water productivity and nutrient use efficiency delivered, likely to lead to a doubling or tripling of crop yields	Safe wastewater re-use	Improved land and soil health and water quality to reduce degradation and rehabilitation of degraded land; improved ecosystem services; building resilience by enhancing the ability of people to manage water and land to sustain ecosystem services

6. Forest, trees and agroforestry: Livelihoods, landscapes and governance	Improved household incomes from tree products and management options; climate change adaptation programs and REDD credits worth between US$108 million and US$2,695 million			Environmental services to agriculture from forests and trees maintained; changes in climate mitigated; between 0.5 and 1.7 million hectares of forest saved annually; useful biodiversity conserved; carbon emissions reduced by between 0.16 and 0.68 Gt CO_2 yr^{-1}
7. Climate change, agriculture and food security	Enhanced rural livelihoods through reduction in vulnerability to abiotic and biotic stresses and shocks from climate change, helping to reduce poverty by 10%; 25% reduction in number of rural poor who are undernourished	Improved food security for rural and urban poor through more stable food production		Reduced greenhouse gas emissions by 1000 t CO_2-eq from agriculture and improved carbon storage

1 Process and Sources

The overall framework and objectives of the SRF were built over many months of research, analysis, consultation, and discussion. The overall approach taken was to:

- Consult broadly with research communities inside and outside the CGIAR and use related systematic surveys;
- Draw on modeling and mapping tools and studies; and
- Communicate with leaders in relevant professions and with well-known visionaries.

Much of the work is documented in the following materials:

- Scenario analyses using the IFPRI IMPACT model ("Agriculture and Food Security under Global Change: Prospects for 2025/2050")
- Simulations of the needed scale and impact of agricultural R&D investment ("R&D Investment in National and International Agricultural Research: Productivity and Poverty Impact and Allocation among Regions")
- Comprehensive mapping ("Geographic domain analysis")
- Decision support with an analytical hierarchy (expert choice) model ("An AHP-Expert Choice Model for the Strategic Results Framework of the CGIAR")
- Large-scale scientists' survey of key opportunities for international agricultural research ("Analysis of the Questionnaire for Elicitation of Key Opportunities for International Agricultural Research")
- Workshops with leading scientists ("Summary Report from the Technical Design and Implementation Meeting of Scientists")
- Workshop on poverty ("Current Status and Future of Poverty Research in the CGIAR")
- Report on gender in the CGIAR strategy, with findings from e-consultations ("Recommendations for Gender Integration in the CGIAR Strategy and Results Framework")

The initial steps in the process of working from the system level objectives to a series of Thematic Areas or CGIAR main competencies and the CRPs that would deliver them was iterative and evolutionary.

To define the specific location of the CGIAR investments, comprehensive and innovative mapping methods were used to complement modeling in developing the SRF

and the CRPs. This approach brought together for the first time information on poverty, production, market access, and ecosystems challenges in spatially disaggregated ways. It also helped to identify sub regional and agro-ecosystem priorities and hot-spots for R&D activities. The detailed mapping of multiple, overlaid categories of information can contribute to the detailed planning of the CRPs, now under way.

A large-scale survey of scientists was also undertaken and used to explore Thematic Areas and CRP opportunities. About 400 scientists participated, suggesting altogether more than 500 research opportunities. The findings were also used in the regional consultations undertaken by GFAR.

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