

**CGIAR
Research
Program 4**

Proposal Submitted by:
International Food
Policy Research
Institute

IFPRI

ILRI

BIOVERSITY

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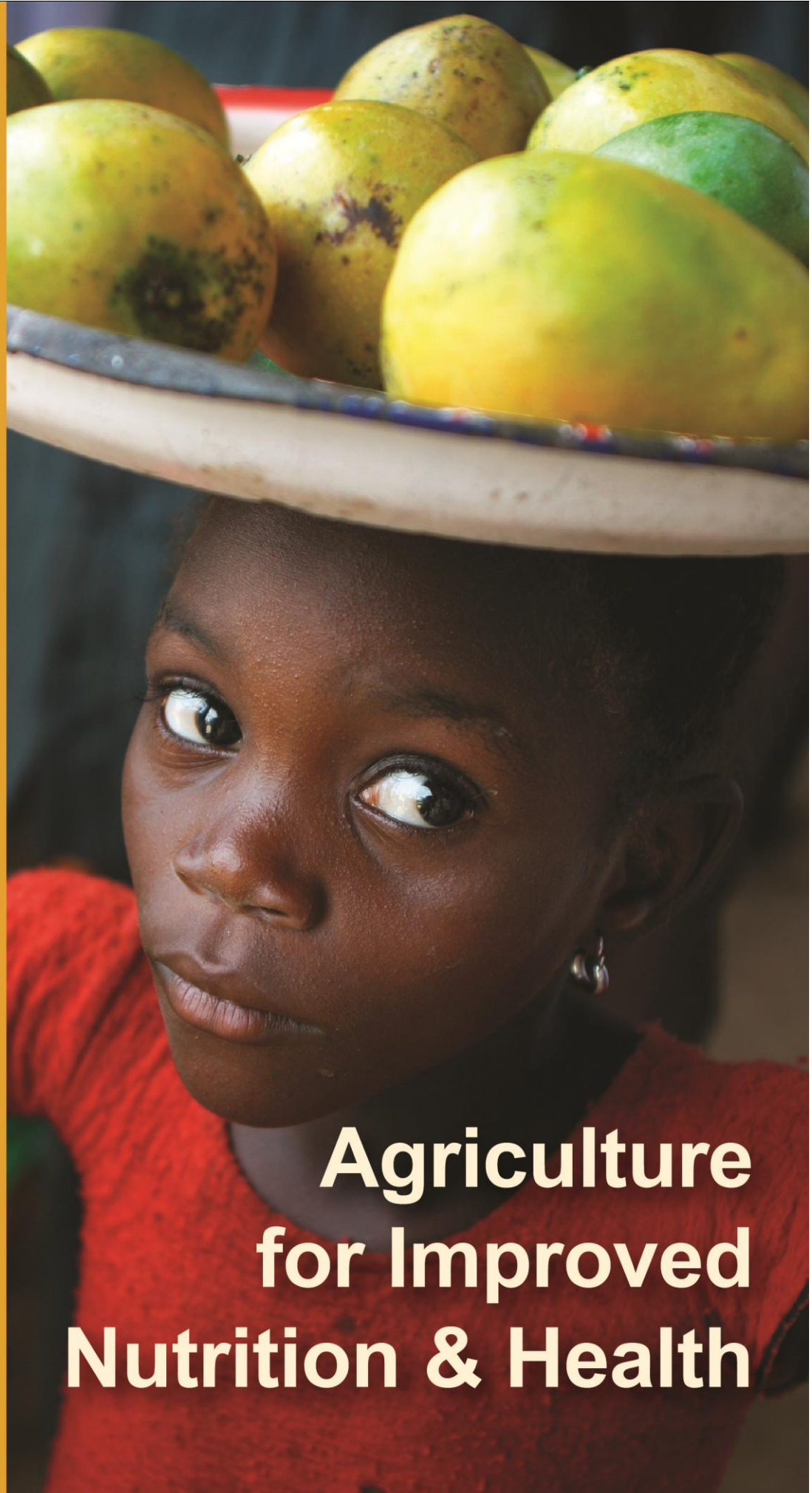
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WORLD FISH



**Agriculture
for Improved
Nutrition & Health**

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ACRONYMS

AAD	agriculture associated disease
ANH	agriculture nutrition health
ARDAP	Appropriate Rural Development Agriculture Program
ARIs	advanced research institutes
ART	antiretroviral therapy
AU-IBAR	African Union Interafrican Bureau for Animal Resources
CAADP	Comprehensive Africa Agriculture Development Program
CBA	cost benefit analysis
CBO	community-based organizations
CEA	cost-effective analysis
CGIAR or CG	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CIRAD	Agricultural Research Development
CREADIS	Community Research in Environment and Development Initiatives
CRP	CGIAR Research Program
CRS	Catholic Relief Services
CSO	civil society organizations
DALYs	Disability Adjusted Life Years
DFID	United Kingdom Department for International Development
DRC	Democratic Republic of Congo
ECOWAS	Economic Community of West African States
E-HFP	Enhanced Homestead Food Production
EID	Emerging Infectious Diseases
EMBRAPA	Brazilian Agricultural Research Cooperation
EU FP-7	European Union Framework Program 7
FAO	Food and Agriculture Organization of the United Nations
FERG	Foodborne Disease Burden Epidemiology Reference Group
FIND	Foundation for Innovative New Diagnostics
GAIN	Global Alliance for Improved Nutrition
GALVmed	Global Alliance for Livestock Veterinary Medicines
GFSI	Global Food Safety Initiative
GXE	gene by environment
HIV/AIDS	<i>Human immunodeficiency virus</i> /acquired immune deficiency syndrome
HKI	Helen Keller International
IARC	International Association of Research of Cancer
ICARDA	International Center for Agricultural Research in Dry Areas
icipe	International Centre of Insect Physiology and Ecology
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre
IEC	Information, Education and Communication
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILAC	Institutional Learning and Change
ILO	International Labor Organization
ILRI	International Livestock Research Institute

IPMA	Integrated Partnership for Malaria in Africa
IRD	Institut de Recherche pour le Développement
ITG	International Technology Group
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
KARI	Kenyan Agricultural Research Institute
London-RVC	London – Royal Veterinary College
LSHTM	London School of Hygiene & Tropical Medicine
M&E	monitoring and evaluation
MDG	Millennium Development Goals
NARS	National Agriculture Research System
NGO	Nongovernmental organization
OFSP	Orange-Fleshed Sweet Potato
OIE	The World Organization for Animal Health
PACA	Partnership for Aflatoxin Control in Africa
PATH	Program for Appropriate Technology in Health
PHAST	Participatory Hygiene and Sanitation Transformation
QCRA	Quantitative Comparative Risk Assessment
QMRA	Quantitative Microbial Risk Assessment
RAIN	Realigning Agriculture to Integrate Nutrition
REACH	Ending Child Hunger and Undernutrition
ReSAKSS	Regional Strategic Analysis and Knowledge Support System
RRCs	Rural Resource Centers
RVF	Rift Valley fever
SA	South Asia
SARS	severe acute respiratory syndrome
SSA	Sub-Saharan Africa
STPH	Swiss Tropical and Public Health Institute
SUN	Scaling-Up Nutrition
TropIKA	Tropical Diseases Research to Foster Innovation & Knowledge Application
UN	United Nations
UNAIDS	The Joint United Nations Program on HIV/AIDS
UNICEF	The United Nations Children’s Fund
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VMFs	Village Model Farms
WAHO	West African Health Organization
WB	The World Bank
WFP	World Food Programme
WHO	World Health Organization
WTP	Willingness to pay
WWF	World Wildlife Fund
β-ODAP	β-diaminopropionic acid

FOREWORD

The CGIAR has committed itself to ensuring that agricultural research serves the needs of the poor. Two urgent needs for the poor are better nutrition and better health. In its new vision (CGIAR SRF 2010), the CGIAR commits to *reduce poverty and hunger, improve human health and nutrition, and enhance ecosystem resilience through high-quality international agricultural research, partnership, and leadership*. This CGIAR Research Program, *Agriculture for Improved Nutrition and Health*, directly and strategically supports this new vision.

Agriculture will need to develop and expand to meet the food needs of a growing population from a finite resource base. How agriculture develops to do this can have critical consequences on the health and nutrition of people. This program is designed to support the overall CGIAR research agenda by improving our understanding and options for how agriculture can better accentuate the positive benefits and mitigate the risks of agricultural development on human health and nutrition. These lessons are meant to serve the entire CGIAR agenda, within agroecological production systems and along food value chains.

Emphasis will be placed on two populations of people. The first group is those people who are left behind by socioeconomic development, suffer from high rates of malnutrition and agriculture associated diseases, and rely on aid and development support. Research in the program will meet the demands of development implementers and investors for better knowledge, technologies, and learning approaches to improving their performance.

The second group is those poor people in dynamically intensifying and changing systems in which research can help shape agricultural development more positively and safely. This program will support policy- and decisionmakers and development implementers. Managing the benefits and risks of agricultural development on human health and nutrition are central to achieving the CGIAR-stated impact goals of poverty reduction, food security, and environmental sustainability for people in developing countries.

This program will work at the interface of the agriculture, health, and nutrition sectors. These are three critical pillars for development. For the ambitions of this program to be met, partnerships will be critical. Twelve CGIAR Centers and multiple partners from agriculture, health, and nutrition communities have actively participated in contributing to the development of this proposal through written contributions, stakeholder and partner workshops, and oral discussions. This program proposes a much closer partnership between the agriculture, health, and nutrition research and development communities than seen previously. New approaches to cross-sectoral work are proposed. While new, this program will build on past successes of CGIAR and partners working together on agriculture, health, and nutrition programs and seeks to complement a number of new international initiatives for improving agriculture-nutrition and agriculture-health integration and synergies.

ACKNOWLEDGEMENTS

This proposal is the culmination of the effort of many internal and external collaborators who worked closely together for more than one year. The process of drafting the initial concept note, which serves as the basis for the proposal, was led by Marie Ruel (IFPRI) and John McDermott (ILRI), with important contributions from Howdy Bouis (HarvestPlus) and focal points from 12 CGIAR Centers. The concept note was submitted to the Consortium Board on May 9, 2010.

The project leaders allowed for comments on the concept note by posting it online for more than 10 weeks. During this time, the note benefited from the useful feedback of the Consortium Board, peer reviewers, CGIAR centers, and external partner organizations. Key internal and external stakeholders were also interviewed in person and by phone to further incorporate their perspectives and ideas.

The centers and partners, representing the full spectrum of the agriculture, nutrition, and health fields, met on July 28-30, 2010, in Addis Ababa, Ethiopia. The three-day workshop was attended by more than 60 stakeholders and represented a unique opportunity to incorporate diverse viewpoints on the research and development goals of the CRP4 program. The meeting was supported by Lynette Aspillera (IFPRI), Loza Mesfin (ILRI), Ginette Mignot (IFPRI), Terry Muindi (ILRI), Nicole Rosenvaigue (IFPRI), and Sivan Yosef (IFPRI). Special thanks goes to Jürgen Hagmann, Global Team Leader for the People, Innovation, and Change in Organisations (PICO Team, www.picoteam.org), for his excellent facilitation, and to his assistant Judith Odhiambo.

The complex task of synthesizing all the components into one document was led by Marie Ruel, John McDermott, and Howard Elliott, who coordinated a core writing team to develop the proposal. The writing team included: Jessica Fanzo and Stefano Padulosi (Bioversity); Bonnie McClafferty (HarvestPlus), Helena Pachón (CIAT), Maximo Torero (IFPRI) and Delia Grace (ILRI). Numerous CGIAR colleagues and partners provided key contributions to the research proposal development, which was submitted to the Consortium Board (CB) on September 11, 2010.

Comments from the CB and four reviewers were received on February 4th, 2011. Marie Ruel and John McDermott coordinated the revisions to the proposal, with strong support from several members of the original writing teams. The revised proposal was shared with the key contact points from all participating CGIAR centers, who contributed extensively to the revisions.

The final proposal benefited from the support of Rajul Pandya-Lorch, Klaus von Grebmer, Teunis van Rheenen and Suresh Babu (IFPRI) and continuous efforts of IFPRI's communications team, including Gwendolyn Stansbury, Evelyn Banda, Pat Fowlkes, Julia Vivalo, Nicole Rosenvaigue, Jody Harris and Clare Wolfowitz (independent consultant).

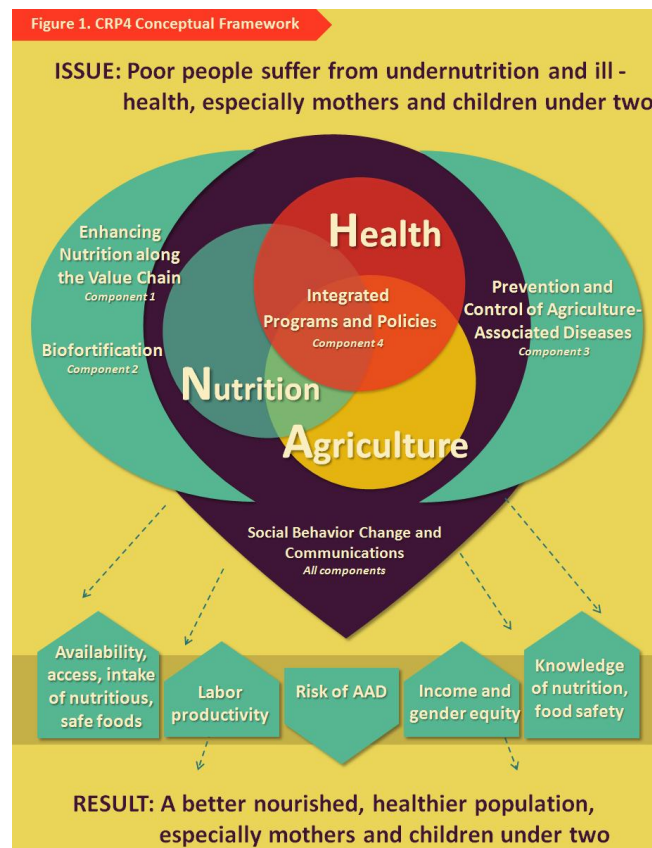
The enthusiasm and responsiveness of all CGIAR partners and their continued support in revising and strengthening this proposal is gratefully acknowledged. Leading organizations in agriculture, nutrition, and health expressed interest in different components of the program and are committed to its development and success. This proposal represents a starting point in an exciting process of operationalizing a cross-sectoral research for development program on agriculture for improved nutrition and health.

1. EXECUTIVE SUMMARY

Background

Hunger, malnutrition, and poor health are widespread and stubborn development challenges. Agriculture has made remarkable advances in the past decades, but progress in improving the nutrition and health of poor farmers and consumers in developing countries is lagging behind. A recent IFPRI 2020 Conference in New Delhi, “Leveraging Agriculture for Improving Nutrition and Health,” brought together about 1,000 stakeholders to examine how agriculture could be energized to become a more powerful tool to tackle the persistent problems of food insecurity, malnutrition, and poor health. Building on the momentum created by those discussions, the CGIAR Research Program on Agriculture for Nutrition and Health (CRP4) is designed to fill the existing gap between agricultural development and its unfulfilled health and nutritional benefits.

The starting point for CRP4 is that agricultural practices, interventions, and policies can be better adapted and redesigned to maximize health and nutrition benefits and to reduce health risks. This concept reflects the new vision of the CGIAR Strategic Results Framework (April 2011), which has four strategic objectives: improving human nutrition and health, reducing rural poverty, improving food security, and achieving sustainable management of resources. While CRP4 will contribute to the achievement of all four CGIAR strategic objectives, its primary focus will be on improving human nutrition and health. In order to achieve this goal, CRP4 will bring together research and development professionals across the agriculture, nutrition, and health (ANH) sectors to jointly tackle key challenges and design joint solutions.



CRP4 Strategic Goal

CRP4 is a research program that will **work to accelerate progress in improving the nutrition and health of poor people** by exploiting and enhancing the synergies between agriculture, nutrition, and health through four key research components: value chains, biofortification, control of agriculture-associated diseases, and integrated agriculture, nutrition, and health development programs and policies.

CRP4 Strategic Framework and Research Components

Figure 1 presents the overall strategic framework of CRP4. The key development challenges that the program will address are the stubborn problems of undernutrition and ill health that affect millions of poor people in developing countries. CRP4 will leverage agriculture to improve the nutrition and health of the poor through four research components that will directly address the problems of low diet quality—

the main cause of undernutrition worldwide—and of vulnerability to agriculture-associated diseases. Component 1 focuses on opportunities to improve nutrition along value chains to increase the poor’s access to nutritious foods. Component 2 aims to improve the availability, access, and intake of nutrient-rich, biofortified staple foods for the poor. Component 3 addresses food safety issues along the value chain, including the control of zoonotic diseases and the better management of agricultural systems to reduce the risk of human diseases. Component 4 addresses the need for integration among the agriculture, nutrition, and health sectors, at both the program and policy levels.

These four components were selected based on discussions and brainstorming with representatives from 12 CGIAR centers and a wide range of partners who participated in the CRP4 planning meeting in July 2010. Their selection arises from the recognition and consensus that poor diet quality and related micronutrient deficiencies are now the most pressing nutritional problem affecting the poor. Similarly, the severe disease burden from food-borne infections and zoonotic diseases is associated with changes in agricultural practice and policy, and therefore requires agricultural solutions. As agriculture is the main livelihood strategy for the poor, it is they who are disproportionately affected by these health and nutrition problems. For CRP4 to adequately tackle these challenges, the program team carefully assessed the opportunities that exist within the current (and future) research portfolio of the CGIAR and its partners in order to leverage agriculture to improve nutrition and health and to exploit their potentially powerful synergies to achieve the common goal of improving the nutrition and health of the poor.

Research Objectives

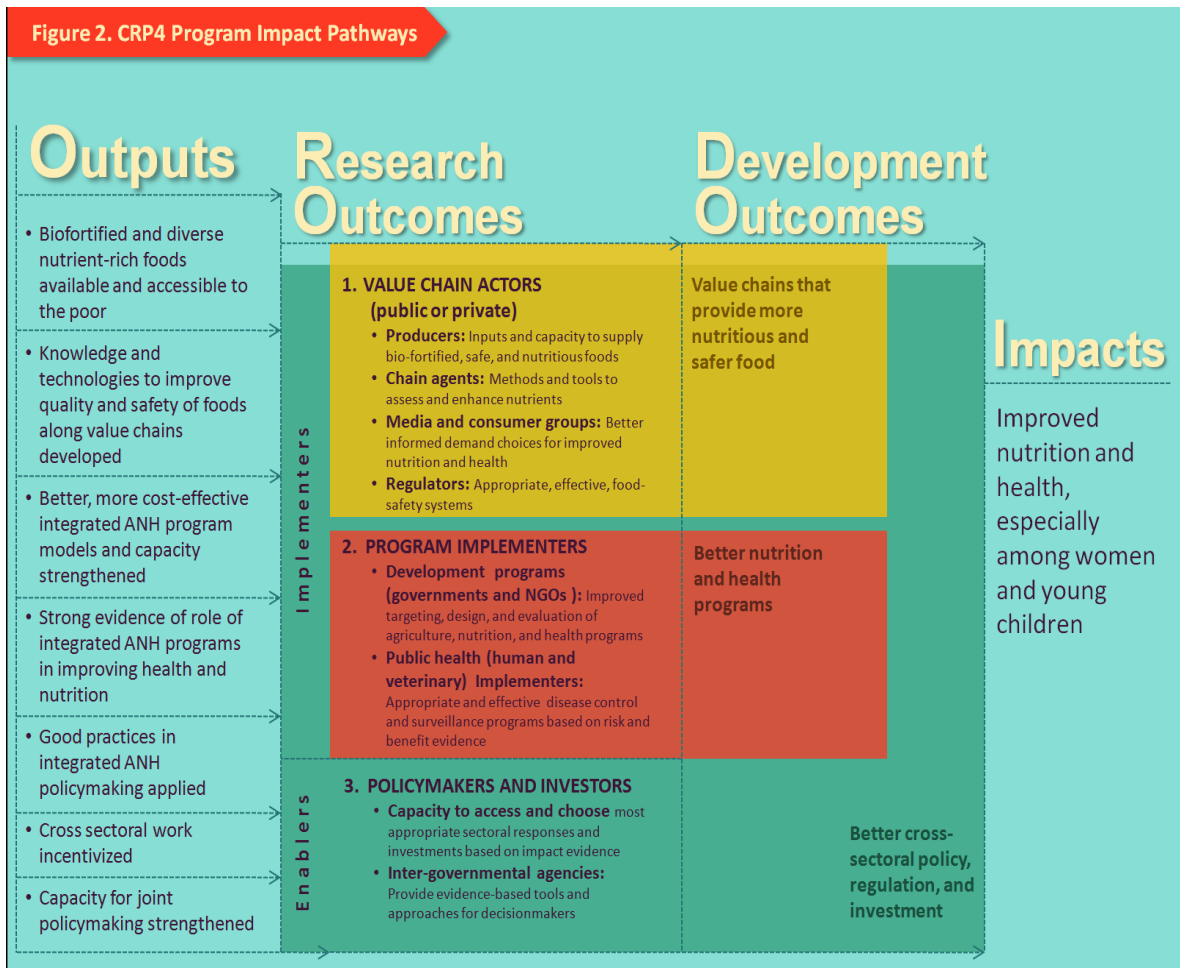
The CRP research objectives across the different components are as follows:

1. Generate knowledge and technologies to improve the nutritional quality and safety of foods along value chains (Components 1, 2, and 3).
2. Develop, test, and release a variety of biofortified foods, as well as other nutrient-rich foods that are affordable for the poor and accessible to them (Components 1 and 2).
3. Generate knowledge and technologies for the control of zoonotic, food-borne, water-borne, and occupational diseases (Component 3).
4. Develop methods and tools to improve the effectiveness, efficiency, and timeliness of surveillance and monitoring systems and to permit meaningful evaluation of complex multisectoral programs and policies (Components 1-4).
5. Produce evidence of nutritional and health burdens and benefits and of the returns to different interventions in different sectors. (Components 1-4).

Impact Pathways

Figure 2 presents the overall program impact pathway. CRP4 is expected to enhance the contribution of agriculture research outputs to nutrition and health impacts through three major impact pathways and their respective actors: 1) *value chains* that provide more nutritious and safer foods; 2) *development programs* that successfully integrate agriculture, nutrition, and health; and 3) *policy* that promotes a supportive and enabling cross-sectoral policymaking process and investment environment. Expected outputs from CRP4 are: value chains that provide more nutritious and safer foods accessible to the poor; stronger and more effective integrated ANH programs; and better cross-sectoral policies, investments and regulation. CRP4 will contribute to large-scale sustainable impacts by developing strong linkages with development implementers, including value chain actors and ANH program implementers, and with enablers such as international and national policy makers and governments.

Figure 2. CRP4 Program Impact Pathways



Partnerships

Effective partnerships and new partnership practices will be essential for achieving CRP4’s ambitious research outputs and development outcomes and impacts. A *partnership strategy* will be developed initially, to create the best conditions for carrying out the research and making full use of the subsequent findings. The unique complexity of CRP4, which requires working across sectors, calls for a range of partnership types and partnership depths. CRP4 will work with four broad categories of partners: enablers (policymakers and decisionmakers), development implementers, value-chain actors, and research partners. We are committed to a partnership process that incorporates strategic thinking, systematic processes with partners, innovative behaviors and resources, and implementation of best partnership performance practices. We regard partners as the essential ingredient of a successful joint effort.

Research Components: An In-Depth Look

Component 1: Value Chains for Enhanced Nutrition—will focus on increasing the demand for nutritious foods among poor rural and peri-urban households, and on identifying leverage points along the value chain where innovative nutrition interventions can be incorporated to stimulate both the supply and the demand for nutritious foods. It will build on work on value chains carried out by the CGIAR and other partners on nutritious (usually high-value) foods. Specifically, it will:

- develop innovative approaches and tools to analyze the value chain, using a “nutrition lens” combined with a consumer focus.
- implement research to identify leverage points to enhance the nutritional value of select nutrient-rich foods.
- develop tools to assess and correct information asymmetries regarding nutrition among different value-chain actors, including consumers.

This component’s impact will result from (1) enhanced nutritional knowledge and awareness created among value chain actors, including consumers, and (2) the greater selection of affordable nutrient-rich foods available and accessible to the poor through informal and formal markets.

Component 2: Biofortification—will develop and test biofortified nutrient-dense staple crops and make these novel crops available to the poor and undernourished. This component will have the desired impact via an increased production and consumption of biofortified staple foods; an increased intake of iron, zinc, and vitamin A; and a resulting reduction in the prevalence of iron, zinc, and vitamin A deficiencies.

Component 3: Prevention and Control of Agriculture-Associated Diseases—will enhance environmental sustainability, reduce poverty, increase food security, and contribute to the health of poor communities by assessing, preventing, and mitigating agriculture-associated health risks, through research for improved food and water safety; control of bacterial, viral, parasitic, or fungal diseases that can be transmitted from animals to humans (zoonoses); and managing agroecosystems for better health. This component will find and develop solutions and innovations to reduce the risks of agriculture-associated diseases; understand and support appropriate institutions and incentives that will make these efforts sustainable; assess the impact of interventions; and develop communications, advocacy, and influence strategies that will enable the uptake and use of those interventions.

Component 4: Integrated Agriculture, Nutrition, and Health Programs and Policies—will exploit and enhance the synergies between agriculture, nutrition, and health through operational and policy research that permits (i) more effective integrated community-level programming, and (ii) the cultivation and strengthening of an enabling policy and institutional environment to support relevant action. This component will harness both the synergy of integrated programming and the potential for sustained policy commitment, to best realize the benefits of agriculture, health, and nutrition.

Cross-cutting Issues

Gender

Throughout much of the world, women are the guardians of household food security and nutrition. At the same time, biological and cultural factors can put women and girls at particular risk of undernutrition, micronutrient malnutrition, and poor health, especially during the reproductive period. Good agriculture, nutrition, and health programming must therefore account for gender issues at all stages of the project cycle, from participatory assessment and analysis through surveillance, implementation of interventions, monitoring, and evaluation. CRP4 will focus on the following broad areas: (i) gender analysis of needs and differential exposure to risks; (ii) fostering women’s participation in and benefits from agriculture, nutrition, and health programs; (iii) empowering women and increasing their access to assets; (iv)

promoting equitable intrahousehold food allocation and consumption for all members; (v) ensuring gender-friendly technology and delivery systems; and (vi) building capacity.

Capacity Strengthening

Capacity strengthening is a crucial element for CRP4's longer-term and more sustainable impacts, essential for program scale-up and sustainability. Implementing CRP4 will require adequate capacity for translating research methods and outputs into adopted technologies and institutional and policy changes. Just as important, it will mean developing *cross-disciplinary capacity* at various levels, including government and development agencies as well as educational and research institutions. Research teams working on CRP4 will undertake, as a preliminary step, comprehensive assessments of capacity gaps and needs in targeted countries and institutions, to develop an appropriate capacity-development strategy.

Innovation

Bringing together agriculture, nutrition, and health is not a new idea, but CRP4 will be innovative in a number of areas. It will:

- foster new partnerships to ensure that agriculture, nutrition, and health are integrated and delivered—at the community level, in large development programs, and in policymaking.
- undertake cutting-edge research to meet emerging challenges—for instance, it will work with partners to design mechanisms for enhancing nutrition along the agricultural value chain and to apply new molecular biology tools informed by population biology and social research to improve our understanding of how agricultural intensification can be more sustainably managed.
- invest in designing new tools and approaches to build the evidence base to usefully guide policy and practice across sectors.

Management Structure

The governance and management arrangements for CRP4 follow the guidelines set out in the CGIAR Strategic Results Framework. IFPRI will be the lead center, and will have overall fiduciary and operational responsibility for the implementation of CRP4. The International Livestock Research Institute (ILRI) will play a strong supporting role, providing the Chair of the Planning and Management Committee (PMC) for the initial two years. The PMC will oversee the planning, management, implementation, and monitoring and evaluation of the CRP. An Independent Advisory Committee, composed of 6 members representing scientists and program development experts, will provide advice on research program performance, research priorities and focus, and management and partnership issues.

Monitoring and Evaluation

Indicators for tracking and assessing achievements will be constructed according to the SMART framework—*specific, measurable, achievable, relevant, and time-bound*—allowing for clear, results-based management of the CRP. A monitoring and evaluation plan will be developed under each component and subcomponent. The plans will provide a framework to track both the process of implementation and the attainment of interim targets. They will include milestones for activities, outputs (such as publications, datasets, training materials, and training activities), communication, dissemination, and networking (to ensure appropriate uptake of project outcomes). Plans will also specify corrective actions to be taken if milestones are missed.

Conclusion

The CGIAR has long played a unique role as an internationally coordinated agricultural research system that provides international public goods. With its partners, it is well equipped to provide leadership in developing new technologies, evidence, and applied field research for leveraging agriculture to improve nutrition and health. The CGIAR can work closely with partners in all three sectors to develop innovative and evidence-based solutions, strategies, and policies. Fully utilizing the CGIAR's scientific competence and reputation in this complex interdisciplinary area and its vast collaborative network at all levels of the impact pathway, CRP4 will achieve meaningful outcomes and tremendously benefit the health and nutrition status of poor people, especially women and young children.

2. STATEMENT OF OBJECTIVES AND STRATEGIC FRAMEWORK

Hunger, malnutrition, and poor health are widespread and stubborn development challenges. Agriculture has made remarkable advances in the past decades, but progress in improving the nutrition and health of poor farmers and consumers in developing countries is lagging behind. The recent IFPRI 2020 Conference, “Leveraging Agriculture for Improving Nutrition and Health” (New Delhi, 2011) brought together about 1000 stakeholders to think through how agriculture could be energized to become a more powerful tool to tackle the persistent problems of food insecurity, malnutrition, and poor health. Building on the momentum created by those discussions, the Consultative Group on International Agricultural Research (CGIAR) Research Program on Agriculture for Nutrition and Health (CRP4) is designed to fill the existing gap between agricultural development and its unfulfilled health and nutritional benefits.

2.1 The Potential Contribution of CRP4 to the Achievement of the CGIAR’s System Level Outcomes (SLOs)

Agricultural practices and interventions can be better adapted to maximize health and nutrition benefits and to reduce health risks. This concept—the starting point for CRP4—reflects the new vision of the CGIAR Strategic Results Framework (April 2011). Improving human nutrition and health is one of the four strategic objectives of that Framework, along with reducing rural poverty, improving food security, and achieving sustainable management of resources. The CGIAR thus recognizes that nutrition and health are global priorities, and that agricultural research can have a profound influence on both of these outcomes.

Thus, while CRP4 will contribute to the achievement of all four CGIAR strategic objectives, its primary focus will be on improving human nutrition and health. In order to achieve this goal, CRP4 is designed to bring together research and development professionals across the agriculture, nutrition, and health (ANH) sectors to jointly tackle key challenges and design joint solutions. The program recognizes that increasing agricultural productivity is not sufficient in itself to improve health and nutrition, and that the three sectors need to join forces in tackling their common development goals. The persistence of high rates of maternal and child undernutrition, especially in Sub-Saharan Africa and South Asia, calls for new approaches and new partnerships across the ANH sectors. Similarly, there are persistent health risks associated with agriculture—such as water-related, food-borne, and zoonotic diseases—that also require joint solutions to be managed between the agriculture and health sectors. The CGIAR has long played a unique role as an internationally coordinated agricultural research system, and, with its partners, it is well equipped to provide leadership in developing new technologies, evidence, and applied field research for leveraging agriculture to improve nutrition and health.

2.2 CRP4 Objectives

CRP4’s strategic goal is presented in Box 1. To achieve its strategic goal, the program is organized around four components, listed in Table 1 along with their overall objectives.

Box 1. CRP4’s strategic goal

CRP4 is a research and development program that will **work to accelerate progress in improving the nutrition and health of poor people** by exploiting and enhancing the synergies between agriculture, nutrition, and health through four research components: value chains, biofortification, control of agriculture-associated diseases, and integrated ANH development programs and policies.

Table 1. CRP4 Components and objectives

Component	Objective
1. Value chains for enhanced nutrition and health	Leverage the value chain for select nutrient-rich foods to increase the demand for, and access to, affordable and nutritious foods for the poor.
2. Biofortification	Develop and test nutrient-dense staple crops through biofortification; make these novel crops available to the poor and undernourished, either as individual staple crops or as part of a food basket.
3. Prevention and control of agriculture-associated diseases	Prevent and control agriculture-associated diseases through research for improved food safety, water quality, agricultural practices, and better control of infectious (zoonotic and emerging) diseases.
4. Agriculture, nutrition, and health — Integrated programs and harmonized policies	Exploit and enhance the synergies between agriculture, nutrition, and health, through operational and policy research that supports a) more effective integrated community-level programming, and b) the cultivation and strengthening of an enabling policy and institutional environment to support relevant action.

The CRP research objectives across the different components are as follows:

1. Generate knowledge and technologies to improve the nutritional quality and safety of foods along value chains (Components 1, 2, and 3).
2. Develop, test, and release a variety of biofortified foods, as well as other nutrient-rich foods that are affordable and accessible to the poor (Components 1 and 2).
3. Generate knowledge and technologies for the control of zoonotic, food-borne, water-borne, and occupational diseases (Component 3).
4. Develop methods and tools to improve the effectiveness and efficiency of surveillance and monitoring systems and to permit meaningful evaluation of complex multi-sectoral programs and policies (Components 1-4).
5. Produce evidence of nutritional and health burdens and benefits and of the returns to different interventions in different sectors. (Components 1-4).

The four research components of CRP4 were selected based on a broad consultation process with representatives from 12 CGIAR centers and with a wide range of partners who participated in the CRP4 planning meeting in July 2010 (see <https://sites.google.com/a/cgxchange.org/mp4/home>). Taking into consideration the CGIAR's comparative advantage, the components were selected by taking into consideration the following key questions: a) what is the nature, scope, dimension and causes of the nutrition and health problems that the CGIAR needs to address in order to achieve its strategic goal of improving health and nutrition through agriculture; b) what opportunities exist within the current (and future) research portfolio of the CGIAR and its partners to leverage agriculture to improve nutrition and health; and c) how can CRP4 best use these opportunities to exploit the potentially powerful synergies between agriculture, nutrition, and health and to achieve the common goal of improved nutrition and health. These considerations led the team of partners to select the four broad research components listed in Table 1.

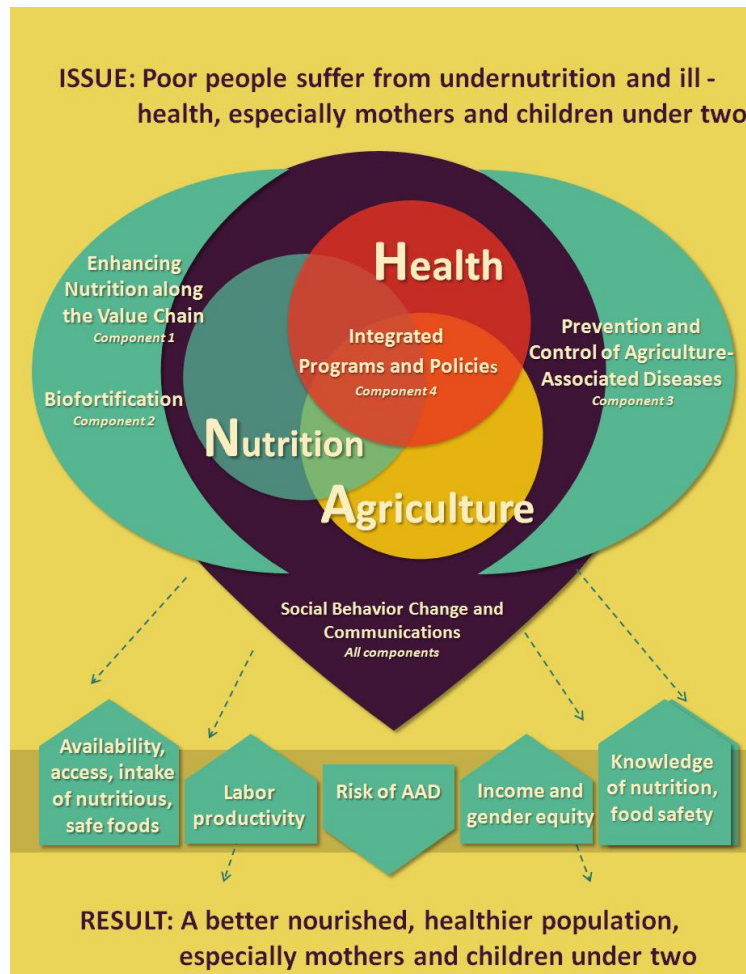
2.3 CRP4's Strategic Framework

Figure 1 presents the overall strategic framework of CRP4. The key development challenges that the program is addressing are the stubborn problems of undernutrition and ill health that affect millions of poor people globally. Root causes of poor nutrition and health include poverty, food insecurity, gender inequity and a limited access to water, sanitation and health services. Tackling undernutrition and poor health will thus require joint ANH solutions; each sector is essential but insufficient by itself to solve the nutrition and health challenges faced by the poor. This CRP aims at bringing these three sectors together in research, development programs, and policy.

It is well recognized that poor quality diets and related micronutrient are a much more widespread nutritional problem than the lack of food. Solutions to improving the poor's *access to nutritious foods* are therefore needed, rather than a narrow focus on producing *more food*. Similarly, the severe disease burden from food-borne infections and zoonotic diseases is associated with changes in agricultural practice and policy, and therefore requires agricultural solutions. As agriculture is the main livelihood strategy for the poor, it is they who are disproportionately affected by these health and nutrition problems.

CRP4 will leverage agriculture to improve nutrition and health of the poor through four research components that will directly address the problems of poor diet quality and of vulnerability to agriculture-associated diseases of the poor. Components 1-3 focus on pragmatic nutrition and health solutions to improve the poor's access to nutritious and safe foods and to reduce agriculture-associated health risks. Component 1 focuses on opportunities to improve nutrition along value chains, from production through to consumption; Component 2 aims at improving the availability, access, and intake of nutrient-rich biofortified staple crops for the poor; and Component 3 addresses food safety issues along the value chain, including the control of zoonotic diseases and the better management of agricultural systems to reduce risk of human diseases. Component 4 addresses the need for integration among the agriculture, nutrition, and health sectors, at both the program level and the policy level (Subcomponents 4.1 and 4.2). More specifically, the inputs generated by research on Components 1-3 will be incorporated into integrated ANH programs, which will be tested, evaluated, and scaled up under Component 4 (Subcomponent 1 on integrated ANH programs). Finally, evidence generated through Components 1-4.1 and through policy research (Subcomponent 4.2) will be used to create and sustain an enabling environment, to develop institutional capacity, and to foster synergies between agriculture, nutrition, and health at the policy level.

Figure 1. CRP4 Strategic framework



The lower part of Figure 1 highlights some of the development impacts that will be achieved through CRP4’s work, by integrating agriculture, nutrition and health into value chains, development programs, and policies. Biofortification research and value chains focused on enhancing the nutrition and safety of foods and on stimulating the demand for such foods will lead to new options that can contribute to increasing the availability, accessibility and consumer awareness of the benefits of high-quality and safe foods. Higher quality diets combined with lower risks of agricultural associated diseases in the population will result in healthier, better nourished and more productive men and women farmers. Better access to nutritious food, and better information about nutrition and food safety, will yield cross-cutting benefits to poor consumers and producers.

To achieve the program objectives, researchers in CRP4 will coordinate and initiate cutting-edge research on catalyzing nutrition and health outcomes. Forging partnerships will be an essential element for strengthening the connections between agriculture and health organizations and for exploiting synergies in research, policy, and practice. Delivering impacts will require examining the context of the broader agrifood production system and value chain and engaging critical actors through different impact pathways.

Within the health sector, the program focuses on two main areas of impact. The first area is promoting overall improvement in the health of women, infants, and young children through better nutrition, by exploiting the window of opportunity for improving nutrition—the thousand days between conception and the child’s second birthday—and by targeting girls and women at all stages of the

lifecycle. The second area is reducing agriculture-associated diseases through improved food safety, better agricultural practices, and water management, as well as by controlling zoonoses (endemic and emerging). This focus area targets people from all population groups and at all stages of the lifecycle.

In addition, more specific targeting efforts will increase program impact in particular regions. These target areas will include mainstreaming HIV/AIDS in heavy burden countries, and addressing the rapid rises in obesity and related chronic disease risks in countries undergoing rapid economic growth and changing agrifood systems. These additional health outcomes, although important, will not be a main research focus in the initial phase of the program.

2.4 Target Population

This program will target two specific populations: (1) poor, food insecure and malnourished populations, and (2) populations affected by agricultural intensification. Increasing population, incomes, and urbanization are driving increasing demand for food, which in turn has led to an intensification of agricultural production. The expansion and intensification of agrifood systems has had enormous benefits for farmers, market agents, private sector business, and consumers. However, in many rapidly intensifying systems, these benefits have been accompanied by negative environmental, nutritional, and health effects, including food-borne and zoonotic diseases. At the same time, despite the overall trend toward dynamic change and intensification in developing-country agrifood systems, many areas have been left behind, and people in remote and marginal areas and conflict zones have been particularly disadvantaged. In many cases, population has increased more rapidly than the capacity of agricultural production and value chains, leading to chronic food and nutrition insecurity and poor health.

- The first target group consists of poor populations who suffer from food insecurity, low diet quality and related poor micronutrient intake, and undernutrition. These populations may be served by social protection and development programs—and CRP4 will work on leveraging these programs with better-integrated ANH interventions to achieve improved health and nutrition. For those left behind, CRP4 will focus on reaching them and improving their access to either biofortified staple crops, or new and better targeted integrated ANH programs.
- The second target group consists of populations that are exposed to changing and intensifying agrifood systems, in various regions of the developing world. Critical questions must be answered by research, to design policies, technologies, and institutional arrangements that address the associated challenges to equity, nutrition, and health.

2.5 Geographic Focus

CRP4 will focus particularly on Sub-Saharan Africa and South Asia—regions where the severity and depth of the problems, and the large number of people affected, translate to the greatest potential impact (Consortium SRF 2010). The latest report by the Food and Agriculture Organization of the United Nations (FAO) on the State of the World Food Insecurity estimates that 202 million people (28 percent of the population) were undernourished in Sub-Saharan Africa in 2005/07, as well as 333 million (33 percent of the population) in South Asia (FAO SOFI 2010). Targeted work will be carried out in select regions of Latin America, especially on biofortification. Within these targeted regions, specific sites for research will be selected according to the locations of our partners' work on value chains and ANH development programming. Program links will include: value chain work in CRP3.5 on high-value animal source foods in Mali, Ethiopia, Tanzania, India, and Vietnam (Component 1); community-based ANH programs implemented by Helen Keller International, governments, and other partners, in locations such as Nepal and West Africa (Component 4); and institutional commodity procurement for food emergency by agencies such as the World Food Programme (Component 3 on mycotoxins).

3. JUSTIFICATION OF THE PROGRAM

3.1 Agriculture, Nutrition, and Health: Essential Links

The world's poor and hungry have been hard-hit in recent years. Food and financial crises have undermined food security, bringing the number of hungry people to around 1 billion (FAO 2009). Progress in combating maternal and child undernutrition and micronutrient deficiencies has stalled in many high-burden areas, leading to long-term, irreversible damage to the cognitive and physical abilities of many people in developing countries—and diminishing those countries' economic productivity (World Bank 2006). Maternal and child undernutrition contributes to more than one-third of child deaths and 10 percent of the global burden of disease (Black et al. 2008). Zoonotic diseases are causing unprecedented concern, threatening pandemics and placing an especially heavy burden on the world's most vulnerable people. Agriculture-related health losses are massive, accounting for up to 25 percent of all disability-adjusted life years lost (DALYs) and 10 percent of deaths in low-income countries (Gilbert et al. 2010). The economic toll of these health losses is also huge. For example, severe acute respiratory syndrome (SARS), a zoonotic disease associated with food safety, cost an estimated \$50 -100 billion¹ (Aguirre and Gomez 2009), and a major avian influenza pandemic could cost more than \$1 trillion (Burns et al. 2008). The cost of undernutrition to economic development is estimated at \$20-30 billion annually (UNICEF 2006). Without well-designed investments, programs, and policies to address these challenges, the human and economic costs will continue to be enormous.

Agriculture plays a key role in the interrelationship between nutrition and health. It is the primary source of human energy and essential nutrients; it is a source of income for 80 percent of the world's poor; and it is an essential element of human life, health, and culture. On the other hand, livestock and wild animals are the source of the great majority of human infectious and emerging diseases, and agricultural products and practices can pose serious health risks. And while increased agricultural development is fundamental for sustaining the nutrition and health of billions of people, it also contributes to many challenges—such as population growth, urbanization, and climate change—that threaten the availability of water, land, and other natural resources. Finally, millions of the world's poor are rural people who are trapped in a combination of low-productivity agriculture, poor health, and undernutrition (Ahmed et al. 2007).

The importance of agriculture for nutrition and health—in terms of both benefits and risks—is recognized now as never before. The unprecedented enthusiasm and commitment of stakeholders from all three sectors at the landmark IFPRI 2020 Conference on this topic in early 2011 strongly indicate that a global consensus from the development community is emerging on the need to act quickly (IFPRI 2011; <http://2020conference.ifpri.info>). Yet a lot needs to be done to design the approaches and tools needed to bring the three sectors together to achieve their common goals. Links among the ANH communities have traditionally been weak, jeopardizing the effectiveness and efficiency of efforts to improve health and nutrition outcomes.

Indeed, agricultural conditions and interventions may sometimes undermine health and nutrition. Agricultural intensification, for example, has the potential to exacerbate the spread of agriculture-associated diseases and to spur the development of new ones. The failure of agriculture to provide access to nutritious foods and high-quality diets may aggravate the widespread problem of micronutrient deficiencies. For example, past agricultural policies have focused on increasing production of staple cereals, without commensurate investments in productivity increases for other food commodities, leading to lower prices of food staples and higher prices for nutrient-rich foods such as pulses. Dietary *energy* thus became more affordable to the poor (up until the recent food price rises), while dietary *quality* became more expensive (Bouis, Eozenou, and Rahman 2011). The need for greater understanding of these links will become even more critical as countries face the double burden of under- and over-nutrition, and the emergence of obesity and related chronic diseases among the poor.

¹ All dollar figures are USD.

A focus on agricultural development thus presents enormous opportunities for improving health and nutrition. The health and nutrition of vulnerable populations can be vastly improved by managing agricultural intensification in a sustainable way. Better food safety, water quality, and control of occupational, zoonotic, and emerging diseases can reduce the risk of debilitating diseases. Greater access to more nutritious and diversified diets can address maternal and child undernutrition and help tackle the huge burden of micronutrient deficiencies. Improved nutrition and health, in turn, can reduce poverty for the 1.4 billion people living on less than \$1.25 a day (World Bank 2010). A greater focus on the role of women in agriculture—as potential mediators of household and individual food and nutrition security—could accelerate improvements in the nutrition and health of women and young children. The key is to act now, as the ANH communities are beginning to recognize that they cannot meet these challenges in isolation. Only well-coordinated efforts can offer any hope of meeting the shared goals of reducing poverty, undernutrition, and ill health.

3.2 A Unique Opportunity

A succession of alarming recent events—global food price rises, threats of pandemics, and the spread of animal diseases and pests across established boundaries—have threatened livelihoods, health, and nutrition world-wide. These challenges have raised policymakers' awareness of the problem of sectoral boundaries between disciplines and ministries, “stovepipes” that act as barriers to achieving solutions.

The need for multisectoral approaches—tools, programs, and policies—to achieve impacts at scale is now well recognized among stakeholders in all three sectors, as signaled by a burgeoning of multi-sectoral global initiatives: on nutrition and health, the Scaling Up Nutrition (SUN) movement and the 1000 Days Initiative; on agriculture and food security, the High Level Task Force on Food Security's Comprehensive Framework for Action (CFA), the Committee on World Food Security, the Comprehensive Africa Agriculture Development Program (CAADP), and the recently funded Global Agriculture and Food Security Programs (GAFSP); on infectious diseases, the One Health Initiative; and on food safety, several global food safety alliances, such as the World Health Organization's Foodborne Disease Burden Epidemiology Reference Group (FERG), the Global Food Safety Initiative (GFSI), and the Partnership for Aflatoxin Control in Africa (PACA).

Several national governments have also realized the importance of building stronger links between agricultural growth and improved nutrition. The Indian Prime Minister, for example, has expressed great concern regarding the persistence of high rates of undernutrition among Indian children, in spite of significant agricultural growth over the past decade. China formed a national food security and nutrition committee and is planning to set up a research institute on food and nutrition under the Chinese Academy of Agricultural Science. NEPAD's African Union program launched the African Food and Nutrition Security Day on October 31, 2010.

The IFPRI 2020 Conference provided a much-needed platform for sharing knowledge and practice in linking agriculture, health, and nutrition. It identified a huge task ahead: filling knowledge gaps, designing and scaling up innovative joint ANH programs, and creating an enabling environment for joint policy based on solid partnerships and mutual accountability.

The CGIAR, with its partners, is uniquely positioned to draw on its collective experience and research capacity in all three areas—agriculture, health, and nutrition—to start filling some of the critical knowledge gaps and to generate and communicate evidence and learning on the linkages between agriculture, nutrition and health. This CRP is designed to make a difference to the lives of the rural poor by (1) taking a systematic view of how agriculture, health, and nutrition interact globally, nationally, and locally; (2) developing a strong body of evidence based on rigorous research to help decisionmakers evaluate trade-offs between different investments and policy options; (3) conducting action research to develop technologies that induce positive changes in the lives of the poor; and (4) fostering effective approaches that bridge sectoral boundaries. Within the CGIAR, this CRP represents an opportunity for collective action with partners at all levels of the impact pathway, from research discovery to development outputs, for achieving meaningful outcomes for poor people.

4. IMPACT PATHWAYS

4.1 Research Strategy

CRP4 is designed to strengthen the role of agriculture in improving human nutrition and health, through both enhancing its positive benefits and reducing its potentially negative effects. In creating critical linkages between agriculture, nutrition, and health, CRP4 has two overarching strategies. The first is to influence agricultural research and development efforts to more actively pursue nutrition and health outcomes. The second is to influence the health and nutrition communities to consider and include agricultural solutions for improving nutrition and health outcomes. This CRP will seek to influence and catalyze interactions among the ANH sectors in both directions.

In influencing the agricultural research community to focus on better nutrition and health outcomes, the emphasis will be on broadening the paradigm of agricultural productivity and value chain research to ensure that food produced is more nutritious, safer, and accessible to the poor. For the *agriculture and nutrition communities*, this work will involve developing joint solutions for the delivery of better nutrition through production of higher-quality foods (such as biofortified, nutrient-rich staple crops) and through nutrition-sensitive value chains.² Between the *agriculture and health communities*, research will focus on joint programs for the control of agriculture-associated diseases (AAD). CRP4 will also undertake joint research that brings the three sectors together to design efficient and effective cross-sectoral approaches to achieve common ANH impacts. This will work through two main areas of research partnership: to develop tools and solutions for development implementers; and to generate knowledge, evidence, and options for policy and decisionmakers.

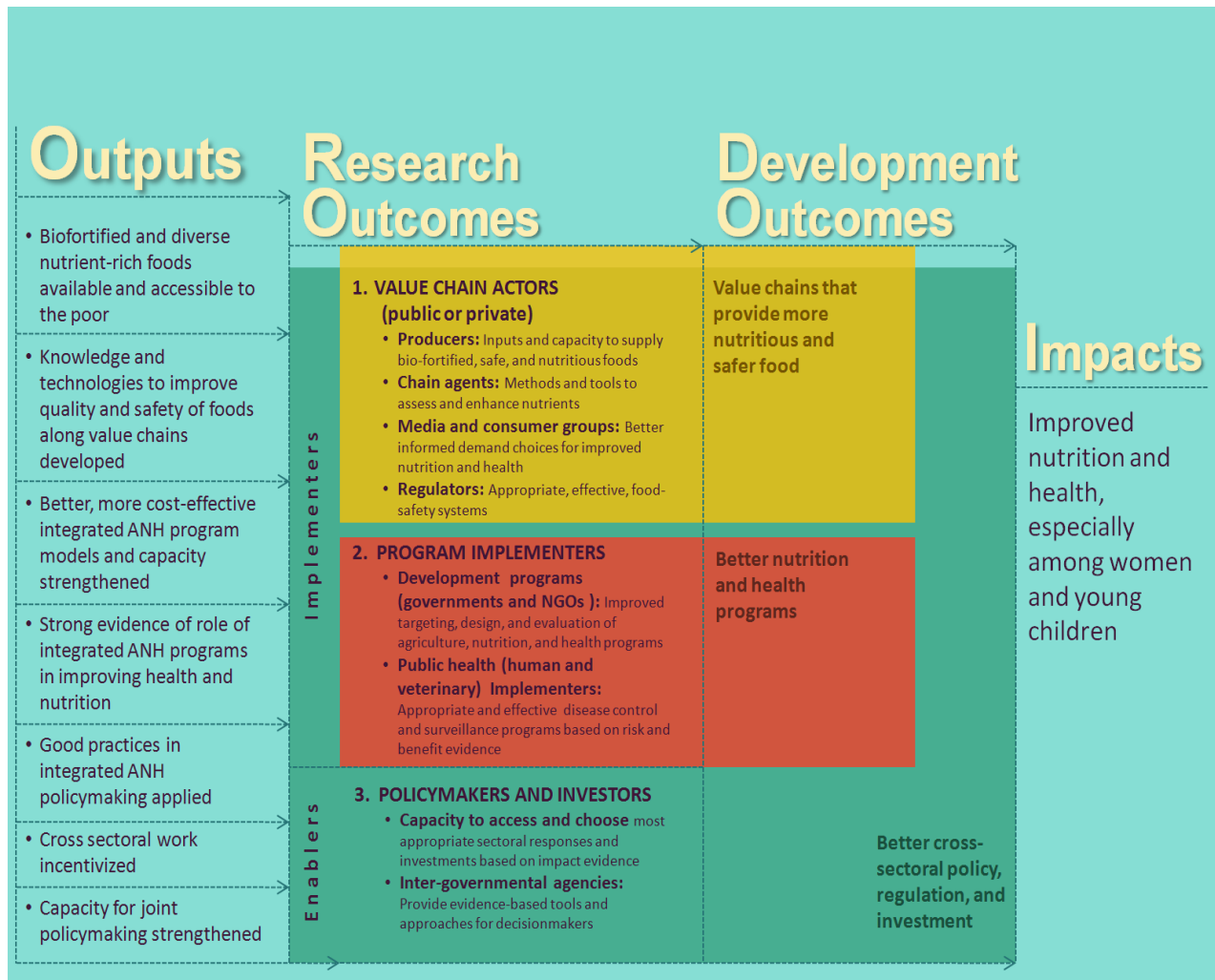
This research agenda will require incorporating innovative elements into the work of planning and implementing research. New emphasis will be placed on: communication and improved information systems; integration of actions across the ANH sectors; tools and approaches for cross-sectoral policy and decisionmaking; studying agriculture intervention options (through testing, evaluation, documentation, and scaling-up) to provide evidence on health and nutrition outcomes; and integration of ANH programs into the broader social protection agenda for marginalized and vulnerable populations. A major incentive to cross-sectoral cooperation for all three sectors is the potential for far greater returns to investment and much larger impacts, as compared to interventions in single sectors.

4.2 Impact Pathways

Figure 2 highlights the strategy leading from research outputs to development impacts. CRP4 will enhance the contribution of agriculture research outputs to nutrition and health impacts through three major impact pathways: 1) *value chains* that provide more nutritious and safer foods; 2) *development programs* that successfully integrate agriculture, nutrition, and health; and 3) *policy* that promotes a supportive and enabling cross-sectoral policymaking process and investment environment.

² Nutrition-sensitive value chains are defined here as value chains that incorporate nutrition objectives and interventions to enhance the nutrient content of foods and prevent nutrient losses along the value chain; and focus on educating the different value chain actors, including the consumers about the nutritional benefits of the targeted foods.

Figure 2. CRP4 Impact pathway



4.2.1 Value Chain Impact Pathways

CRP4 (Component 1) focuses on enhancing and protecting the nutritional content of nutritious foods along the value chain while mitigating key food safety risks. CRP4 will add value to existing research by bringing focused attention to the quality and safety of foods in value chains. This will include collaborations with value chain work conducted on highly nutritious foods such as livestock and fish (CRP 3.7), legumes (CRP 3.5), and fruits and vegetables (CRP 6, World Vegetable Center, and the Global Horticulture initiative), as well as on enhancing the nutritional value and safety of staple cereals, roots, and tubers (CRP 3.1, 3.2, 3.3, 3.4, and 3.6).

Figure 2 highlights four principal ways that CRP4 research will contribute to value chains:

- Providing food producers technical and knowledge inputs to produce more diverse and higher nutritional value foods (Components 1 and 2).
- Enhancing or protecting the nutritional value of foods along the value chain, from production to post-harvest handling and storage, through processing and distribution to consumers. This will involve identifying *entry points* and methods to protect or enhance the nutritional value of foods, and *exit points* where nutrient losses can be prevented (Component 1).

- Providing information and knowledge to consumers to positively influence behavior in seeking more nutritious and safer foods (Components 1, 2, and 3).
- Helping regulators assess safety risks of food at different points along the value chains; developing appropriate and effective methods for mitigating public health risks while optimizing economic benefits to poor producers and market agents (Component 3).

There are several points of entry along the value chain where CRP4 research outputs can be used by different value chain actors. The value chains important to poor people are highly diverse, ranging from small scale, informal value chains involving only a few actors (such as farmers, traders, and consumers) to more formal value chains involving a much larger number of value chain actors (including input providers, farmers, market agents, processors, distributors, transporters, retailers, and consumers). Many of the value chains CRP4 will engage in will be local and informal markets in rural areas. Over time, as urban demand increases, more complex value chains develop, bringing both new opportunities and greater challenges for the poor.

There are great potential benefits to links with agribusiness in developing more efficient and effective input and output markets, including the capacity to meet market demand for nutritional quality and food safety standards, but such a strategy poses the risk of leaving behind small producers and poor consumers. Two objectives of CRP4 research will be to support the ability of poor producers to participate in these new market opportunities, and to ensure that nutritious and safe foods are available, accessible, and affordable to poor consumers.

At the policy level, evidence from nutrition- and food safety-focused value chains research would inform policymakers, regulators, and public and private investors on the nutritional, health, income, and other benefits and risks to be considered in any decisionmaking on value chains.

4.2.2 Development Program Impact Pathway

Research outputs from Components 1-3 will provide important inputs for integration into current and future ANH programs, through evaluation activities by development partners (Subcomponent 4.1). Enhanced monitoring, evaluation, and learning by development partners, supported by CRP4, will include testing and adapting and scaling-up some of the research findings of other program components. This will require CRP4 to provide inputs at critical stages in the program design, targeting, planning, implementation, evaluation, scale-up, and assessment cycle.

Outputs from Components 1 and 3 are expected to contribute to other, more specific agriculture-nutrition and agriculture-health programs implemented by development partners. For example, research in Component 3 would contribute to the public health programs for zoonotic and emerging diseases. Research in Components 1 and 2 could contribute to specific nutrition interventions by being integrated into development programs implemented by partners such as the Ending Child Hunger and Undernutrition (REACH) partnership, the Global Alliance to Improve Nutrition (GAIN), and other nutrition development actors.

4.2.3 Policy Impact Pathway

Research outputs from Components 1, 2, and 3 and Subcomponent 4.1 will provide the evidence base, knowledge, tools and technical inputs to help decisionmakers make better investment and policy choices. In particular, better approaches for data collection, analysis, and metrics to assess cross-sectoral outcomes will be needed. CRP4 researchers will collaborate with universities, other advanced research institutes, and key developing country research institutions in this area. The ability of the CRP4 partnership to engage policy makers and national governments in evidence-based process will be critical to initial success in the first few years of the program.

While better evidence for decision making is necessary, it is far from sufficient in achieving policy impacts. One step is that evidence needs to be communicated effectively so that it is useful to

decisionmakers. At the moment, there is strong international and national consensus on the importance of leveraging agriculture for improving nutrition and health, which is evidenced by major international and national initiatives such as the SUN, REACH and the WHO FERG initiative on food safety, and a variety of One Health initiatives for zoonoses and emerging diseases control. But this support can only be sustained effectively if it fits with policy making processes. The role of CRP4 will be to bring the cross-sectoral ANH knowledge and tools into broader policy processes, in close partnership with CRP2. These processes must closely align and support broader policy approaches. Fortunately, there is increasing scope for doing this in Africa through the AU-NEPAD CAADP process that links broader continental and regional policy processes to specific policies and implementation plans at national level. Appendix 5 provides further details of how CRP4 can link to the CAADP process. For the other major CRP4 target region of South Asia, important efforts to engage governments in policy processes will be built upon, both at regional and national levels. IFPRI has very strong links with policy making processes and with economic research institutions in the region.

While the CRP4 research partnership can play a catalytic role in evidence-based policy making, sustaining and deepening impacts along this pathway will require a concerted effort to strengthen the capacity in national governments for analysis, planning, program design and evaluation of cross-sectoral agriculture-nutrition-health. Efforts have already started to develop a coalition of research and capacity training partners for this purpose. In India, the Public Health Foundation of India will be a critical partner in the interface between capacity, policy and practice for agriculture-nutrition-health interventions.

4.2.4 Longer-Term and Broader Impacts

CRP4 will only be able to contribute to large-scale sustainable impacts through strong linkages with effective development implementers and enablers, including national governments. There are strong indications that development implementers and enablers are now, more than ever before, committed to scaling-up ANH interventions. There also seems to be much enthusiasm, expressed at both the CRP4 partnership meeting in developing this proposal and in the recent IFPRI 2020 Conference in New Delhi that CGIAR research is considered important to strengthen agriculture's contribution to improving nutrition and health and providing research evidence to guide interventions, policies and practice.

For CRP4 to be successful in contributing to these impact pathways, its research must add value to some specific and neglected areas of evidence. The first addresses how agricultural interventions can reach the malnourished and ill. This will require research that informs programs and policies that work for the poor. Clearly, gender and social science research will be critical components of this. The second addresses how interventions can enhance *food and nutrition security* by increasing the poor's access to and demand for nutritious foods. A major neglected research area that this CRP will tackle is the demand and the practices of poor consumers with respect to nutritious and safe foods. The program will also begin to address priority issues around the *environmental sustainability* of agriculture linked to better nutrition and health. There will be two initial priorities. The first will be to improve our understanding of the diversity of foods that can support nutritious diets; the second will be to look at the health risks linked to rapid and uncontrolled intensification of agricultural production system and food systems.

At the IFPRI 2020 Conference, there was an overwhelming consensus that high-quality research is missing on the impacts of multi-sectoral interventions and programs. Thus, a strong data and evidence research focus is planned for the first three years of the program. Results will be critical to catalyze and support the strong current momentum for national governments and international agencies around ANH initiatives. CRP4 will work towards catalyzing impacts at different scales, according to the level of partnership. At the regional and international level, impacts are potentially far-reaching. Potentially large-scale impacts, to be further refined in initial ex-ante impact assessments, can be achieved through global partnerships of several kinds. Some examples include:

- The generation of research outputs to inform and support major international development initiatives in nutrition. These include the previously mentioned SUN movement, planned to operate in 36 countries and cover 2.8 billion people (356 million undernourished children); REACH, focusing on a minimum of 10 African countries and aiming to include a large agriculture for improved nutrition component; and a number of national government programs.
- Supporting integrated ANH programming implemented by government agencies and nongovernmental organizations (NGOs). This would build on the previous experience of CGIAR centers working with some large international NGOs, such as Helen Keller International and Concern Worldwide.
- The provision of evidence and good practice for food safety linked to WHO's FERG, in partnership with institutions in select African and Asian countries.
- Collaboration with international zoonotic and emerging disease control initiatives, programs, and networks (such as One Health and Ecohealth initiatives) through the OIE, FAO and WHO.
- Collaboration with international NGOs and inter-governmental development agencies on complex multi-sectoral decisionmaking in policy, regulations, and investments,
- Leveraging major CGIAR agricultural research investments within the new CRP portfolio. Those most likely to go to scale are: (1) supporting value chain work in other CRPs to enhance their impacts on improving nutrition and health; and (2) providing information for the scaling up of biofortified staple crops in value chains and ANH programs.

In the impact planning for CRP4, a critical element for achieving longer-term and more sustainable impacts is through the contribution to *capacity strengthening*. The CGIAR, working with its research partners, has a comparative advantage in supporting developing-country agriculture research organizations and researchers, with long experience of working collaboratively in programs to strengthen the capacity of both development enablers and implementers. A capacity-strengthening consortium is being developed to include universities and research institutions from developed and developing countries linked to CRP4.

5. PARTNERSHIPS

5.1 Principles and Practices

Agricultural research can improve the lives of the poor only by working with—and through—implementing partners, to help shape research strategies and to translate opportunities into impacts. Effective partnerships and new partnership practices will therefore be essential for achieving CRP4's ambitious research outputs and development outcomes and impacts. A partnership strategy will be developed initially, with support from IFPRI's Partnership Coordinator, to create the best conditions for carrying out the research and making full use of the subsequent findings. The partnership strategy will include a roadmap, a plan of action, and a partnership monitoring and tracking system. One of the first steps in implementing the strategy will be to do a stakeholder mapping and a landscape analysis of public health, agriculture, and nutrition research and development actors, and to identify opportunities for partnerships. This will be done both at the international level and at the level of the program focus countries.

A key strategic concept in developing the partnership strategy is value addition. The lead role in defining, designing, and implementing local policies and programs must be taken by the relevant decisionmaking organizations and their stakeholders at all levels, including research organizations; the role of CRP4 (and the CGIAR) is to add value to the efforts of these stakeholders. The concept of value addition allows CRP4 to focus on its mandate as provider of international public goods, while ensuring local relevance in implementation.

The CGIAR centers involved in this program have considerable experience in partnerships across the types of development processes involved in CRP4 (support to policy and decisionmakers, development implementers, and value chain actors). In addition, all have experience in specific domains of ANH linkages, through previous and ongoing research and research-development partnerships as well as, collectively, through the CGIAR Agriculture and Health Research Platform. (See <http://programs.ifpri.org/ahrp/ahrp.asp> for further information.)

This impressive body of experience will be critical in fulfilling the partnership requirements of this program, which are much broader and bolder than previous endeavors. CGIAR centers have considerable depth of knowledge of partnerships: see Horton et al. 2009 for a recent review of partnership literature, and ILRI 2006's Partnership Strategy for partnership practices. At the partners' meeting held in July 2010, as part of the process of developing this proposal, tremendous enthusiasm was expressed for partnering with CRP4, as well as solid agreement on its broad framework and components. (The proposal planning documentation is available at <https://sites.google.com/a/cgxchange.org/mp4/>). This enthusiasm reflects the growing interest and investment in the critical linkages between agriculture, health and nutrition, and it is evident in many initiatives described in this proposal (including the IFPRI 2020 Conference noted earlier).

We identify four broad categories of partners: 1) enablers (policy and decision makers); 2) development implementers; 3) value chain actors (and representatives); and 4) research partners. The unique complexity of CRP4, which requires working across sectors, calls for a range of partnership types and depths. Partnerships will be dynamic, ranging from joint fundraising and planning to implementation, including communication and dissemination of outputs. They will entail shared financial and human resources. Some will be extensive and profound; others may be limited to common research interests and the sharing of knowledge and information. Partnership relationships can also change over time, as initial research outputs move to outcomes.

In managing partnerships, CRP4 will focus on and monitor a number of principles and practices:

- Mutual accountability for achieving strategic goals, outcomes, and impacts
- Shared goals to create international public goods that will contribute to the achievement of the vision of the CGIAR, with an emphasis on improving human health and nutrition

- Mutual respect, with open and transparent discussions between partners
- Emphasis on identifying and meeting the needs of partners for evidence, innovation, and other research outputs
- Clear guidelines and practices for joint communication, publication, and sharing of credit, based on comparative advantage and consensus
- Priority support for developing country institutions and partners in building capacity and skills

5.2 Nature and Types of Partnerships

CRP4 will work with four broad categories of partners: enablers, development implementers, value chain actors, and research partners. Each category is described below, along with examples of prospective partners.

1. **Enablers.** These partners include policy and decisionmakers as well as investors at different levels.
 - *Intergovernmental organizations* engaged in policy and regulations related to nutrition and health, such as WHO, the World Food Programme (WFP), FAO, and OIE (World Animal Health Organization).

Intergovernmental agencies have increased their coordination in relevant areas: nutrition, through the Subcommittee on Nutrition (SCN), the SUN movement and the REACH initiative; food safety, through CODEX and SPS technical standards for WTO; and zoonoses and emerging diseases, around the One Health initiative. CGIAR centers have engaged with these organizations individually, around major programmatic areas, as well as collectively through the Agriculture and Health Research Platform.

- *Continental, regional, and subregional organizations* in the ANH sectors that support decisionmaking related to policy, regulations, and investment.

Recent years have seen a strengthening of capacity in these organizations, with greater harmonization of actions and political commitment, offering new opportunities for engagement. For example, major progress can be seen in the development and implementation of CAADP, at several levels: AU/NEPAD; regional economic communities (RECs); FARA and subregional organizations (SROs); and national governments.

CRP4 has several mechanisms to engage with CAADP's pillars of action to strengthen policy, decisionmaking, and capacity development. This will build on the strong and well-established role of IFPRI with AU/NEPAD in this area, as well as on the important role played by the regional centers for strategic analysis and knowledge support (RESAKSS) associated with three hubs (hosted by ILRI, IITA, and the International Crops Research Institute for the Semi-Arid Tropics [ICRISAT]/the International Water Management Institute [IWMI]). Several regional and national actors in public health will also be engaged, such as the West African Health Organization (WAHO) and the Public Health Foundation of India (PHFI).

- *International and regional development banks and other major bilateral investors* support the regional and national enablers: the World Bank, the African Development Bank, the Asian Development Bank, and the Inter-American Development Bank are significant investors in research and development in this area.
- *National governments* will be partnered for cross-sectoral policymaking, strategic planning, and capacity development, either directly or mediated through regional processes, as appropriate.
- *Civil society organizations and various public and private organizations* will be supported with knowledge and evidence relevant to key areas of policy and advocacy.

2. **Development (or program) implementers.** Several of the participating CGIAR centers in CRP4 have extensive experience in working closely with relevant government departments and nongovernmental organizations, who will play a critical role in the impact pathway for CRP4. The ambition is to expand, enhance and deepen these partnerships.
 - *Government ministries* engaged in agriculture for improved nutrition and health programs (such as the Ministries of Agriculture and Health in Uganda, and other countries) who have important cross-sectoral ANH activities; and government ministries engaged in broader development programming focused on poor and marginal areas (such as Kenya’s Ministry of Northern Development).
 - *United Nations and other global initiatives* that bring networks of organizations together to achieve a common goal. Examples include the global initiatives that promote multi-sectoral approaches to reduce poverty, food insecurity, undernutrition, and poor health; and those that support country-owned processes such as the closely-linked SUN movement, the REACH initiative, the Global Horticulture Initiative, and the One Health initiative.
 - *NGOs, civil society organizations and farmers groups* engaged in agriculture and rural development programs to improve ANH outcomes, such as Catholic Relief Services (CRS), Helen Keller International (HKI), Concern Worldwide, Save the Children, and World Vision (WV), at both the international and local partner level. CRP4 will support evidence-based programming, including research to enhance program design, targeting, monitoring, evaluation, and scaling up. For relatively small marginal investments, the program can help generate and disseminate knowledge and learning and improve impacts in a critical development domain, potentially leveraging billions of dollars of outside investment.
3. **Value chain actors and their representatives:** CRP4 will work with researchers and value chain actors and partners to *add value* to their work by focusing on the quality and safety of foods in value chains.
 - *Private-sector companies and public-private initiatives* working to enhance health and nutrition through agriculture. Only a few initiatives in this area have focused on nutrition value chains and biomedical research partners. Major entry points for expansion will be along value chains for staple foods for both nutrition and health outcomes, working principally around food safety, in collaboration with other CRPs. We will expand our relationships with public-private partnerships, engaging with GAIN in the area of agriculture and nutrition and with the Global Alliance for Livestock Veterinary Medicines (GALVmed) on zoonoses.
 - *Associations and groups* provide a conduit for working with producers, value chain intermediaries, and consumers. We will work with special interest groups (for example, consumers’ associations) as well as state and other entities bringing together stakeholders (such as national dairy boards).
4. **Research partners.** CRP4 will expand beyond existing *agriculture-nutrition* and *agriculture-health* partnerships to develop new research partnerships that work across all three areas. CRP4 will build on existing partnerships and develop new ones with several types of research partners:
 - *Advanced research institutes and academic institutions (universities)* will be key partners. Many of these are already well-established collaborators with CGIAR centers around nutrition and health issues, including (for agriculture and nutrition issues) the United States Department of Agriculture (USDA), Cornell University, the University of California at Davis, and other universities; and (for agriculture and health issues) the Agricultural Research Development (CIRAD), the International

Centre of Insect Physiology and Ecology (icipe), and the Universities of London, Basel (Swiss Tropical and Public Health Institute), Edinburgh, Cornell, Guelph, and others. The new Leverhulme Center for Integrated Research on Agriculture and Health (LCIRAH), coordinated by the London International Development Centre (LIDC), will be a key CRP4 research partner, especially as it is currently in the process of creating a University Network on Agriculture, Nutrition and Health for Development.

- ***Developing-country research institutes and universities*** will be an important element of the CRP research partnerships. Current partnerships in this area will be expanded, particularly relating to zoonoses, food safety, and ecohealth, with universities in eastern and southern Africa and South and Southeast Asia. In India, key partners in research on agriculture and nutrition issues include the Tata Institute of Social Sciences, the Institute of Dalit Studies, and the Sitaram Bhartia Institute of Science and Research. Another type of partnership opportunity is offered by regional initiatives, such as the Southern Africa Center for Infectious Disease (SACIDS)—a virtual center, serving eastern and southern Africa.

5.3 Partnership Engagement and Development Process

During the consultative process for developing this proposal, partners provided comments online, and many attended a partners' workshop, resulting in two important foundational accomplishments. First, partners contributed to, and took ownership of, the research program development process, including the design of the overall conceptual framework, priority setting, and selection and definition of the key areas of research. Second, CGIAR centers and partners developed and shared an inventory of current interests, activities, and capacities to be considered for inclusion in the program, as captured in the workshop documentation (<https://sites.google.com/a/cgxchange.org/mp4/>). The partnership development process resulted in strong support and agreement on the overall framework and research plan for CRP4.

While not part of the CRP4 planning, the IFPRI 2020 Conference on ANH also provided a forum for key stakeholders working at the interface between agriculture, nutrition, and health to share perspectives and build commitment and consensus on the way forward.

CRP4 will build on these partnerships by developing a partnership strategy for various stages of the impact pathway, as well as a detailed implementation and monitoring plan for the overall program and its components and subcomponents. Social network analysis tools will be used to describe and evaluate the science and implementation networks emerging from CRP4. The program will consider and choose from a variety of potential strategic partnership mechanisms, such as *knowledge and information platforms* and *communities of practice*, and will explore how to engage existing platforms of international organizations (such as WHO and FAO, or RESAKSS, in which several participating centers are already active)—and possibly expand their scope. CRP4 may also develop new platforms to support partners in agriculture and rural development who serve as champions in developing evidence and advocacy related to cross-sectoral ANH interventions. Critical in this will be supporting coalitions of developing-country organizations.

We find great enthusiasm as well as extensive opportunities to enhance partnerships in this area. We are committed to a partnership process that incorporates strategic thinking, systematic processes with partners, new behaviors and resources, and implementation of best partnership performance practices—the essential ingredients of a successful joint effort.

6. MAIN ACTIVITIES PROPOSED TO GENERATE OUTPUTS, OUTCOMES, AND IMPACTS

This section describes the four components and their subcomponents (See Table 2) of CRP4's research program.

Table 2. CRP4 components and subcomponents

Component	Subcomponent
1. Value chain for enhanced nutrition and health	
2. Biofortification	<ol style="list-style-type: none"> 1. HarvestPlus 2. Agrosalud
3. Prevention and control of agriculture-associated diseases	<ol style="list-style-type: none"> 1. Improving food safety 2. Zoonotic diseases and diseases emerging from animals 3. Other health risks in agroecosystems
4. Agriculture, nutrition and health – Integrated programs and harmonized policies	<ol style="list-style-type: none"> 1. Integrated programs 2. Harmonized policies

6.1 Component 1: Value Chains for Enhanced Nutrition

6.1.1 Rationale, Objective, and Research Questions

Rationale

The challenge of addressing food security is not simply a matter of ensuring that all people have enough food—or energy (calories)—to live a healthy life. A much more daunting problem is to ensure that poor people have access to *nutritious*³ and high-quality diets. Typically, poor households subsist on monotonous staple-based diets; they lack access to nutritious foods, such as fruits, vegetables, animal source foods (fish, meat, eggs, and dairy products), or wild foods of high nutrient content. Lack of diversity in the diet is strongly associated with inadequate intake and risks of deficiencies of essential micronutrients (Ruel 2003; Leakey 1999; Arimond et al. 2010). The resulting deficiencies have far-reaching health and nutrition consequences, both in the short and the long term. Economic constraints, lack of knowledge and information, and related lack of demand for nutritious foods are critical factors that limit poor populations' access to such foods.

Food production is just one factor in the consumption and availability of nutrients. Food is stored, distributed, processed, retailed, prepared, and consumed in a range of ways that affect the access, acceptability, and nutritional quality of foods for the consumer. Producing for consumption in the home or for local markets remains important in many places; but today, the more market-oriented nature of agricultural policies means that more farmers are net-food buyers and are thus affected by commercial markets.

Value-chain concepts and approaches have been widely used in international development (and in the CGIAR) with the objective of enhancing the livelihoods of food producers. Although they often address food safety issues, value chain analyses rarely incorporate nutritional and other health considerations (Hawkes and Ruel 2011). The food supply chain is most often discussed from the perspective of value chain actors—the *supply* side. Little emphasis is placed on how informed consumers can play a role in influencing the value chains, and how changes in the *demand* for specific foods can influence the processes and outputs of value chains. There is also little emphasis on how actors along the value chain can be better informed on how to enhance nutritional value and safety of foods as they move along the value chain.

This component will build on work on value chains carried out by the CGIAR and other partners on nutritious (usually high-value) foods.

- It will develop new approaches and tools to analyze the value chain, using a “nutrition lens” combined with a consumer focus.
- It will implement research to identify leverage points to enhance the nutritional value of select nutrient-rich foods.
- It will develop tools to assess and correct information asymmetries regarding nutrition among different value chain actors, including consumers.

Component 1 will focus on increasing the demand for nutritious foods among poor rural and peri-urban, marginal households, and on identifying leverage points along the value chain where innovative nutrition interventions can be incorporated to stimulate both the supply and the demand for nutritious foods.

³ Nutritious (or “nutrient-rich”) foods are defined as foods high in essential nutrients, including animal source foods (fish, meat, eggs, and dairy products), fruits and vegetables, biofortified staples, fortified foods, and traditional local crops sourced from biodiverse systems (including neglected and underutilized species and wild foods). Specialized processed and/or fortified foods for populations with special needs (acutely malnourished children, people living with HIV/AIDS, infants) are also included in nutrient-rich (or nutritious) foods. Medicinal plants, though not classified as foods, represent an additional potential set of commodities that may be explored in this component, in partnership with CRP6.

Boxes 2-4 present case studies that illustrate some emerging work incorporating nutrition considerations and interventions into value chains (Hawkes and Ruel 2011). They show that value chain concepts and approaches offer considerable potential for enhancing efforts to improve nutrition, and they provide a framework for identifying and implementing opportunities to leverage agriculture for improved nutrition.

The first case study (Box 2) describes an ongoing program aimed at strengthening the *bean* value chain in Uganda, to foster both nutrition and income gains among small-scale farming households. We note that 77 percent of farmers involved in the production, harvesting, and marketing of beans in the study area are women, and that women also play a central role in decisions regarding food preparation and distribution as well as child feeding and care. The program thus has great potential to improve the food security and nutrition of household members, and especially of young children.

Box 2. Case Study 1: Enhancing nutritional value and marketability of beans through research and strengthening of key value-chain stakeholders in Uganda

Iowa State University (ISU) and its Ugandan partners have been working on improving the bean value chain to improve agricultural production, income, health, and nutrition among small-scale farming households in the Kamali district of Uganda. Beans are a major food and cash crop in Uganda. Their relatively high nutritional content and high market price mean that they have the potential to improve both nutrition and income among producer households.

The potential nutritional and economic benefits of beans are diminished, however, by inadequate pre- and postharvest handling techniques. Late harvest exposes beans to fungus, damage, and breakage during threshing; high levels of insect infestation occur during storage. Moreover, bean preparation generally requires long preparation time (with significant fuel use), resulting in decreasing bean consumption especially among peri-urban and urban residents.

In view of the interrelated nature of problems that extend along the value chain—from production to postharvest handling, processing, marketing, and consumption (demand)—the project adopted a *participatory market chain approach* (PMCA). The goal was to understand barriers to participation and consumption, and to develop solutions for producers and consumers in different parts of the bean value chain, through participatory research involving improved management practices and technologies, development of training materials, peer extension and outreach, and monitoring and evaluation. By developing solutions for key points along the value chain, coordinating these activities so that they reinforce each other, and including diverse sectors and partners (including consumers), the project reflects core value chain concepts and theories and has good prospects for effectively promoting sustainable change and development. It also highlights the clear potential of value chains to leverage agriculture for improved nutrition.

Note: The project was implemented under the framework of the USAID-funded Dry Grain Pulse collaborative Research Support Program (CRSP) (2008-12).

Source: Mazur et al. 2011; Hawkes and Ruel 2011

In the second case study (Box 3), a value chain approach was used to create a market and stimulate the demand for—and consumption of—a new type of sweet potato: a biofortified, vitamin A-rich orange-fleshed sweet potato (OFSP) in Uganda and Mozambique. This study is an excellent example of a value chain for a newly introduced nutritious product that includes specific nutrition goals: to increase not only production of OFSP but also its consumption, as well as the vitamin A intake and status of poor households, with a focus on women and young children. The rigorous evaluation carried out in both countries shows that the approach was highly successful in enhancing production, market opportunities among small farm producers, and consumption of OFSP, resulting in greater vitamin A intake among particularly vulnerable groups—mothers, infants, and young children.

Box 3. Case Study 2: Increasing production, availability, and consumption of vitamin A-rich orange-fleshed sweet potato (OFSP) in Mozambique and Uganda

Most sweet potatoes consumed in Africa are white-fleshed. Replacing these in the diet of the rural and urban poor with orange-fleshed varieties, rich in vitamin A (beta-carotene), has the potential to reduce vitamin A deficiency. To help achieve this potential, the HarvestPlus project “Reaching End Users” undertook a series of activities to increase the production, availability, and consumption of orange-flesh sweet potato (OSFP) among rural producer-households. The project aimed also to raise the income of producers, who can sell excess production, and to stimulate consumption by nonproducing households, thus increasing demand for this excess production. Actions were taken to develop the value chain for OFSP at all three levels—farmer, trader, and consumer.

- At the *farmer* level, it was important to build confidence that market demand existed, to increase skills in marketing, and to ensure that there was a market for the produce.
- At the *trader* level, it was important to raise awareness of the nutritional advantages of OFSP, to identify where it could be sourced, and to define the role traders could play in promoting consumption. It was also important to show traders that they could make higher returns from selling OFSP, as diagnostic work indicated that it was often sold at a higher price. This was substantiated by willingness-to-pay studies with purchasers.
- For consumers, it was vital to raise awareness of OFSP’s nutritional benefits and to encourage replacement of white-fleshed varieties with the vitamin A-enhanced orange variety.

The results showed that it was possible to create a market for OFSP and to stimulate consumption among both producers and net consumers. In Mozambique, the percentage of orange (compared to white) sweet potatoes sold rose from zero in 2006 to 18 percent in 2008 and to 50 percent in 2009. As many as 82 percent of sweet potato purchasers indicated that they would buy OFSP in the future, largely because of its nutritional and health benefits, which they understood from the education messages. A rigorous impact evaluation showed that the project led to large increases in the consumption of OFSP and, more importantly, in vitamin A intake among women, infants and young children—the key target groups because of their high susceptibility to vitamin A deficiency (Hotz et al. forthcoming).

The value-chain approach was particularly useful in this study, to help coordinate actions across the supply chain and to engage with a range of value-chain actors, including producers, traders and consumers. Agriculture was linked to nutrition, not just through greater production, but also through market linkages created in the value chain. Value was conceptualized as *economic value* for the producers and traders, and as *nutritional and health value* for the consumers. Importantly, consumers were willing to pay more for the product when they were made aware of its nutritional and health benefits.

Source: Coote et al. 2011; Hawkes and Ruel 2011.

In the third case study (Box 4), demand and supply were raised in tandem, by working with producers within existing local production and consumption systems. The project aimed (1) to promote nutritious, traditional foods to increase demand; and (2) to open markets to respond to this demand, potentially enhancing producers’ income. Women continue to be the main actors in African leafy green vegetable production and marketing—a positive aspect that can be leveraged to enhance the economic empowerment of women.

Box 4. Case Study 3: Traditional African green leafy vegetables find their way to formal markets

African Leafy Vegetables (ALVs) are an important source of essential macro- and micronutrients. They also offer a source of livelihood when marketed, and they contribute to crop biodiversity. Sub-Saharan Africa contains a large variety of nutritious, leafy vegetables—an estimated 800–1000 species. In Kenya, where approximately 210 species are available, only about 10 find their way to markets (mainly African nightshade, leafy amaranth, cowpeas, and spider-plant).

Bioversity works with resource-poor vegetable farmers on the outskirts of Nairobi, in peri-urban areas. Together they have inventoried leafy vegetable species and identified the key issues hindering their cultivation, conservation, and marketing. Other activities include nutritional and agronomic studies, distributing seeds to farmers, and disseminating local recipes featuring leafy vegetables to stimulate demand. With support and training from the project, farmers on the outskirts of Nairobi began growing leafy vegetables.

Results from a 2006 study commissioned by the Global Facilitation Unit for Underutilized Species (GFU) show the tremendous growth of the ALV market within Nairobi over the last decade: the market gross value increased by about 213% from 2001 to 2006. The campaign for traditional vegetables between 1997 and 2007 brought notable positive changes in growing, consumption, marketing, and nutritional awareness of ALVs.

The growth of this market has been greatly influenced by increased consumer demand that has been stimulated by a number of factors. These include: promotional strategies of local NGOs and international organizations; increased health awareness and consciousness of Nairobi dwellers; livelihood effects of HIV/AIDs; and improved ALV presentation in supermarkets as well as upmarket groceries. Supply has in turn been enhanced: by promotion of production in peri-urban and upcountry areas, by international organizations and local NGOs; by external marketing support provided by NGOs; by farmers' capacity for self-organization; and by improvement of telecommunication technology.

Work is now under way to understand how these foods contribute to improved diet diversity and micronutrient intake in these communities.

Source: Gotor and Irungu 2010; Gotor et al 2010

Objectives

The overall objective of this component is to leverage the value chain for select nutrient-rich (high value) foods to increase the demand for, and access to, affordable nutritious foods among poor rural and peri-urban marginal households, with a particular focus on benefiting vulnerable women, infants, and young children.

The specific objectives are listed below and illustrated in Figure 3.

Specific Objectives

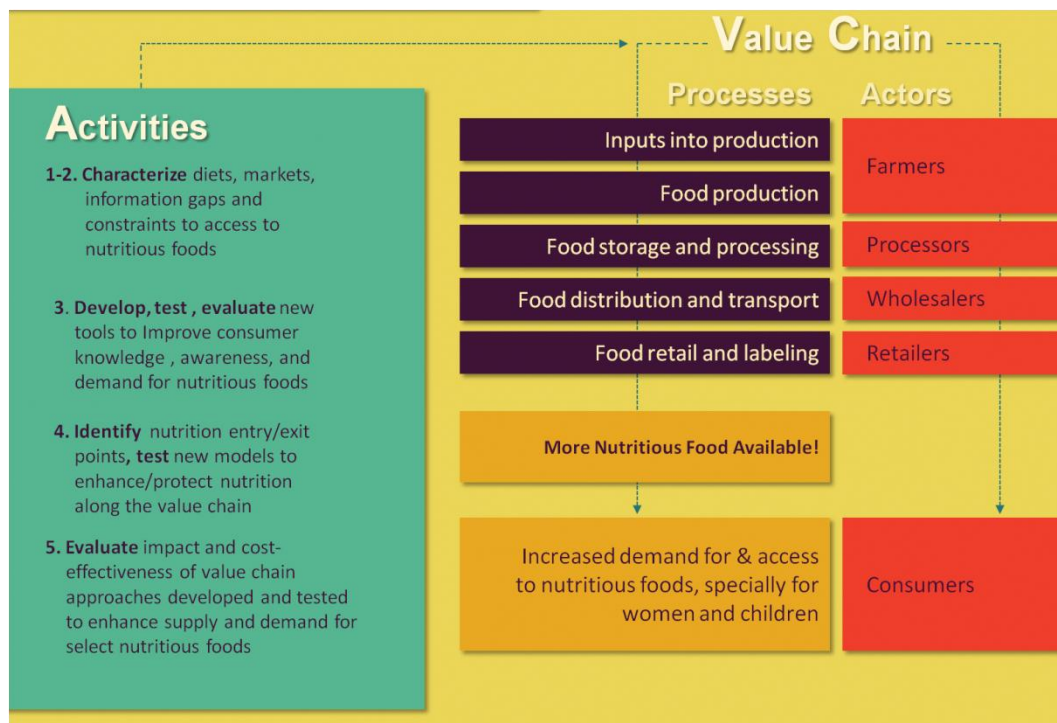
1. Characterize the dietary patterns of vulnerable and marginal populations and communities; identify the available nutrient-rich foods that could be made more accessible to these communities through value chains.
2. Understand information gaps and constraints to the consumption of nutrient-rich foods (economic, social, and cultural).
3. Develop, test, and evaluate new tools to increase awareness, access to information, and knowledge among consumers to stimulate demand for nutritious foods.
4. Identify nutrition entry points (where nutrients are gained) and exit points (where nutrients are lost), at different points along the value chain; test new models to enhance or protect the

nutritional value of foods (including fortification) during post-harvest handling, processing and preserving, transportation, distribution, storage, and food preparation.

- Evaluate the impact and cost-effectiveness of the approaches developed and tested in objectives 3 and 4 in enhancing demand for, and access to, these targeted nutrient-rich foods among rural and peri-urban poor populations.

Figure 3 shows a simplified value chain. On the right are shown some of its key actors; on the left are the list of objectives and the related broad categories of activities to be undertaken under this component. The figure shows that the starting point in this approach is the consumer rather than the producer (as in typical value chain work); the ultimate goal is to stimulate demand and increase access for the poor to nutritious food, instead of the usual focus on enhancing production and producer income.

Figure 3. Research strategy for enhancing nutrition along the value chain



Research Questions

Objective 1. Characterize dietary patterns and identify available nutrient-rich foods.

- What are the dietary patterns of consumption and use, in target populations, of traditional local foods, animal source foods, fruits and vegetables, biofortified staple foods, and processed (including micronutrient-fortified) foods?
- How do these patterns differ across different groups of consumers, as defined by gender, education, household composition, income level, culture, geographic location, access to markets, and levels of food self-sufficiency?
- What is the nutritional value of these nutrient-rich foods (both nutrient content and functional properties)? How is their nutritional value affected by post-harvest handling, processing, storage, and food preparation?

- Can diversified agricultural production be scaled for commercial use while maintaining biodiversity and ecosystems, and improving human nutrition and health? What does agricultural biodiversity imply for peri-urban value chains, and what do trends in peri-urban markets imply for potential success of agricultural biodiversity?
- How adequate is the supply (quantity, quality, and seasonality) of nutrient-rich foods at informal and formal markets?
- What is the cost of these nutrient-rich foods in these settings? What contributions do they make (or could they make) in the diet of the poor? Which nutrient gaps do they (or could they) fill, especially for vulnerable women and young children?
- What is the potential of biodiverse systems in providing rich and varied sources of nutrients for foods? How does this contribute to household consumption and diet quality or income generation? (Examples of such systems include root and tuber crop diversity in the Andes, sweet potato in Papua New Guinea, leafy green vegetables in Kenya, and minor millets in India.)

Objective 2. Understand information gaps and constraints to consumption.

- What are the main constraints to consumption and use, in target populations, of traditional local foods, animal source foods, fruits and vegetables, biofortified staple foods, and processed foods—including cultural, economic, availability, and information constraints? What are the constraints to better use of local knowledge of biodiverse systems to improve the nutrition of households?
- What are the opportunities and barriers to increasing demand for and consumption of these nutrient-rich foods among the poor? What is the role of women in decisionmaking regarding food purchases and intra-household distribution?
- What is the current level of nutritional knowledge and awareness of consumers and actors along the value chain regarding nutrition, during phases of food processing, handling and preparation? What sources of information do they trust the most for information regarding healthy diets and nutrition? How is information diffused and acquired? What is the role of social networks in knowledge diffusion?
- What is the willingness of poor rural and peri-urban consumers to pay for foods that are rich in nutrients? How can their willingness to pay be increased (for example, through education, information dissemination, and media)?
- How do the previous four questions vary across different groups of consumers, as defined by gender, education, household composition, income level, culture, geographic location, access to markets, and level of food self-sufficiency?

Objective 3. Develop, test, and evaluate new tools to increase knowledge and awareness regarding nutrition among key value chain actors.

- What are the most efficient and effective approaches, methods, tools, and media outlets to disseminate information and raise public awareness about nutrient-rich foods? How can the value chains be leveraged to inform value chain actors, including consumers?
- How can women participate more actively in various processes along the value chain and play a greater role in producing high-quality nutrient-rich (and commercial) products, as well as in shaping the demand for such foods?
- What is the nutritional impact of commercial producers' participation in rural markets for the poor?

Objective 4. Identify nutrition entry and exit points, and test new models to enhance nutrition along the value chain.

- For nutrient-rich foods, what are the potential points of entry to enrich, replace, or preserve nutrients along the value chain?
- What exit points along the value chain should be mitigated to avoid nutrient losses?
- What is the added cost of making nutrient-rich foods more nutritious along the value chain?
- How can local value chains be used to produce specialized products for populations with special needs (such as undernourished or pregnant mothers, persons living with HIV/AIDS, and infants)? Strategies might include ready-to-use therapeutic foods (see case study 1), fortified blended foods, biofortified crops, and improved complementary foods.
- What nutritious products could be developed and promoted from available local foods and underutilized crops? What scale would be appropriate and cost-effective for local production from biodiverse systems of affordable, high-quality, specialized foods for these vulnerable population groups?
- How can women farmers be linked in as producers and processors of nutrient-rich foods, or as ingredient suppliers to commercial manufacturers of specialized foods?

Objective 5. Evaluate the impact and cost-effectiveness of the approaches developed under Objectives 3 and 4.

- What is the impact of the approaches developed in Objectives 3 and 4 on availability, access, and consumption of nutrient-rich foods among the target populations? How does the impact differ across groups of consumers, as defined by gender, education, household composition, income level, culture, geographical location, access to markets, and level of food self-sufficiency?
- What is the impact on particularly vulnerable subpopulation groups, such as the poorest of the poor and women and young children within poor households?
- What is the cost-effectiveness of the different approaches developed?
- What are the lessons learned for other value chains in other contexts, and at a greater scale?
- How are the trade-offs addressed between economic gains for producers and other actors along the value chain for nutrient-rich foods and the higher cost for consumers? Are consumers willing to pay for additional nutritional value of foods? Which consumers? What happens to the poorest of the poor?

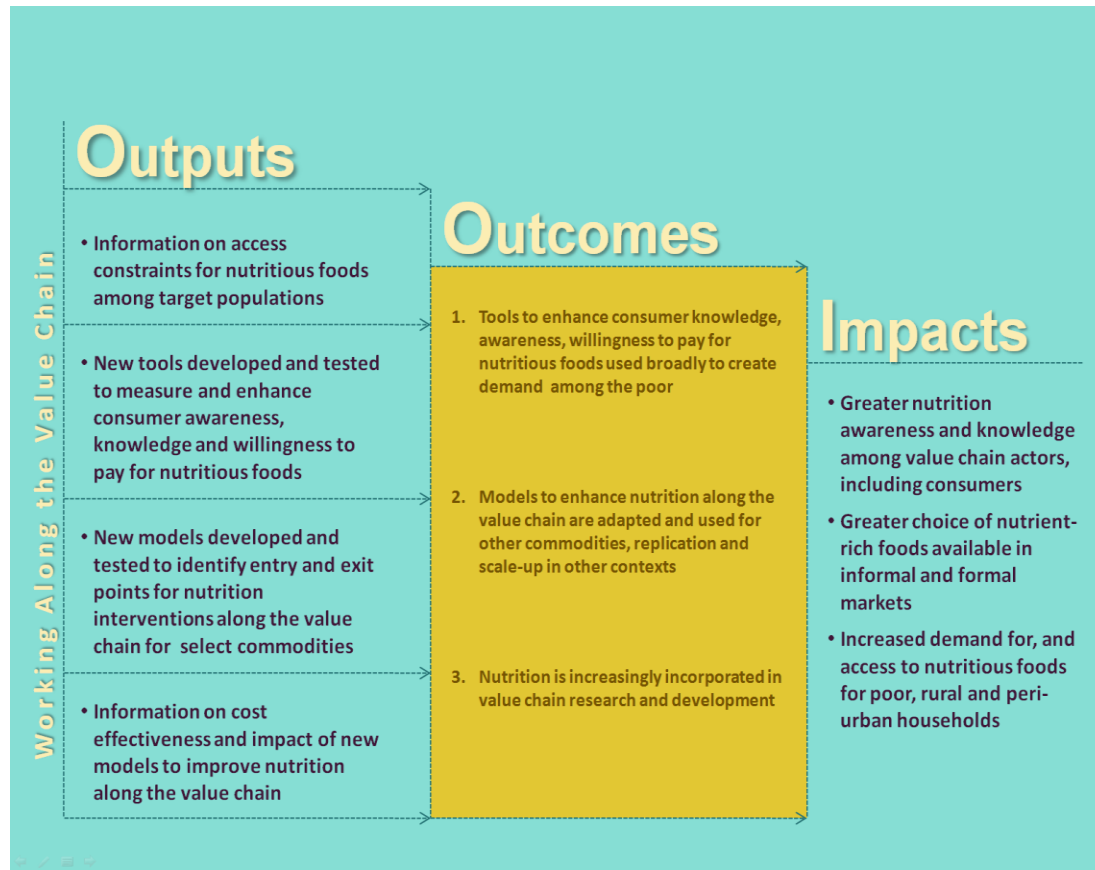
6.1.2 Impact Pathway

This component will have the desired impact if it contributes to increasing the demand for—and access to—a larger variety of affordable nutritious foods, among vulnerable and marginalized households in rural and peri-urban areas. This will result from (1) enhanced nutritional knowledge and awareness created among value chain actors, including consumers, and (2) the greater selection of affordable nutrient-rich foods available through informal and formal markets. The pathway to achieving these impacts will be mediated through the following three outcomes (as shown in Figure 4):

1. Tools developed to enhance consumer knowledge, awareness, and willingness to pay for nutritious foods are used broadly to create demand for such foods among the poor.
2. Models developed and tested to enhance nutrition along the value chain are adapted and used for other commodities, as well as for replication and scale-up in other contexts.

- Nutritional considerations, analysis, and interventions are increasingly incorporated in value chain research and development.

Figure 4. Impact pathway of Component 1



Commodities with intrinsic nutritional value that are typically out of reach for poor consumers (and that tend to be sold for income rather than consumed by producer households) will be prioritized for value chain analysis and improvement. Research outputs from work on these selected food commodities will fall into three categories:

- detailed information on diets, consumption patterns, and access constraints for the poor to nutritious foods
- new tools and approaches to measure and increase consumer awareness, knowledge, and willingness to pay for nutritious foods
- new cost-effective models to improve the nutritional value of these foods through the value chain

The research in this component will be closely linked with food safety research in component 3 to provide outputs to enhance nutritional quality and food safety along the value chain. This will require significant engagement with three key stakeholder groups involved in value chain work. The CGIAR and other research institutions working on highly nutritious food value chains. For example, close linkages are planned with CRP3.7 for meat, dairy and fish along with their partners, and with CRP2 and partners for the promotion of nutrient-rich food production.

Development actors involved in social protection programs or in integrated ANH programs promoting healthy diets and increased demand for nutritious foods.

The private sector food chain actors, which are increasingly engaged in the production, processing, distribution, and marketing of specialized foods and nutrient-rich foods.

Private sector initiatives include programs focusing on the distribution and demand creation for specialized foods and locally produced fortified products targeted to vulnerable groups such as pregnant or lactating women, young children, or other individuals with special needs. A key actor will be pharmaceutical companies involved in nutrition product development and in fortifying foods with essential micronutrients, such as DSM, Nutriset, and others. The Global Alliance for Improved Nutrition (GAIN), which facilitates private-sector investment in adding nutritional value to foods along the value chain, will be an important partner and enabler for this component. Other key actors include the United Nations (UN) REACH initiative, WFP and its development assistance programs, and governments and nongovernmental organizations implementing social protection and targeted nutrition programs, to name a few.

6.1.3 Activities, Outputs, and Outcomes

The proposed activities, with related outputs and outcomes, are presented in Table 3, listed by objective. A preliminary plan for the prioritization, sequencing, and timing of activities follows below.

Table 3. Activities, outputs, and outcomes of Component 1, by objective

Activities	Outputs	Outcomes
Objective 1. Characterize the dietary patterns of vulnerable and marginal populations and identify the available nutrient-rich foods that could be made more accessible to these communities through nutrition-sensitive value chains.		
<i>Years 1-2</i>		
Carry out dietary surveys complemented with qualitative research on individuals, households, and communities in diverse agroecological systems and rural and peri-urban areas.	Information on consumption patterns and nutrient gaps for populations in diverse agrosystems (in rural areas) and of different socioeconomic groups. Evidence on the use of nutrient-rich foods (production, post-harvest handling, processing, preservation, and preparation). Evidence on determinants of use in households and communities (knowledge, beliefs, intrahousehold allocation of foods, sociocultural factors, and gender dimensions).	Better understanding of availability, consumption patterns, use, processing, and storage of nutritious foods, and of nutrient gaps in target households and communities, by rural areas and socioeconomic groups.

Table 3. Activities, outputs, and outcomes of Component 1, by objective (continued)

Activities	Outputs	Outcomes
<p>Objective 1. Characterize the dietary patterns of vulnerable and marginal populations and identify the available nutrient-rich foods that could be made more accessible to these communities through nutrition-sensitive value chains. (continued)</p>		
<p><i>Years 1-2</i></p>		
<p>Use laboratory methods to determine the nutritional value of nutritious but lesser known foods (including intraspecies variation) as well as nutrient losses during processing, storage, and cooking.</p>	<p>Database developed on the nutritional value of lesser known and local foods, using innovative nutrient scoring models.</p>	<p>Database is used in the real-time formulation of action plans based on better information on the nutritional value of lesser known foods; database information is made accessible to consumers and producers.</p>
<p>Carry out market surveys on availability and cost of nutritious foods within markets; survey target populations to assess access to markets.</p>	<p>Data collected and analyzed on the dynamics of food purchases, production for home consumption, and sales.</p> <ul style="list-style-type: none"> • Information on foods available on markets: prices, who sells and retails, and gender dimensions within markets. • Analysis showing geographical distribution and types of markets as well as community access to these markets 	<p>Better understanding of households' food purchasing and production patterns, the role of markets, and who uses them. Ability to plan more efficient initiatives to boost availability of key nutritious foods crops and to facilitate access of target population to markets.</p>
<p>Objective 2. Understand information gaps and constraints to consumption of nutrient-rich foods (including economic, social, and cultural constraints).</p>		
<p><i>Years 1-2</i></p>		
<p>Use qualitative and quantitative methods to document: consumers' knowledge and awareness of nutrient-rich foods (in rural and peri-urban areas); the sources of information they normally use; and their preferred ways of receiving such information.</p>	<p>Qualitative and quantitative data and analysis on consumers' knowledge and awareness about nutrient-rich foods. Data on the sources of information consumers rely on (formal or informal, public or private) regarding nutrition, diets, and health. Data on the preferred information channels for different population groups.</p>	<p>Increased knowledge of consumers' level of nutrition awareness, and their actual/preferred ways of obtaining information on food and nutrition. Possibility of implementing more specific initiatives geared towards increasing consumer knowledge and awareness.</p>
<p>Use non-survey methods to assess consumers' acceptance and valuation of nutrient-rich foods based on different levels of information on nutrition.</p>	<p>Valuation data collected and analyzed on:</p> <ol style="list-style-type: none"> 1. Consumers' initial acceptance and valuation (willingness to pay [WTP] of nutrient-rich food (as the status quo or baseline level); consumers' preferences regarding types and format of such foods 2. Effect of varying the source (or media) of nutrition information on consumers' acceptance and valuation of nutrient-rich foods 3. How consumers make decisions based on taste and sociocultural influences relating to specific foods that may have nutritional benefits 	<p>Improved understanding of the role of nutrition education and information in influencing consumers' acceptance and willingness to buy nutrient-rich food.</p>

Table 3. Activities, outputs, and outcomes of Component 1, by objective (continued)

Activities	Outputs	Outcomes
<p>Objective 2. Understand information gaps and constraints to consumption of nutrient-rich foods (including economic, social, and cultural constraints). (Continued) <i>Years 1-2</i></p>		
<p>Assess the food preparation and storage methods of the target populations and identify any knowledge gaps relative to the utilization, preparation, and storage of nutrient-rich foods.</p>	<p>Qualitative and quantitative data describing the methods and customs of consumers pertaining to the utilization of food with respect to nutritional quality. Specifically, information regarding:</p> <ol style="list-style-type: none"> 1. Cooking and food preparation customs 2. Storage habits for cooked and uncooked foods 	<p>Acquire a better understanding of practices related to utilization, preparation and storage of nutrient-rich foods in the target population, to help design educational tools to promote their use and the retention of their nutritional value.</p>
<p>Objective 3. Develop, test, and evaluate new tools to increase awareness, access to information, and knowledge among consumers to stimulate demand for nutrient-rich foods. <i>Implementation starting in Years 3-5; completion in Years 6-10</i></p>		
<p>Develop, test, and evaluate new tools, as well as information, education and communication (IEC) materials, designed to increase consumer awareness and promote nutritious foods for different consumer groups, in partnership with market and retail companies.</p>	<ol style="list-style-type: none"> 1. New tools developed, tested, and evaluated to increase consumer awareness and promote nutritious foods among different consumer groups. 2. Portfolio of information, education, and communication (IEC) materials assembled for different consumer groups with careful review of socio-cultural influences. 	<p>New tools and materials are widely available to private sector, NGOs, governments, and consumers, to increase consumer awareness and promote selected nutritious foods.</p>
<p>Objective 4. Identify nutrition entry points (where nutrients are gained) and exit points (where nutrients are lost) along the value chain, and test new models to enhance or protect the nutritional value of foods during post-harvest handling, processing and preserving, transportation, distribution, preparation, and storage. <i>Implementation starting in Years 3-5; completion in Years 6-10</i></p>		
<p>Identify value chains with potential to increase nutrient entry points and minimize exit points in different agroecological zones; prioritize these commodity value chains for research under this component (in collaboration with CRP3).</p>	<p>Value chains with greatest potential for nutrition interventions identified and prioritized for research under this component.</p>	<p>Set of value chains with greatest potential for nutrition interventions selected for research in different environments.</p>
<p>Objective 4. Identify nutrition entry points (where nutrients are gained) and exit points (where nutrients are lost) along the value chain, and test new models to enhance or protect the nutritional value of foods during post-harvest handling, processing and preserving, transportation, distribution, preparation, and storage. <i>Implementation starting in Years 3-5; completion in Years 6-10 (continued)</i></p>		
<p>Assess points of entry in the value chain for enhancing or preserving the nutritional value of specific food commodities (such as processing fresh fish into fish powder; drying biofortified orange flesh sweet potatoes)</p>	<p>Value chain analysis carried out in collaboration with relevant CRPs to identify significant nutrient entry points and exit points for different commodities.</p>	<p>Better understanding of opportunities and points of entry to enhance the nutritional value (or reduce losses) of specific food commodities along the value chain.</p>

Table 3. Activities, outputs, and outcomes of Component 1, by objective (continued)

Activities	Outputs	Outcomes
Objective 4. Identify nutrition entry points (where nutrients are gained) and exit points (where nutrients are lost) along the value chain, and test new models to enhance or protect the nutritional value of foods during post-harvest handling, processing and preserving, transportation, distribution, preparation, and storage. Implementation starting in Years 3-5; completion in Years 6-10 (continued)		
Develop and test improved tools and technologies to reduce nutrient loss, enhance nutrient content, or improve nutritional value of specific commodities working with large to small commercial producers and retailers.	Top-performing technologies identified for different commodities, in areas such as: <ol style="list-style-type: none"> 1. aquaculture and livestock product processing; 2. domestication of neglected and underutilized foods; and 3. regional milling, processing, and fortification facilities. 	New tools and technologies are available to reduce nutrient losses, enhance nutrient content, and improve nutritional value along the value chain for different commodities in different environments.
Objective 5. Evaluate the impact and cost-effectiveness of the approaches developed under Objectives 3 and 4. Implementation starting in Years 3-5; completion in Years 6-10)		
Select evaluation design (experimental vs. quasi experimental) for different projects and settings. Carry out baseline and endline surveys (with or without control group) for cost and impact assessment. Set up costing data collection; collect cost data. Carry out qualitative assessments to complement and help interpret quantitative data collection and results. Carry out process evaluation to assess fidelity and quality of implementation, identify bottlenecks in implementation, and analyze coordination of different actors along the value-chain. Analyze data and prepare reports. Disseminate results to variety of stakeholders.	Evidence on impact and cost-effectiveness of approaches developed in 3 and 4 to increase the availability of, and access to nutritious foods among the poor; evidence of the nutritional knowledge and awareness of different actors along the value chain	Models to enhance nutrition along the value chain are available, and are adapted and used for different commodities and in different environments.

6.1.4 Priority Setting and Sequencing of Activities

The first activity in this component will be to select suitable value chains and contexts to initiate research on integrating nutrition considerations and interventions into value chain research and development. The team will first organize a meeting of relevant CGIAR centers, CRPs, and other partners who are working on value chains for select commodities with a focus on nutrient-rich foods. Examples of experts and partners for this workshop include those working on CRP3.7 on meat, dairy and fish and on CRP3.5 on grain legumes; experts working on biodiversity (including staff from Bioversity and partners); staff and partners from the World Agroforestry Centre (ICRAF) and the World Vegetable Center working on fruits vegetables; staff working on biofortification (component 2 of this CRP); and development partners such as REACH, GAIN, and private companies interested in working on value chains for enhanced nutrition. The outcome of this initial workshop will be the selection of four to five value chains for start-up research. The criteria for value chain selection will include a series of factors, including (but not limited to) the potential to effectively reach the poor and improve their access to nutritious foods, the likelihood of success in working with value chain actors on incorporating nutrition interventions, and the goal of working in a diversity of environments, contexts, countries, and populations, including populations exposed to different stages of economic development, market access, and agroecological zones.

Once value chains and contexts are selected, work will be phased in, in roughly in the order in which the activities are listed in Table 3. Research under objectives 1 and 2 will be launched in Years 1-2; this will include a series of assessments using quantitative multi-level surveys, qualitative enquiry, social network censuses, nutritional analysis of foods (where relevant), and non-survey methods to assess consumers' acceptance and valuation of nutrient-rich foods. This rich information will be used, starting in Year 3, to address objectives 3-5. Tool and method development and impact evaluation (starting with baseline in Year 3) will be implemented gradually in different contexts in Years 3-5 and will take perhaps three to five years to complete, depending on the scope and rigor of the evaluation methods selected. We therefore envision at a minimum a ten-year process to complete a full set of case studies and to generate the planned research outputs and outcomes.

6.1.5 Methods

A variety of quantitative and qualitative methods will be used to address the five objectives of this component. Table 4 provides an overview of methods and indicators that will be used for each objective. Note that all analyses will generate gender-disaggregated data, where relevant.

Table 4. Methods and indicators for Component 1

Methods	Examples of indicators
Objective 1. Characterization of dietary patterns and nutrient composition of foods	
Quantitative, representative household surveys to collect basic information on (1) household demographics, socioeconomic conditions, consumption/expenditure, agricultural production, access to services and markets, and food security; (2) detailed information on food consumption and acquisition; and (3) gender-disaggregated dietary intake data using detailed 24-hour recall methods, food frequency questionnaires, dietary diversity assessments, and anthropometric measurements, as well as biomarkers (for micronutrient status) where appropriate	<ul style="list-style-type: none"> - Total expenditure; food expenditure; budget shares for different nutritious and other foods - Household food security indicators (household hunger scale, household food insecurity access scale, coping strategies) - Quantified food production (types and amounts of different foods produced; % consumed; % sold, and so forth) - Intake of energy, protein, fat, and select micronutrients by vulnerable individuals (such as women and young children); nutrient gaps (at household and individual level) - Anthropometric measurements (weight-for-age z-scores, height-for-age z-scores, weight-for-height z-scores; stunting, wasting, underweight), focusing on women and young children - Biomarkers of micronutrient status, where relevant (such as serum retinol for vitamin A, haemoglobin for anemia, serum zinc for zinc status), focusing on women and young children - Reported illness symptoms in past two weeks (focus on child)
Quantitative community surveys to collect information on community characteristics and availability of services	<ul style="list-style-type: none"> - Community characteristics (number of schools, health facilities, water source, agriculture, and the like)
Market surveys to collect data on the availability and cost of nutrient-rich foods	<ul style="list-style-type: none"> - Food supply; food prices, market processes; mapping of foods available in markets

Table 4. Methods and indicators for Component 1 (continued)

Methods	Examples of indicators
Objective 1. Characterization of dietary patterns and nutrient composition of foods (continued)	
Laboratory methods to estimate the macro- and micronutrient content of selected traditional local foods	<ul style="list-style-type: none"> - Data on calories, protein, fat, and micronutrient content of traditional foods of importance in the population, which are not included in food composition tables
Agriculture, ecosystem, and biodiversity tools to characterize the food diversity of agriculture landscapes and ethno-botanical characteristics of potential food sources	<ul style="list-style-type: none"> - Species numbers, abundances, densities - Shannon diversity and evenness indices - Number of uses per species and species per use category
Linear programming to (1) identify nutrient gaps and (2) select diets (based on local foods available in markets) that satisfy a set of nutritional constraints	
Objective 2. Understand information gaps and constraints to consumption of nutrient-rich foods	
<i>Quantitative:</i> surveys in objective 1 will also collect relevant data on: knowledge, practices, and attitudes in relation to nutrition/nutritious foods; perceived constraints to use of nutritious foods; preparation and storage of nutritious foods; sources, uses, and preferences regarding knowledge acquisition and information gathering (using social network census approaches).	<ul style="list-style-type: none"> - Knowledge score (based on knowledge test) - Practices scales (for different dimensions of practices) - Lists (and quantification) of constraints identified - Lists (and quantification) of social networks, sources and providers of information, and so forth
<i>Qualitative:</i> to be selected from a variety of potential approaches, depending on context and specific questions addressed. Examples of approaches include: focused ethnographic studies; focus group discussions; in-depth structure, semi-structured, and unstructured interviews; observations; shadowing. Topics same as for quantitative surveys	<ul style="list-style-type: none"> - In-depth information on knowledge, attitudes, and practices regarding nutritious food use, intake, preparation, and storage. Information on constraints to intake of nutritious foods (such as sociological, cultural, economic, and gender-related) and on preferred sources of information relating to issues around food use.
<i>Survey methods</i> to assess consumers' acceptance and willingness to pay for nutrient-rich foods based on different levels of information. Methods include: hypothetical non-market stated preference methods (SPMs) encompassing both contingent valuation and choice experiments (see Alfnes et al. 2006); real non-market valuation methods, such as Vickery and Becker-DeGroot and Marschack experimental auctions (Train and Wilson 2011; Plot and Zeiler 2005; Horowitz and McConnell 2002; Shogren et al. 2001); and real market randomized experiment methods to understand the effects of information about nutritious attributes of food, including their effect on the WTP (Masters and Sanogo 2002; Birol, Roy, and Torero 2010).	<ul style="list-style-type: none"> - Measures of expected willingness to pay as compared to existing market prices. This will be developed across the income distribution to control for low ability to pay (ATP). - Measurement of the nutritious attributes more valued by consumers. - Measures of the effects of better information about the nutritional attributes of food.

Table 4. Methods and indicators for Component 1 (continued)

Methods	Examples of indicators
Objective 3. Develop, test, and evaluate tools to increase consumer awareness, access to information, and knowledge about nutrient-rich foods.	
<p><i>Formative research</i> will be used to develop new education/behavior change approaches. Data collected under Objectives 1 and 2 will also be used to design education interventions.</p> <p><i>Rigorous evaluation methods</i> will be used to compare and evaluate approaches; see component 4 for description of evaluation methods, including impact, process and cost evaluation. Qualitative data collection will be used to assess constraints to adoption and use of recommended practices, and to interpret results of evaluation.</p>	<ul style="list-style-type: none"> - Impact will be evaluated on the same indicators as above: knowledge and practices test scores; changes in constraints; changes in use of information; changes in use of nutrient-rich food.
Objective 4.: Identify nutrition entry and exit points and test new models to enhance or protect the nutritional value of foods along the value chain.	
<p><i>Value chain analysis:</i> This activity will first define the value chain for analysis by identifying key commodities that could be sensitive to increases in nutritional content. Once the key commodities are identified, a mapping of the specific value chains will be done with key stakeholders, and field instruments will be developed to identify key exit and entry points of nutritional content across the value chain. The detailed analysis of the value chain will include measuring its performance and evaluating the benefits and costs associated with nutrition upgrading options. Then we will identify opportunities and mechanisms for small farmers to benefit, based on the WTP studies of consumers; we will pilot possible interventions and assess their impact, in terms of costs and benefits to producers and consumers of the upgrading options implemented.</p> <p><i>Laboratory evaluation methods</i> will be used to quantify the losses/increases in nutrient content along the value chain, to enable comparisons and evaluation among different models/interventions.</p>	<ul style="list-style-type: none"> - Key commodities to be targeted to improve nutrition at key entry and exist points - Cost benefit analysis by commodity of potential interventions to enhance nutrition at specific entry points and to prevent losses at exit points along the value chain - Best practices identified in improving the nutritional content of value chains
Objective 5. Evaluate the effectiveness and cost-effectiveness of the approaches developed in Objectives 3-4	
<p>Rigorous evaluation methods will be used based on sound program impact theory, using process evaluation and cost effectiveness assessments (see component 4 for details on methods).</p>	<ul style="list-style-type: none"> - Impact indicators: household consumption and individual intake of targeted nutritious foods; contribution of these foods to changes in micronutrient intake and micronutrient status, and possibly to child growth and morbidity symptoms (depending on the micronutrient)

6.1.6 Partnerships

In addition to CG centers and the World Vegetable Center (an international agriculture research center focusing on vegetables), the list of potential partners for this component includes a wide variety of stakeholders, including NARES, NGOs (such as CRS, Concern Worldwide, and Helen Keller International), intergovernmental organizations (UN agencies and programs such as FAO, WHO and REACH), government institutions, foundations, and academic institutions. Beyond these partners, many regional and locally specific partnerships and stakeholders have been identified under individual research activity descriptions.

A strong collaboration with the private sector will be pursued under this research component for testing sustainability of methods and tools along case study value chains. Public-private partnerships will be fostered in collaboration with GAIN. Strategic alliances will be pursued with existing agricultural investment projects, such as those supported by the International Fund for Agricultural Development (IFAD) (like the Orissa Tribal Empowerment and Livelihood Program), by GAIN, and by the food and retail industries.

Table 5. Examples of partnerships for Component 1

Enablers	Development implementers	Value Chain actors	Research partners	CGIAR centers
IFAD	NGOs:	- Private	- World	Bioversity
FAO	- CRS	sector (e.g.	- Vegetable	CIAT
WHO	- Concern	Land	Center	CIMMYT
REACH	Worldwide	O'Lakes)	- LCIRAH	CIP
GAIN	- HKI	- GAIN	- NARES	ICARDA
Governments institutions in countries of emphasis				ICRAF
				ICRISAT
				IITA
				ILRI
				World Fish

6.2 Component 2: Biofortification

6.2.1 Rationale, Objectives, and Research Questions

Rationale

A primary underlying cause of malnutrition is poor diet quality, characterized by high intake of food staples and low consumption of foods rich in vitamins and minerals, leading to widespread micronutrient malnutrition among people who cannot afford to buy (or manage to produce) more nutritious foods. By developing staple crop varieties whose edible portions are richer in bioavailable nutrients (through a process called biofortification), agricultural research can provide farmers with crop varieties that can readily improve nutrition for millions of people (Nestel et al. 2006).

CRP4 will encompass two programs designed to do just that: HarvestPlus, and AgroSalud. Since 2003, the Consultative Group on International Research (the CGIAR) has supported HarvestPlus, the CGIAR Challenge program on biofortification. HarvestPlus has produced promising varieties of seven nutrient-rich staple crops, poised to be released within the next three years. HarvestPlus is now performing nutritional testing on these crops in target areas in Africa and Asia, to ensure they deliver bioavailable nutrients. AgroSalud is undertaking biofortification work for the Latin American region. In addition, AgroSalud proposes to explore the possible impact of the production and consumption of several biofortified crops in the food basket that represents the typical staple crop diet in Latin America.

HarvestPlus and AgroSalud are independent programs with their own well-established goals, visions, governance, management, and funding base. Nevertheless, the two programs work closely and share research methods, protocols, germplasm, scientists, and communication capabilities. Published nutrition studies under both programs have added to the growing body of evidence that biofortification can reduce micronutrient malnutrition in a cost-effective way. In particular, biofortified beans (developed at CIAT) and biofortified maize (developed at the International Maize and Wheat Improvement Center [CIMMYT]) contribute to variety development globally.

Component 2 proposes to channel investments into these two geographically distinct but related subcomponents:

- *Subcomponent 1:* HarvestPlus (www.harvestplus.org)
- *Subcomponent 2:* Biofortified Food Basket for Latin America and the Caribbean (www.AgroSalud.org)

Objectives

The objective of Component 2 is to develop and test nutrient-dense staple crops through biofortification and to make these novel crops available to the poor and undernourished.

Research Questions

For biofortification to be successful, four broad questions must be addressed:

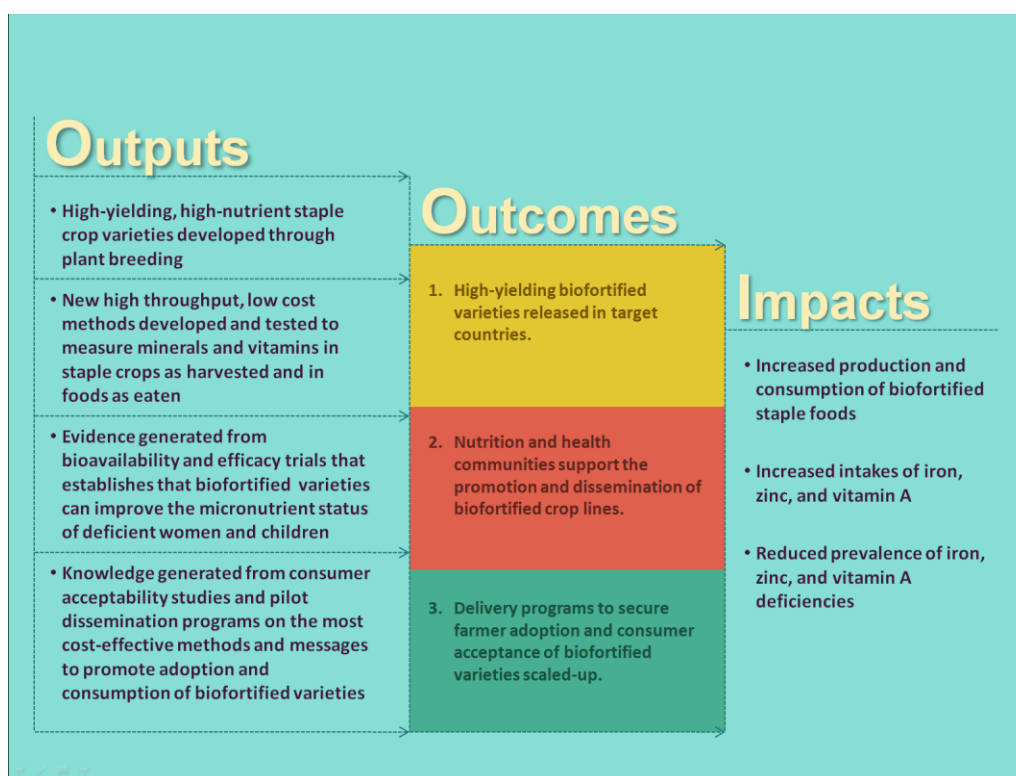
1. Can plant breeding and modern agricultural biotechnology techniques increase the nutrient density of food staples to target levels that can potentially have a measurable and significant impact on human nutritional status?
2. When consumed under controlled conditions, will these extra nutrients be bioavailable and absorbed at sufficient levels to improve the nutrient status in target populations?
3. Will farmers adopt the biofortified varieties?
4. Will consumers purchase/eat the biofortified varieties?

6.2.2 Impact Pathway, Outputs, and Outcomes

Figure 5 shows the impact pathway for biofortification. Outputs and outcomes revolve around (1) the release of biofortified crop varieties, (2) their use by the farm households, and (3) subsequent distribution through the marketing system. Details are provided for individual crops under development under each subcomponent.

Agricultural research scientists (at CGIAR centers and National Agricultural Research Systems [NARS]) develop high-yielding, high-nutrient lines which are tested in target countries for agronomic performance. If they test well, the next step is for nutritionists (from both developed country and target country institutions) to test that the varieties can improve micronutrient status under controlled conditions through efficacy trials. Finally, dissemination of biofortified varieties is organized through partnerships with agriculture- and health-oriented NGOs, government extension agencies, and communications experts.

Figure 5. Impact pathway of Component 2



6.2.3 Subcomponent 2.1: HarvestPlus

Approved in 2003, HarvestPlus was one of the first Challenge Programs supported by the CGIAR. Since its inception it has been heralded as a successful institutional innovation, invigorating both interdisciplinary research and cross-sectoral investment in the CGIAR. HarvestPlus is co-convened by two of the CGIAR centers: the International Center for Tropical Agriculture (CIAT), with headquarters in Cali, Colombia; and the International Food Policy Research Institute (IFPRI), with headquarters in Washington, D.C. As a Challenge Program, HarvestPlus is designed and managed as a “time-bound,

independently-governed program of high-impact research that targets the CGIAR goals in relation to complex issues of overwhelming global and/or regional significance, and requires partnerships among a wide range of institutions in order to deliver its products.”

Rationale, Objectives, and Research Questions

Rationale

Since 2003 HarvestPlus has built an alliance of over 200 scientists in 40 countries who breed nutrient-dense crops and test these crops for nutritional efficacy and effectiveness. In its next phase, HarvestPlus will focus its efforts on designing and building effective partnerships to disseminate these new nutritious crops in nutritionally challenged regions of Africa and Asia. In this way, HarvestPlus seeks to harness the full potential of agricultural, nutrition, and marketing sciences to develop and disseminate more nutritious staple foods in order to directly address the persistent problem of micronutrient malnutrition, especially for the poor.

Objectives

The goal of HarvestPlus is to improve the health of poor people by breeding staple food crops that are rich in micronutrients, a process referred to as “biofortification.” HarvestPlus focuses on three micronutrients that are widely recognized by the World Health Organization (WHO) as limiting in diets of the poor: iron, zinc, and vitamin A. While spillover benefits are expected to extend beyond national borders, seven focus country crop products make up the HarvestPlus portfolio (see Appendix 1):

- Zinc rice for Bangladesh and India
- Zinc wheat for India and Pakistan
- Provitamin A maize for Zambia
- Provitamin A cassava for Nigeria and DR Congo
- Iron pearl millet for India
- Iron-rich beans for Rwanda and DR Congo
- Provitamin A sweet potato for Uganda and Mozambique

Research Questions

Who are the hungry, what do they eat, and will biofortification have an impact?

For biofortification to be most effective, HarvestPlus crops must be tailored to the needs and local context of the undernourished. HarvestPlus researchers must determine who the hungry are, where they live, and what they are consuming. They must estimate existing consumption patterns as well as potential contributions from biofortified products, to determine which crop/nutrient combination would generate the most impact for which populations. These initial questions have been largely answered during the first five years of the program; for these and other research findings visit www.harvestplus.org.

Can HarvestPlus breed nutrients into staple crops without negatively effecting yield?

The ultimate end users of HarvestPlus crops are farmers as well as consumers. As rural-based nutrition interventions, the new crops must first and foremost be attractive to farmers, with yields equal to or greater than current varieties. Intensive plant breeding has been devoted to ensuring acceptable yield and other positive characteristics of biofortified varieties. For each crop cycle, breeders work to incrementally increase the level of nutrient in the edible portion of the staple crop, aiming for a level that nutritionists have determined to have a measurable nutritional impact. HarvestPlus employs the latest agricultural research technology—developed within the CGIAR, in international institutions and universities around the globe, and at national agricultural research systems—to screen germplasm, breed crops, and test and disseminate the new nutritious staple crops.

Will these crops improve nutritional status?

Improving the nutritional quality of food is a complicated endeavor. People eat food, not nutrients; and the complexities surrounding the absorption and bioavailability of nutrients from foods still represent, to some extent, an uncharted science. HarvestPlus nutritionists are applying the latest understanding of nutrient inhibiting and promoting compounds that exist in foods and in humans, to maximize the bioavailability of the micronutrients added via biofortification—and advancing the body of knowledge in this area is one of several public goods emerging from the program. Two other critical areas of program research are testing the efficacy of HarvestPlus crops in a *controlled setting*, and testing their effectiveness in improving nutritional status in a *community setting*. Finally, the nutritional quality of foods often gets compromised as food is stored and prepared. HarvestPlus nutritionists are testing the retention of the nutrients under local conditions and have discovered, among other things, that nutrient retention is in fact a heritable characteristic. This has therefore become an additional breeding objective for HarvestPlus plant breeders.

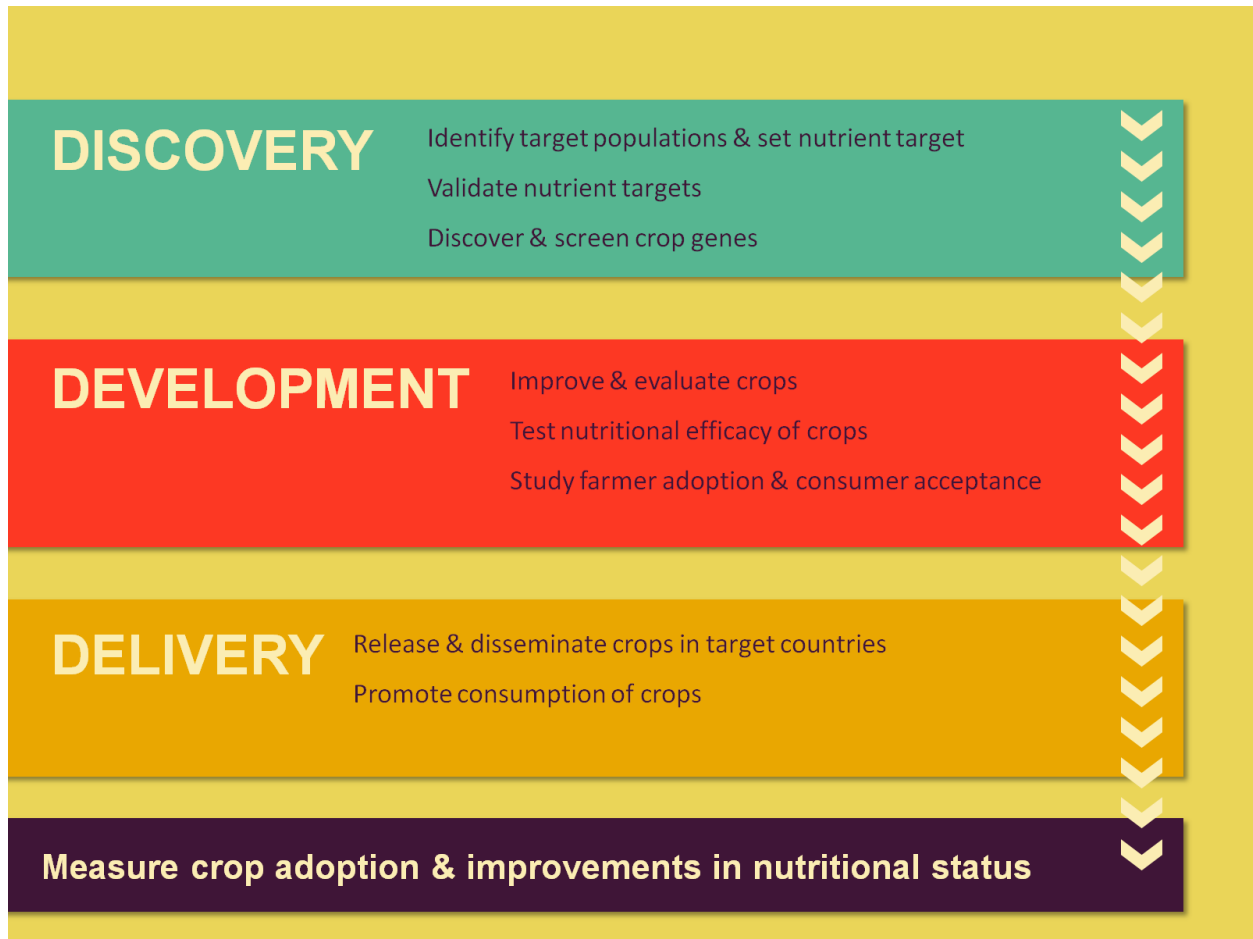
What are the determinants of farmer adoption of biofortified varieties in different settings? What will be the incentives and disincentives for consumers to purchase/eat the biofortified varieties?

There are two main strategies for introducing a new product. The *push* strategy is supply-driven. It focuses on the supply of seed and relies on breeding high nutrients into agronomically superior and high-profit varieties. The *pull* strategy focuses on the demand for biofortified crops or processed products. Well-designed consumer communication and mass media campaigns will play a major role in generating consumer demand.

Impact Pathways

The impact pathways for biofortification are described in section 6.2.2 above. Figure 6 presents the specific research steps involved.

Figure 6. Steps in research process for biofortification



The research process involves three phases: discovery, development, and delivery.

Discovery

Appropriate target populations for biofortification are determined through analysis of cropping patterns, consumption trends, and prevalence of malnutrition. This intersection in turn determines the selection of focus crops and the areas where biofortified varieties should be directed (Arsenault et al. 2010; Zapata-Caldas et al. 2009). Nutritionists work with agricultural scientists to establish nutritional breeding targets based on several factors: the food intake of populations in need; nutrient losses during cooking, storage, and processing; bioavailability of nutrients, related to the presence or absence of complementary compounds; and the probability/difficulty of breeding for specific nutrients (Hotz and McClafferty 2007). Once targets are set, the global germplasm banks of the CGIAR institutes, as well as the germplasm banks held in trust by national partners, provide a reservoir of staple-crop germplasm to be screened for nutrient genetic diversity (Pfeiffer and McClafferty 2007), available to be drawn on for breeding programs (Beebe et al. 2000).

Development

To date, the largest research endeavors under biofortification have focused on crop development, including testing for nutritional bioavailability, efficacy, and effectiveness. Crop development includes all breeding activities to produce varieties with the desired farmer and consumer characteristics—improved nutrient content, ideal consumer quality features, and farmer-preferred agronomic performance (Pfeiffer and McClafferty 2007). Along with breeding, nutrition studies are of paramount importance to establish that the nutrients added through biofortification will in fact be absorbed by the human body, through extensive and complex research into bioavailability, efficacy, and effectiveness.

Delivery

Varietal release regulations differ by country. Registering new varieties of crops requires proof (a) that the variety is new and distinguishable, and (b) that it adds value. After registration and release comes the least understood/most challenging aspect of biofortification: ensuring farmer and consumer acceptance of nutrient-rich staple crops. Sustainable extension and seed production systems are the foundation of a delivery process that will help *push* the products into market—but well-designed marketing and demand-creation techniques must also be employed to generate *pull* by consumers. Attention to consumer acceptance is particularly important when the additional nutrient is visible—as with provitamin A; consumer behavior change must then be part of the delivery strategy. Finally, biofortified products must be disseminated in an enabling public policy environment. Advocacy campaigns for biofortification can help create space for this new nutrition intervention, in both the agriculture and public health sectors.

Activities, Outputs and Outcomes

Table 6 presents a summary of broad activities, outputs, and outcomes for HarvestPlus. The emerging HarvestPlus delivery program is ambitious. The first pilot launches will concentrate on delivering provitamin A maize in Zambia, iron-rich bean in Rwanda, provitamin A-rich cassava in Nigeria, and iron-rich pearl millet in India. During its first delivery campaign, HarvestPlus aims to reach 100,000 farmers with these pilot crops by 2013. Lessons learned from this initial delivery exercise will be applied to continued expansion in those areas as well as rollout of other crops in other target regions. HarvestPlus will disseminate crops through strategic partnerships with the private sector, civil society, and governmental organizations.

Table 6. Overview of HarvestPlus activities, outputs, and outcomes

Activities	Outputs	Outcomes
Continued crop improvement, including evaluation of Genotype X Environment Interactions on nutrient density of edible portions	Improved lines of seven biofortified parents introduced into the product pathway	New nutritious crops are made available to NARES and implementing partners in Africa and Asia.
Nutrient retention and bioavailability studies	Nutritious crops that will overcome losses during storage, processing, and cooking	HarvestPlus crops are available that deliver nutritional benefits to the consumers.
Nutritional efficacy studies on human subjects	Published evidence that micronutrients in HarvestPlus crops are bioavailable and that the crops are efficacious in improving micronutrient status (for targeted micronutrients) in humans	HarvestPlus crops will be nutritionally efficacious and are assured to have a positive impact on human nutritional status.
Release and delivery of HarvestPlus crops.	Biofortified crops rich in bioavailable nutrients are available on the market and/or available to poor farmers via the public seed distribution system.	Farmers and consumers have access to new varieties of nutrient-dense maize, cassava, bean, and sweet potato—and consume them regularly

Table 7 provides some detail relating to research on specific crops and the delivery of key biofortified varieties, through 2015. Beyond 2015, the strategy envisions three broad areas of activity: to establish breeding for minerals and vitamins as a core activity at CGIAR centers and NARS; to scale up delivery in additional non-target countries; and to carry out follow-up surveys to measure impact.

Table 7. Some crop-specific HarvestPlus activities, outputs, and outcomes

Activities	Outputs	Outcomes
Provitamin A Sweet Potato (Uganda)		
Pilot studies completed in 2010		Orange sweet potato dissemination scaled up based on lessons learned from initial pilot studies
Iron beans (DR Congo, Rwanda)		
<ul style="list-style-type: none"> • CIAT –continue to develop varieties higher in iron with best agronomic properties; send multiple finished lines each year to Rwanda and DRC for GxE testing • Rwanda and DRC NARS—test varieties for breeding for high-iron lines; select most promising varieties for submission for varietal release; complete efficacy trial in 2012 	<p>First releases expected in 2012 in Rwanda, later in DRC; second wave, even higher in iron, available for dissemination</p> <p>Published evidence that high-iron beans are efficacious in improving iron status in humans</p>	<p>First trial packets of bean seeds distributed in 2012 by collaborating NGOs and government agencies</p> <p>Government Health Ministry supports efforts to disseminate high iron beans.</p>
Iron Pearl Millet (India)		
<ul style="list-style-type: none"> • ICRISAT—continue to develop varieties higher in iron with best agronomic properties; share germplasm with private seed companies in India for development of high iron hybrids; provide finished OPV lines for national testing • India NARS—breeding for high-iron lines, select most promising varieties for submission for varietal release; complete bioavailability and efficacy trials in 2012 	<p>First release of an OPV expected in 2012; high-iron hybrids distributed as truthfully labeled by private companies in 2014</p> <p>Published evidence that iron in high-iron pearl millet is bioavailable and that high-iron pearl millet is efficacious in improving iron status in humans</p>	<p>First packets of OPVs sold in 2012 by private seed companies</p> <p>High iron pearl millets used in public food distribution programs.</p>
Provitamin A Maize (Zambia)		
<ul style="list-style-type: none"> • CIMMYT and IITA—continue to develop varieties higher in provitamin A with best agronomic properties; send multiple finished lines each year to Zambia for GxE testing • Zambia NARS—test varieties for adaptability to growing environments, breeding for high-provitamin A lines; select most promising varieties for submission for varietal release; complete efficacy trial in 2012 in Zambia 	<p>First releases expected in 2012 in Zambia, later second waves</p> <p>Published evidence that provitamin A maize is efficacious in improving vitamin A status in humans</p>	<p>First trial packets of maize seeds distributed in Zambia by collaborating NGOs and private seed companies in 2012</p> <p>Government Health Ministry supports efforts to disseminate high provitamin A maize.</p>

Table 7. Some crop-specific HarvestPlus activities, outputs, and outcomes (continued)

Activities	Outputs	Outcomes
Provitamin A Cassava (DR Congo, Nigeria)		
<ul style="list-style-type: none"> IITA and CIAT—continue to develop varieties higher in provitamin A with best agronomic properties; send multiple finished lines each year to Nigeria and DRC for GxE testing Nigeria and DRC NARS—test varieties for adaptability to growing environments, breeding for high-provitamin A lines; select most promising varieties for submission for varietal release; complete efficacy trial in 2013 in Kenya; collaboration with INSTAPA 	<p>First releases expected in 2011 in Nigeria, later in DRC, and later second waves</p> <p>Published evidence that provitamin A cassava is efficacious in improving vitamin A status in humans</p>	<p>First trial stems distributed by collaborating NGOs in 2012 in Nigeria</p> <p>Government Health Ministry supports efforts to disseminate high provitamin A cassava.</p>
Zinc rice (Bangladesh, India)		
<ul style="list-style-type: none"> IRRI—continue to develop varieties higher in zinc with best agronomic properties; send multiple finished lines each year to Bangladesh and India for GxE testing Bangladesh and India NARS—test varieties for adaptability to growing environments, breeding for high-zinc lines; select most promising varieties for submission for varietal release; complete efficacy trial in 2012 in Bangladesh 	<p>First releases expected in 2012 in Bangladesh, later in India, plus second waves</p> <p>Published evidence that high-zinc rice is efficacious in improving zinc status in humans</p>	<p>First seeds distributed in 2013 in Bangladesh by collaborating NGOs and government extension agencies</p> <p>Government Health Ministry supports efforts to disseminate high provitamin A cassava.</p>
Zinc wheat (India, Pakistan)		
<ul style="list-style-type: none"> CIMMYT—continue to develop varieties higher in zinc with best agronomic properties; send multiple finished lines each year to India and Pakistan for GxE testing India and Pakistan NARS—test varieties for adaptability to growing environments, breeding for high-zinc lines; select most promising varieties for submission for varietal release; complete efficacy trial in 2012 in India 	<p>First releases expected in 2013 in India, later in Pakistan, plus second waves</p> <p>Published evidence that high-zinc wheat is efficacious in improving zinc status in humans</p>	<p>First seeds distributed in 2013 in India by collaborating NGOs and government extension agencies</p>

Research Methods

Biofortification strategy ideally follows clear stages of discovery, development, and delivery. However, as products advance down the impact pathway, further research findings may necessitate revisiting previous stages to assure the highest quality nutrient-rich product. Methods used at the ten distinct stages of the research process are as follows.

1. Identify target populations and set nutritional breeding targets

Cropping and food consumption patterns, the incidence of micronutrient malnutrition, and ex-ante benefit-cost analysis are applied to determine where biofortified varieties should be targeted. Breeding targets are set for specific micronutrients and crops.

2. Validate nutrition and micronutrient deficiency data

Nutritionists carry out surveys to assess the levels of food staple consumption and nutrient intakes, by age and gender group. They also measure the effects of processing, storage, and cooking methods for nutrient retention in biofortified crops and identify retention-friendly practices used by target populations. They also study to what extent the nutrients bred into crops are absorbed by the body (bioavailability) as well as the prevalence of micronutrient deficiencies. These studies guide plant breeders in confirming or refining their breeding targets.

The analysis of retention of minerals and vitamins after storage, processing, and cooking involve the use of the following methods:

For minerals (from most accurate to least accurate):

Inductively Coupled Plasma (ICP)

X-ray Fluorescence (XRF)

Atomic Absorption Spectrophotometer (AAS)

Near-infrared spectroscopy (NIRS)

For provitamin A (from most accurate to least accurate):

High-performance liquid chromatography (HPLC)

Thin layer chromatography (TLC)

Near-infrared spectroscopy (NIRS)

3. Screening and applied biotechnology

The global germplasm banks of the CGIAR institutes and other partners provide a reservoir of staple crops germplasm to be screened and drawn on by HarvestPlus. Plant breeders identify the genes that are important in the synthesis of vitamin A and translocation of minerals. They develop procedures to implement marker-assisted selection to “flag” the desired traits for breeding higher levels of micronutrients. Upstream transgenic research is also conducted in the case of nutrient targets that are challenging to reach through conventional breeding

4. Crop improvement

Crop improvement includes all breeding and product development activities to produce new micronutrient-rich crop varieties that perform well in farmers’ fields and meet farmers’ expectations, while also providing better nutrition.

5. Test genotype x environment interactions

How genotypes interact with different environments can greatly influence genotypic performance across different crop growing scenarios. HarvestPlus researchers evaluate crops in target countries to ensure high and stable expression of the micronutrient content in different environments where the crops

may be grown. Scientists also look at farming practices that can improve crop nutrient content by enhancing the uptake of nutrients in the edible portion of the crop.

6. *Test nutritional efficacy*

Nutrition teams develop appropriate indicators of micronutrient status; they conduct controlled feeding trials to evaluate whether vitamins and minerals from biofortified foods are bioavailable and whether biofortified foods improve the nutritional status of target populations. To evaluate bioavailability, minerals and vitamins in the biofortified foods are labeled using stable isotopes and fed to subjects over a fixed number of days. Blood is drawn and absorption of the minerals is evaluated. The evaluation of the nutritional efficacy of biofortified crops in improving nutritional status is done using randomized controlled trials with treatment (fed biofortified crops) and control group (fed non-biofortified crops) in a tightly controlled environment to assess impact across individuals. The relevant biomarkers, for iron, zinc, or vitamin A status, are used to measure efficacy and impact.

7. *Identify factors driving farmer adoption and consumer acceptance*

Researchers study the factors that affect whether farmers and consumers will adopt biofortified crops or products. Crop varietal maps are developed for this purpose and to provide baseline data for assessing impact at a later stage. This applies particularly to vitamin A-rich foods that tend to be orange in color, and thus unfamiliar-looking to consumers.

8. *Release biofortified crops in target countries*

Varieties are identified for selection and submission to registration trials in countries of first release. Following this, procedures are followed to ensure their successful formal release. Proof that the variety is new, distinguishable, and value adding must be assembled in order to register new crop varieties. CGIAR centers work with NARS to gather the relevant information for registration and formal release of biofortified crops in target regions.

9. *Facilitate dissemination, promotion, and consumer acceptance of crops*

Delivery managers ensure that seed production, dissemination, and training and extension systems are in place to promote these new crops. Advocates are identified who can pave the way for crops to be accepted by consumers and adopted by farmers. Branding and other marketing strategies are created to increase demand for biofortified crops and foods by consumers.

10. *Measure impact and changes in nutritional status of target population*

Baseline and follow-up surveys are conducted to measure the number of farming households that have adopted biofortified crops, as well as any improvements in nutritional status. This will help determine the ultimate impact of biofortified crops on public health.

Partnerships

Several CGIAR centers have been and will continue to be key in HarvestPlus crop development. In 2010 those CGIAR institutes included CIMMYT, CIAT, the International Institute of Tropical Agriculture (IITA), IFPRI, Bioversity, CIP, IRRI, the International Center for Agricultural Research in Dry Areas (ICARDA), and ICRISAT. Target country NARS partners are also partners for conducting adaptive research and gene by environment (GXE) analysis, as the crops are transferred from the CGIAR laboratories to the field. HarvestPlus also partners with a number of public health research institutes on the nutrition research, including, among others: Cornell University, UC Davis, ETHZ Switzerland, Wageningen Agricultural University, Makerere University, Micronutrient Initiative, and USDA. Impact analysis is conducted by external consultants as well as by CGIAR impact specialists within the centers. Advocacy trainings employ international consultants and work with institutions in the HarvestPlus target countries.

6.2.4 Subcomponent 2.2: AgroSalud—Biofortified Food Basket for Latin America and the Caribbean (www.AgroSalud.org)

AgroSalud has long experience with bringing enhanced nutritional crops to the Latin American-Caribbean region. In the past five years, AgroSalud partners have implemented successful commercial releases throughout the region: 21 maize cultivars with higher tryptophan and lysine levels in Bolivia, Colombia, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, and Panama; 8 rice cultivars with higher iron in Bolivia, Cuba, and Panama; 5 bean cultivars with higher iron in Bolivia, Brazil, Cuba, and Guatemala; and 8 sweet potato cultivars with more beta-carotene in Brazil, Cuba, Dominican Republic, Haiti, and Peru (AgroSalud 2011). An additional ten nutritionally enhanced cultivars are in the pipeline, to be released in seven countries in 2010–2011.

Rationale, Objectives, and Research Questions

Rationale

According to the World Health Organization (2004), the leading nutrition-related causes of disability in Latin America and the Caribbean (LAC) are childhood and maternal underweight, iron-deficiency anemia, zinc deficiency, and vitamin A deficiency. An estimated 66 million children and women in LAC are anemic (WHO 2008a); and 8.9 million children and pregnant women are vitamin A deficient (WHO 2009). Often, individuals suffer from multiple nutritional insults simultaneously (Albalak et al. 2000). The economic cost of these nutritional deficits in LAC in 2009 was estimated to exceed \$20 billion, based on the average GDP for LAC countries (World Bank 2009): 46 percent is attributable to underweight, 32 percent to iron deficiency, 12 percent to vitamin A deficiency, and 10 percent to zinc deficiency (Salomón Pérez, CIAT, personal communication). In sum, there are severe problems of food and nutrition insecurity in Latin America and the Caribbean.

The impact of a single crop biofortified with a single nutrient has been demonstrated in three cases: amino acid biofortified maize (Gunaratna et al. 2009); iron biofortified rice (Haas et al. 2005); and beta-carotene biofortified sweet potato (van Jaarsveld et al. 2005; Low et al. 2007). These biofortified crops have improved the nutritional status of people who consumed them.

LAC provides an ideal setting to test the impact of *multiple* crops biofortified with *multiple* nutrients. First, the region suffers from multiple nutrient deficiencies and consequences, including zinc deficiency, anemia, and stunting (IZINCG 2004; WHO 2004). Second, the combinations of foods targeted for biofortification make up the traditional combined diet, such as maize and beans or rice and beans (FAO 2009). Third, advances have already been made in breeding and releasing biofortified crops in the region, through the AgroSalud project, as noted above.

Objectives

1. Improve food and nutrition security among the rural and urban poor in six countries (Brazil, Colombia, Guatemala, Haiti, Honduras, and Nicaragua), through the release and dissemination of biofortified germplasm and the promotion of newly and previously released nutritionally enhanced cultivars in those countries. The combinations that will be promoted are specifically related to the nutrition problems in each country and to the foods commonly consumed: higher iron and zinc rice and beans to address iron and zinc deficiencies in Brazil; higher iron rice and beans to address iron deficiency along with higher zinc rice, beans and maize, as well as high tryptophan and lysine maize to address zinc deficiency and stunting in Colombia, Guatemala, Haiti, Honduras and Nicaragua; and higher provitamin A cassava and sweet potato to address vitamin A deficiency in Haiti.
2. Improve food and nutrition security among the urban poor through biofortified food products produced and sold locally in two countries, to be selected from the following: Brazil, Colombia, Cuba, Haiti, Nicaragua, and Panama.

3. Strengthen ongoing breeding efforts to (a) increase yield, disease resistance, and nutritional quality as compared to crops currently available; and (b) offer improved biofortified breeding populations for use by NARS in their breeding programs.
4. Evaluate the agronomic, economic, and nutritional impact of biofortified crops and food products when consumed in combination.
5. Strengthen capacity of institutions in the target countries with regard to breeding, seed dissemination, product development, market evaluation, and impact assessment.

Research Questions

The key research question for this subcomponent is: What is the impact (agronomic, socioeconomic, and nutritional) of farmers producing biofortified crops and consumers eating biofortified food products in combination (for example, rice and beans together)? Integrated planning and implementation between the impact evaluators and the specialists (in the areas of breeding, seeds, food-product development, and market chains) will ensure that timely and relevant impact studies are completed.

Impact Pathways

The AgroSalud subcomponent follows the same impact pathways as those described in section 6.2.2 for biofortification.

Activities, Outputs and Outcomes

Table 8 presents a summary of broad activities for AgroSalud. Table 9 provides some detail related to research on breeding and nutrition and the delivery of key biofortified varieties for target crops.

Table 8. Overview of AgroSalud activities, outputs, and outcomes

Activities	Outputs	Outcomes
In partnership with CRP3: develop cultivars and complete validation and farmer evaluation trials.	Nutritionally and agronomically improved rice, beans, cassava, maize, and sweet potato cultivars developed and tested.	Iron-, zinc-, provitamin A- and amino acid-biofortified cultivars are made available to reduce food and nutrition insecurity in LAC.
Put existing biofortification atlases online, with an interactive feature.	Online analysis tool available to target biofortification activities in countries.	Informed geographic targeting of biofortification activities.
Support partners in seed production and dissemination and commercial release of crops.	Seed multiplied, disseminated, and commercially released in countries.	Strengthened seed production and dissemination systems.
Work with stakeholders to establish food processing technologies and protocols.	Commercially prepared biofortified food products developed.	Urban consumers have access to biofortified food products.
Assess distribution channels in urban markets; pilot and evaluate enhanced distribution channels.	Biofortified crops and commercially prepared biofortified food products distributed in urban centers.	Access to and consumption of biofortified cultivars and food products by urban consumers.
Complete several impact studies for 2+ combinations of different crops and food products.	Quantitative evaluations of the socioeconomic and nutritional impacts of 2+ combinations of biofortified crops and food products.	Information generated on the benefits and costs to farmers and consumers of biofortification.
Develop and disseminate communication modules for different audiences.	Diverse communication modules produced and disseminated through different media.	Demand for biofortified crops and food products by informed farmers, consumers, extensionists, health professionals, and decisionmakers.

Table 9. Some crop-specific AgroSalud activities, outputs, and outcomes

ACTIVITIES	OUTPUTS	OUTCOMES
Higher-iron and –zinc beans (Brazil, Colombia, Guatemala, Haiti, Honduras, Nicaragua)		
<ul style="list-style-type: none"> • CIAT to lead bean breeding work; country NARS to conduct adaption pre-release trials • By 2012, complete simulation analyses in all countries to estimate dietary impact of crops. • By 2013, complete an efficacy trial of higher-iron beans and rice in one country. • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties: 2012 Brazil, Colombia; 2013 Guatemala; 2014 Haiti, Honduras, Nicaragua</p>	<p>In 2013, food-industry partners to deliver food products with biofortified beans as an ingredient in at least one country</p>
Higher-iron and –zinc rice (Brazil, Colombia, Guatemala, Haiti, Honduras, Nicaragua)		
<ul style="list-style-type: none"> • CIAT to lead rice breeding work • Country NARS to conduct adaption pre-release trials • By 2012, complete simulation analyses in all countries to estimate dietary impact of crops • By 2014, complete an efficacy trial of higher-zinc maize, beans, and rice in one country • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties: 2013 Brazil, Colombia; 2014 Guatemala; 2015 Haiti, Honduras, Nicaragua</p>	<p>In 2014, food-industry partners to deliver food products with biofortified rice as an ingredient in at least one country</p>
Higher-zinc maize (Colombia, Guatemala, Haiti, Honduras, Nicaragua)		
<ul style="list-style-type: none"> • CIMMYT to lead maize breeding work; country NARS to conduct adaption pre-release trials • By 2012, complete simulation analyses in all countries to estimate dietary impact of crops • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties: 2014 Guatemala, Honduras, Nicaragua; 2015 Colombia, Haiti</p>	<p>In 2015, food-industry partners to deliver food products with biofortified maize as an ingredient in at least one country</p>

Table 9. Some crop-specific AgroSalud activities, outputs, and outcomes (continued)

ACTIVITIES	OUTPUTS	OUTCOMES
Higher-tryptophan and –lysine maize (Colombia, Guatemala, Haiti, Honduras, Nicaragua)		
<ul style="list-style-type: none"> • CIMMYT to lead maize breeding work; country NARS to conduct adaption pre-release trials • By 2013, complete an efficacy trial of higher-tryptophan/lysine maize and higher-zinc maize, beans, or rice in one country • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties: 2012 Guatemala, Honduras, Nicaragua; 2013 Colombia, Haiti</p>	<p>In 2012, food-industry partners to deliver food products with biofortified maize as an ingredient in at least one country</p>
Provitamin A-rich cassava (Haiti)		
<ul style="list-style-type: none"> • CIAT to lead cassava breeding work; country NARS to conduct adaption pre-release trials • By 2012, complete simulation analyses in all countries to estimate dietary impact of crops • By 2014, complete an efficacy trial of higher-provitamin A cassava and sweet potato in Haiti • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties in 2013</p>	
Provitamin A-rich sweet potato (Haiti)		
<ul style="list-style-type: none"> • CIP to lead sweet potato breeding work; country NARS to conduct adaption pre-release trials • By 2012, complete simulation analyses in all countries to estimate dietary impact of crops • Government, NGOs, and private-sector partners to multiply and disseminate seeds 	<p>Release of biofortified varieties in 2013</p>	

Research Methods

Research methods for AgroSalud are broadly similar to methods used in HarvestPlus, as elaborated in the section "Subcomponent 2.2: AgroSalud—Biofortified Food Basket for Latin America and the Caribbean." To develop biofortified crops, conventional plant breeding methods will be employed by the CGIAR centers, as follows: International Center for Tropical Agriculture (CIAT) for beans, cassava and rice; CIMMYT for maize; and the International Potato Center (CIP) for sweet potato (AgroSalud 2011). Validation and farmer trials will be completed by NARS in each country, with technical support from the CGIAR centers. Geographic information systems tools will be used to update on-line atlases with nutrition, crop production, and socioeconomic status, showing potential sites for biofortification interventions (Zapata-Caldas et al. 2009). Farmers will be trained in tested methods of non-conventional seed production to develop quality and timely seed (AgroSalud 2011). Seed dissemination will be carried out by partners such as NARS, NGOs, Ministries of Agriculture, and UN agencies through their food and nutrition security programs. Food-processing specialists from the Brazilian Agricultural Research Cooperation (EMBRAPA) and CLAYUCA will work closely with industry partners, to determine what, if any changes, are necessary to protocols in order to substitute biofortified crops for non-biofortified crops in product formulations. Urban distribution channels for biofortified crops and for processed foods developed with biofortified crops will be assessed and enhanced distribution channels tested. *Ex-ante* and *post-hoc* evaluations (agronomic, socioeconomic, and nutritional) will be completed to determine the impact of simultaneous consumption of two or more crops biofortified with the same nutrient (for example, beans, maize, and rice biofortified with zinc) (AgroSalud 2011). Finally, tailored communication models will be enhanced, developed, and employed to generate demand for biofortified crops and food products by different consumer populations.

Partnerships

Three CGIAR centers will lead the highlighted activities (CIAT, CIMMYT, and CIP), along with CLAYUCA (a public-private consortium operating out of CIAT) and EMBRAPA (the Brazilian NARS). Breeding activities will be completed by CIAT for rice, beans, and cassava; by CIMMYT for maize; and by CIP for sweet potato. Seed activities will be led by CIAT, which will also lead the market research, geographic targeting, and impact assessment. CLAYUCA and EMBRAPA will lead the food-production activities.

The AgroSalud project had significant success in bringing together partners from diverse sectors, including Ministries of Agriculture (research and extension units), Ministries of Health, universities, the private sector, local municipal governments, and NGOs, among others. At a regional level, partners included HarvestPlus and UN agencies. The same partnership model is proposed for this subcomponent, with subcontracts negotiated with country partners to complete specific activities, and jointly funded activities organized with regional partners. Annual partner meetings will be held to review achievements and plan activities for the coming year.

6.3 Component 3: Prevention and Control of Agriculture-Associated Diseases

6.3.1 Rationale

Addressing the scourge of agriculture-associated disease (AAD): Rationale and scope.

AAD sickens and kills millions of poor people.

In poor countries, diseases associated with agriculture (Box 5) have important health impacts. Food that nourishes can also sicken and kill. Zoonoses (diseases transmissible between animals and man) and diseases recently emerged from animals make up 25 percent of the infectious disease burden⁴ in least developed countries (Gilbert et al. 2010). Other urgent problems include: fungal toxins (mycotoxins) in staple crops and animal source foods; plant toxins; use of wastewater for agriculture; misuse of agricultural chemicals and antibiotics; and health impacts of agricultural alteration of ecosystems (such as irrigation practices that promote malaria).

AAD has multiple burdens that are not fully understood.

As well as adverse health impacts, the direct economic, social, and environmental costs of AAD are of major importance, as suggested by economic assessments of individual problems. For example, beyond their health impacts, mycotoxins lead to trade losses of up to \$1.2 billion a year; and the SARS epidemic cost \$50–100 billion through economy-wide effects (Aguirre 2009).⁵ Indirect effects are also important: impaired human health lowers labor productivity and human capital accumulation (as through schooling and training)—worsening livelihood outcomes in both the short and the long run. Disease and malnutrition burdens are closely related: for example, research has identified nutritional risk factors for diarrhea, the negative impacts of diarrhea on nutritional status, and the importance of dietary therapy during and after enteric infection (Brown 2003). Diseases also interact in complex ways: for example, aflatoxin exposure and hepatitis infection are major risk factors for liver cancer. For these reasons, the question of how agriculture might be better managed to reduce risk is a complex one; our limited ability to assess and attribute the multiple burdens of AAD constitutes a major impediment to rational resource allocation (Roth et al. 2003). This presents an important opportunity for CGIAR research to contribute to human health research and development.

Successful assessment and management of AAD requires inputs from agriculture research. The One Health (and Ecohealth⁶) thinking—now prominent in the health community—recognizes agriculture-based interventions as a key component of multi-disciplinary⁷ approaches for managing many AAD, for several reasons. Food-borne disease requires management throughout the field-to-fork risk pathway; controlling zoonoses, in most cases, requires eliminating disease from the animal reservoir; and agriculture practices that put farm workers at risk obviously require farm-level intervention. Many important diseases, such as HIV and the influenza pandemic of 2009, emerged from animals and research into disease emergence from agro-ecosystems could contribute to averting future disease threats.

Component 3 will generate evidence and develop and test the methods, tools, and approaches that partners need to better support disease management, including prevention of diseases, where agriculture-based actions are important. The resulting benefits are potentially large: for example, an ex ante assessment by IWMI in Ghana found that an integrated package of risk-based measures could avert up to

⁴ Disease burden is measured in DALYs (Disability Adjusted Life Years), defined as years of life lost due to death and disability.

⁵ All dollar figures are US\$.

⁶ One Health has been defined as the collaborative effort of multiple disciplines to attain optimal health for people, animals, and our environment. Ecohealth is defined as systemic, participatory approaches to understanding and promoting health and wellbeing in the context of social and ecological interactions. They have much in common and are increasingly aligned; both emphasize multi-disciplinarity and the importance of agriculture and ecosystem-based interventions (Waltner-Toews 2009).

⁷ Multidisciplinary is used here in the broad sense of involving several areas of research, policy, and practice.

90 percent of the estimated 12,000 DALYs that result from wastewater irrigation, at a cost of less than \$100 per averted DALY (including expenditures to promote and ensure uptake).

Box 5. Agriculture-Associated Diseases: what they are and why they matter

Food-borne disease (FBD). Diarrhea is one of the top three infectious diseases in most poor countries, responsible for loss of 72.8 million DALYs (WHO 2008a) and killing an estimated 1.3 million children a year (Black et al. 2010). Most of this is the result of contaminated food and water. Meat, milk, eggs, and fish are the foods most likely to be implicated (Lynch et al. 2006); contaminated irrigation water is a problem especially in intensifying systems (Drechsel et al. 2010). FBD is estimated to cost America \$152 billion and Nigeria \$3 billion each year (Scharff 2010; Okike et al. 2010). Fungal toxins (especially mycotoxins) are an important food safety problem, leading to acute, chronic, and cumulative ill-health; the Center for Disease Control estimates that over 4.5 billion people may be chronically exposed to mycotoxins, and aflatoxins may play a causative role in 5 to 28 percent of all hepatocellular carcinoma cases (Liu and Wu 2010). Like many food-borne pathogens, mycotoxins can also cause sickness and death in livestock. International trade of crops—particularly maize, groundnuts and chili—is also affected, due to food safety standards.

Plant toxins associated with common foods, including legumes, cassava, and yams, cause specific and non-specific disease. At least tens of thousands are affected by konzo and lathyrism, two neurodegenerative diseases that persist among the poorest and most marginalized communities. Contamination of food with agricultural chemicals urgently requires more research, to understand the health, socioeconomic, and ecological impacts and to develop better management.

FBD also impose costs on animal production, the food industry, and trade (Bennett and Ijpeelaar 2005). Inability to meet food safety standards threatens to exclude small producers from higher value markets and forces them to incur the transaction costs associated with work in the informal sector. Food safety can only be addressed effectively by considering the entire risk pathway from field to fork.

Zoonotic and emerging disease. At least 61 percent of all human pathogens are zoonotic (Taylor et al. 2001). Endemic zoonoses that prevail in poor countries are among the most neglected diseases. To give just one example, echinococcosis (caused by tapeworm larvae) is responsible for 1 million lost DALYs, in addition to human-associated economic losses (including medical costs and lost wages) of \$1.9 billion, and livestock losses of \$2.1 billion (Maudlin et al. 2009). Sleeping sickness, rabies, leishmaniasis, cysticercosis, brucellosis, and leptospirosis are zoonoses of similar impact.

Most emerging diseases (75 percent) jumped species from animals to humans (Taylor et al. 2001), and the actual and potential cost to human health and well-being is enormous. HIV-AIDs, which originated in non-human primates, has probably sickened and killed more people than any other disease in the history of mankind. As natural ecosystems come under more pressure, and as technology supports the keeping of unprecedented numbers of livestock in unprecedented ways, the rate of disease emergence is accelerating—currently, one every four months (Jones et al. 2008).

Other health risks of agroecosystems. Many other diseases and health risks are associated with agriculture. Agriculture can create conditions suitable for diseases, or directly expose people to health hazards. Disease vectors often persist due to poor design or management and harmful agricultural practices (Boelee and Madsen 2006; Diuk-Wasser et al. 2006). For example, irrigation and water storage systems provide breeding grounds for, and exposure to, vectors of water-related diseases such as malaria, schistosomiasis, and cryptosporidiosis (Erlanger et al. 2005; Keiser et al. 2005a; Steinmann et al. 2006). People working in agrifood systems are directly exposed to a range of biological, chemical, and physical hazards. Misuse of agrochemicals (especially pesticides) causes thousands or tens of thousands deaths a year, while there are 170,000 recorded fatal injuries in agriculture annually (Cole 2006).

Many other emerging issues occur at the sub-microscopic level (the gene) or the supra-individual level (the ecosystem). For example, the use of antibiotics in farm animals can select for resistance that can then be passed on to human pathogens by plasmids (Shea 2003); agricultural use of insecticides can foster resistance in the vectors of malaria (IITA, 2011). At a different scale is the role of ecosystems in regulating human health, with the potential for shaping agriculture in ways that are pro-poor and that better support human health.

Agricultural research must include socio-economic, gender, and ecological understanding
From farm to fork, food is a gendered commodity: women and men have different roles in production, processing, and retailing which expose them to different health risks and offer them different benefits (Kimani et al. 2007). Gender roles are also an important determinant of exposure to zoonotic disease, health seeking behaviour and ultimately health burden. Understanding the gender and social determinants of AAD is a prerequisite to developing more appropriate solutions. Similarly, understanding economic incentives, ecological relations, and policy determinants must inform epidemiological assessments and interventions for AAD.

What agricultural research can contribute to improved human health

CGIAR centers have traditionally focused on accentuating the positives rather than eliminating the negatives of agriculture. This component offers an opportunity to direct existing research coalitions to new problems. It can also bring the CGIAR understanding of farming systems to the health community with potentially far-reaching benefits, as shown by a case study from Kenya. Driven by a combination of vested interests and genuine, though ill-founded, public health concern a regulation required all milk to be pasteurized. CGIAR research showed that this imposed costs on milk traders and consumers—\$33 million annually—without creating health benefits, as consumers boil milk before consumption (Kaitibie et al. 2008). A coalition formed by ILRI was able to generate evidence and support advocacy for a new approach that is pro-poor and delivers superior food safety outcomes (Leksmono et al. 2006). Similarly, IFPRI's recent research in Kenya and in Mali has found high levels of aflatoxin contamination in maize and groundnuts respectively. Awareness of aflatoxins is low among small scale producers, while testing of produce in local markets is almost non-existent. Further research is underway to identify cost-effective and locally appropriate interventions and regulatory frameworks that inform both producers and consumers, and incentivize farmers to invest in producing crops safe for home consumption as well as local markets.

The CGIAR has a solid track record in important areas of AAD (see Table 10). The program will initially build on these areas of expertise (especially food safety and zoonoses), by broadening health partnerships and increasing the relevance of research to the health community. Other important areas of AAD will be developed in the medium to long term. One Health/Ecohealth will provide both a framework and a bridge with the health community, crucial to the research-into-use pathway.

Research subcomponents, priority diseases, and sequencing

Development of a research agenda was guided by three principles: (a) the impact of the problem on human health and livelihoods; (b) the relevance of agriculture research to assessing and managing the problem; and (c) the track record, current engagement, and anticipated opportunities of CGIAR centers in addressing the problem (as set out in Table 10). On this basis we identify two initial-priority subcomponents, food safety and zoonoses, to be addressed immediately and with substantial investments. We combine, as a third subcomponent, some other health risks of agroecosystems that are either emerging areas for exploration or areas, which though important, have lower levels of CGIAR involvement (<\$250,000 per annum); work in these areas will be exploratory or at smaller scale (medium priority). As further evidence emerges, some of these areas may become more important in the research agenda. Within the three subcomponents, we target for initial engagement a selective list of risks to human health, based on high potential for getting traction immediately and results within a five-year timeframe.

These components have sub-components whose priority is given in Table 10:

- Food safety: fungal toxins (mycotoxins), biological hazards, plant toxins, chemical hazards
- Zoonoses: neglected zoonoses; emerging diseases
- Other health risks of agro-ecosystems: water-associated disease; occupational hazards; drug and chemical resistance; ecosystem services; climate change and disease; shaping agro-ecosystems for health outcomes

Table 10. Initial priority research areas and relevant CGIAR experience

Category	Priorities	Impact**	Role of agricultural research	CG track record and opportunities	Priority risks	Level of engagement
Food safety	Mycotoxins	Medium health impacts– not in GBD Costs millions of dollars at national level	Agricultural research key to mycotoxin management	• Extensive work on pre- and post-harvest technologies to manage risk, including biocontrol, (IITA, ICRASAT, CIMMYT); breeding for reduced toxin content/resistance to fungal infection (IITA, ICRISAT, CIMMYT); risk mapping and assessment; cost-effectiveness of mitigation strategies (ICRISAT, IITA, IFPRI, ILRI); behavioral analysis to identify incentives for farmers to adopt aflatoxin mitigation measures (IFPRI). Opportunities to partner with ongoing initiatives, including PACA and EMBRAPA.	Aflatoxins in staple crops & other food	Important area with substantial ongoing work: high initial priority
	Biological hazards	Very high health impacts -major contributor to diarrhoeal illness in GBD Costs billions of dollars at national level	Ag research key to management of food safety on farm and along value chain; other research important for household and medical management	• Risk assessment and management for milk and meat hazards along the value chain (ILRI, IFPRI); assessment & management of hazards in wastewater (IWMI, IFPRI, ILRI); pro-poor risk management through policy and organizational change (ILRI, IFPRI); certification and collective action to address food safety and consumer willingness to pay for safe food (ILRI, IFPRI). Opportunities to link with CRP 3.7, CRP 5, and WHO FERG group	Animal source foods in five value chains in CRP 3.7 Wastewater (CRP 5)	
	Plant toxins Chemical hazards	Health impacts less extensive (chemical hazards much less important than biological). Costs not fully assessed.	Ag research key to reducing plant toxins and chemical hazards on farm	Risk-management through plant breeding (ICARDA, IITA) Pesticides and other chemical hazards in food	Cassava, legumes	Focused area with some ongoing work: medium priority

Table 10. Initial priority research areas and relevant CGIAR experience (continued)

Category	Priorities	Impact**	Role of agricultural research	CG track record and opportunities	Priority risks	Level of engagement
Zoonoses & EID	Neglected zoonoses	High- combined GBD and costs probably comparable with malaria or HIV	Ag research key for management of disease in animal reservoirs	Risk assessment, technology development for classical zoonoses including <i>Taenia solium</i> (ILRI). Opportunities to link with WHO	<i>Taenia solium</i>	Important area with significant ongoing work: high initial priority
	Emerging disease	High potential – HIV in GBD, costs millions of dollars per pandemic	Ag research role in understanding emergence and managing at source	• Risk and economic assessment for avian flu and risk management (ILRI, IFPRI); assessment & technology development for Rift Valley Fever (RVF). Opportunities to link with climate change	RVF	
Health risks in agroecosystems	Water associated disease	High – water associated disease	Ag research one of many research inputs into water associated disease; important role in drug resistance and ecosystem related disease	• System-wide program on malaria but overall less extensive in this area: agroecosystem-based vector control in lowland settings (IITA)	Scoping work	Emerging area with some ongoing work: medium priority
	Occupational disease			Integrated pest management to improve pesticide use (CIP, crop centers)	Vector control	
	Resistance			Assessment and management of drug resistance (ILRI); malaria vectors (IITA)	Pesticide toxicity	
	Ecosystem services & change			Ecosystem services for health (ILRI); health in the context of climate change (IFPRI, ILRI).	Resistance to agrochemicals	

* Shaded areas indicate priority research areas.

** For many AAD, the impact in terms of Global Burden of Disease (GBD) or economic losses has not been assessed; ratings reflect our current knowledge.

6.3.2 Subcomponents of Component 3

Subcomponent 1: Improving food safety (Initial priority)

Food-borne diseases (FBD) have enormous impacts on health and livelihoods and are of great concern to consumers, producers, and policymakers. Risk analysis (assessing, managing, and communicating risk) brings a set of common concepts and tools to addressing FBD of different origins (plant, livestock, fish) and in different value chains, presenting an opportunity for creating synergy between centers. Science-based measures to reduce exposure along the food chain are urgently required and must go hand-in-hand with appropriate policies, institutions, and incentives for adoption. The WHO Reference Group, assessing the burden and attribution of important FBD, provides an entry point for bringing CGIAR research on prevalence, impact, and management of FBD to the arena of global governance of food safety.

Under this subcomponent, we identify three food safety health risks that can have significant implications for health, nutrition, and livelihoods in developing countries, and that are generally agreed to require agriculture or value-chain inputs for effective management.

1. Initial priority: *Mycotoxins* are fungal toxins that contaminate staple foods, feeds, and animal source foods in most of the humid tropics; they cause acute poisoning as well as chronic disease.
2. Initial priority: *Biological hazards* cause the great majority of food-borne disease and appear to be increasing in recent years; many are zoonotic (transmissible between man and animals) and many are also transmitted through water.
3. Medium priority: *Plant toxins* are natural substances in plants that can harm health; these include anti-nutritional factors in some legumes and cyanogenic glycosides in cassava. *Chemical hazards* from pesticide residues also harm human health and affect trade in agricultural products.

Subcomponent 2: Zoonotic diseases and diseases emerging from animals (Initial priority)

The whole world bears the burden of *diseases that originate in animals* (such as HIV/AIDs and swine flu). The crucible for emergence of these diseases—and thus the opportunity for improving prevention and early detection—is often located in agroecosystems in poor countries, that are either intensifying or degrading. Richer countries are motivated by self-interest to deal with the problems of emerging disease and pandemics at their source, as the examples of bird flu and hemorrhagic fevers demonstrate, often leveraging donor concern for pro-poor impacts. However, the risks and benefits from emerging disease control may be very different for rich and poor countries, as the anti-poor effects of bird flu control in some places has demonstrated (Roland-Holst et al. 2008). CGIAR research can help correct this imbalance of impacts.

Alongside emerging disease is the problem of established zoonoses that are controlled elsewhere but that persist at high levels among the poorest and most neglected populations. These neglected zoonoses include the pig tapeworm (*Taenia solium*), zoonotic tuberculosis, and brucellosis. The CGIAR has a key role in bringing to the global arena its understanding of disease impacts on the poor.

The successful control of zoonoses, whether tuberculosis in Ireland, rabies in continental Europe, or brucellosis in Canada, has always relied on interventions at animal level. For zoonoses of livestock, this means intervention along the farm-to-fork production pathway. The lesson from these experiences was largely forgotten until the wake-up call of bird flu. It is now generally accepted that control of zoonoses is best managed by multisectoral initiatives grounded in epidemiological studies, with an in-depth understanding of the variables that influence disease emergence and transmission (Schelling et al. 2007). Effective interventions must be grounded in the local context as well as in knowledge of disease transmission pathways; participatory methods have proved a powerful tool for engaging stakeholders and fostering positive change.

Subcomponent 3: Other health risks in agroecosystems (Medium priority)

In addition to food-borne disease and zoonoses, agriculture in ecosystems poses a number of risks to human health.

Irrigation and dam construction expose millions to the vectors of malaria and other diseases. The reduction of health risks from exposure to *water-associated disease vectors* has to be carefully balanced with supporting the livelihoods of farmers. Improved and innovative agricultural and water management practices can help reduce crop contamination, farmer exposure, vector breeding, and vector resistance. Rural populations can be protected while reducing costs for the public health sector.

Occupational health in agriculture and among the world's poor remains an area where more research is needed to understand the current situation and best practices, as well as variations in liability and insurance policies. CGIAR research on integrated pest management provides an entry point.

Other issues at the intersection of human, animal and environmental health include emerging resistance to chemicals used in agriculture, the effect of climate on diseases associated with agriculture, ecosystem-related health services, and shaping agriculture to attain health goals.

Other health risks of agriculture are becoming increasingly important, and new areas are emerging where the CG has a comparative advantage based on systems understanding and biotechnology research. Given the need for an initial focus on a few lead areas, engagement in this research area will be initially exploratory and could expand in the medium term.

6.3.3 Objective and Research Questions

Objective

The objective of this component is to enhance environmental sustainability, reduce poverty, increase food security, and contribute to the health of poor communities by assessing, preventing, and mitigating agriculture-associated health risks, through research for improved food and water safety, animal-based zoonoses control, and managing agroecosystems for better health.

Research Themes

The research questions address the technical issues of prioritization, innovation, technology development, and impact assessment, as well as methodological issues, using an approach that emphasizes understanding and evaluating novel partnerships and approaches. Questions will initially focus on the two initial priority subcomponents (1 and 2) focusing on food safety and zoonoses, as identified in Table 10 and linked to the impact pathways in Figure 7.

- *Prioritization and systems understanding.* What are the critical AAD for the poor? Which AAD require or can benefit from international agricultural research? What is the social and policy context for developing One Health/multidisciplinary approaches that can assess and manage the CG-priority AAD? What is the evidence for impact? What is the specific impact on women, the poor, and other vulnerable groups?
- *Risk and socioeconomic assessment.* What are the health impacts of the diseases in the two priority subcomponents on the poor (absolute and relative to other problems)? What is the evidence that these AAD create other economic, livelihood, equity, and ecological burdens (multiple burdens)? How do sociocultural factors differentially expose men and women to risk?
- *Innovation and risk-based management.* What technological, organizational and social innovations can improve the detection and assessment of the multiple burdens of CG-priority AAD? How can these be developed, tested, and adapted to improve eventual uptake? What new science-based diagnostics, technologies, breeds, biological control, animal vaccines, methodologies, and other innovations can improve the management of CG priority AAD (without reducing production and productivity)? How can these be developed, tested, and

pre-adapted to improve eventual uptake? How can women, often the primary managers of family health and nutrition, have more access to innovations? What are the factors preventing poor producers and consumers, male and female, from adopting risk mitigation and innovations? What type of informational, behavioral, or institutional mechanisms would promote adoption of better management strategies?⁸

Impact Pathway, Outputs, and Outcomes

We will assess the gender-disaggregated risks of AADs, particularly among the poorest producers and consumers; find and develop, jointly with the stakeholders, solutions and innovations to reduce these risks; understand and support appropriate institutions and incentives that will make these sustainable; assess the impact of interventions; and develop communications, advocacy, and influence strategies that will enable their uptake and use.

Outputs

Prioritization and systems understanding:

- Maps and rankings of AADs that identify important risks where CGIAR research can make a difference.
- Contribution to metrics and assessments of the multiple burdens of high-priority agriculture-associated risks.

Risk and socioeconomic assessment:

- New surveillance and diagnostic tools that allow for a better understanding of priority diseases.
- Assessments of health risks and economic, social, and ecological impacts of priority diseases, disaggregated by gender.

Innovation and risk-based management:

- Development of novel technologies, methods and strategies; evaluation of these as well as existing risk management options in terms of disease burden reduction, cost, feasibility, gender and equity, and policy implications.
- Evaluations and impact assessments presented in conferences and documented in peer-reviewed publications.
- Widespread adoption fostered through development programs and value chains.

Cross-cutting:

- Advocacy meetings, briefs, website, and reports disseminating research findings.

Outcomes

These research outputs will be developed in collaboration with, and to meet the demands of, the two major categories of research users: public and civil society programs, charged with improving health and livelihoods; and the value chain actors, faced with increasing demands for managing disease risks (see partnership discussion). This engagement provides a mechanism for linking research to use by including in the design discussions those who rely on evidence and research outputs to attain their own organizational goals. Outcomes will thus be at two levels:

⁸ Throughout this component we stress that innovation includes not only new technologies but also new institutions, configurations, partnerships, policies, mindsets, attitudes, behaviours and practices; and that combinations of these are usually required to bring about pro-poor improvements in health.

a) Research outcomes – changing mindsets and practice in development programs and value chains, through direct engagement and joint development of research outputs

b) Development outcomes – changing mindsets and practice among the poor dependent on agriculture, achieved through development programs and value chains

The research outputs will contribute to the following specific outcomes:

- Improved understanding of the gender-disaggregated risks and livelihood impacts of AADs by farmers and key stakeholders.
- Increased understanding of the poverty, social, gender, and behavioral determinants of adoption of risk-mitigating measures among key stakeholders
- Change in awareness, assessment, and management of the risks of AAD attributable (partially or wholly) to CGIAR research
- Wide use of new technologies for better assessing, diagnosing, preventing, and managing AAD, attributable to CGIAR research
- New One Health/multidisciplinary partnerships that multiply and scale up the results of CGIAR research, leading to better assessment and management of AAD

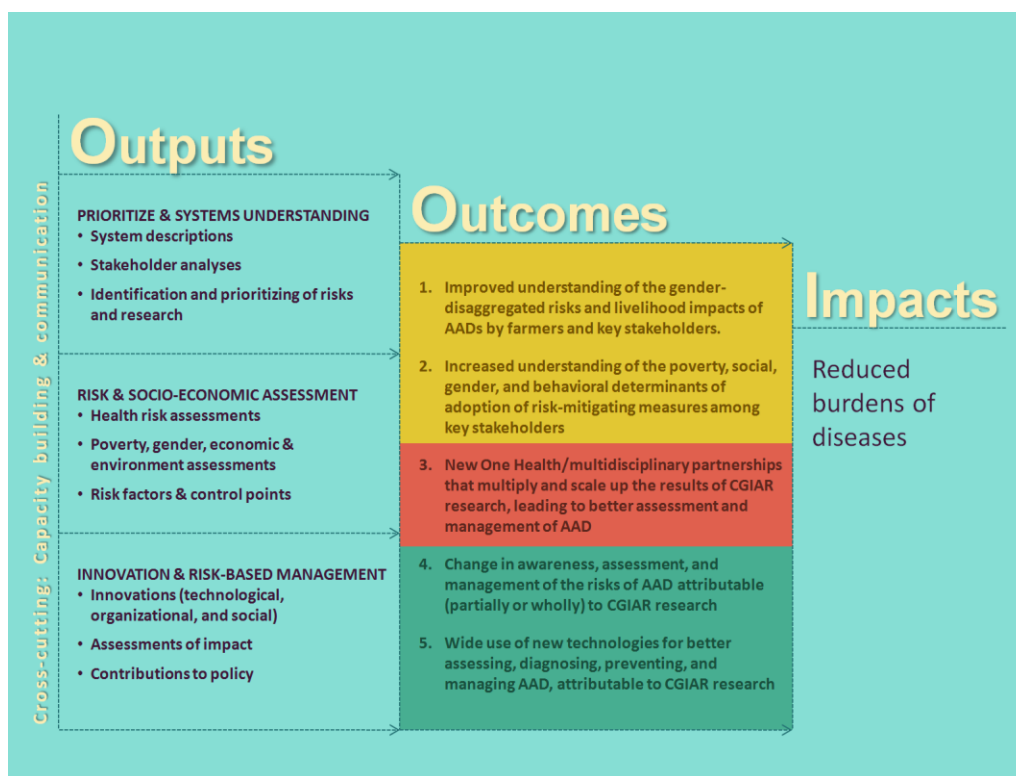
As shown in Table 10, we distinguish between two initial priority subcomponents (1 and 2), where work is ongoing and substantive and major impacts are anticipated within 3 years, and a third component covering emerging or important areas where the CG has less current investment.

Figure 7 shows the impact pathway for all subcomponents. There are three main strands of activities, summarized as prioritization, assessment, and management of risk; cross-cutting activities are capacity-building and risk communication. *Prioritization* involves understanding the system context and comparative risk assessment (risk ranking) to identify which risks to tackle first. This is linked to *assessment* of risk and identification of risk factors and control points. That in turn informs the development of cost-effective risk management methods with partners, including assessing their potential impact and promoting uptake.

In practice, these strands will be sequenced iteratively and not linearly. For some hazards, risk assessment and management activities are ongoing; the question of their relative importance and prioritization would be dealt with as part of the development of metrics, prioritization, and decision support.

This research will be conducted in partnership with the anticipated users of research—that is, development programs and value chains—and will respond to their needs and concerns. In turn, they will bring to the research design an awareness of changes in knowledge, attitudes, and behavior of the poor who are afflicted by AAD or involved in its transmission. The ultimate impact is a useful and substantial reduction in the multiple burdens associated with AAD, a reduction that can be attributed to CGIAR research inputs.

Figure 7. From research to impact: Multiple pathways in a risk management context



6.3.4 Principles

The research will embody three underlying principles:

- a) multidisciplinary—involving different disciplines, policymakers, and communities
- b) participation—including communities and decision-makers in research design, implementation, and evaluation
- c) gender equity and social and economic fairness

Multiple disciplines bring multiple perspectives to understanding the epidemiology, prevention, and management of AAD, addressing the ecological, economic, social, and political subsystems that influence health (Lebel 2003).

Cooperation and collaboration

Collaborative, comprehensive research strategies are a hallmark of the CGIAR approach (see Box 6). For food safety impacts (subcomponent 1), critical actors will vary with the stage of value chain development. CGIAR Centers already have experience and links with multiple actors along the food chain and in the enabling environment—for example, national research organizations, public and private sector service providers, civil societies, NGOs and policy makers. For many poor people, informal markets are developing, and the main actors involved are farmers’ organizations and civil society. For them, the policy context is often disabling, and engagement with policymakers will be key to achieving shifts to more equitable and effective policy and regulation. As markets formalize, private sector companies become more important. For AAD relating to animals (subcomponent 2), public health and veterinary services are important actors. In all cases, actors will be engaged directly in each target system or country. In other areas (subcomponent 3), partners for engagement will be intergovernmental agencies such as WHO, FAO, and OIE and their specific programs for food safety and disease control. The research will

include technology, policy, and institutional work needed to achieve outcomes. In addition, cross-cutting policy and methodology research required for better cross-sectoral engagement and decision making will be implemented in Component 4.

Partners are key to our impact pathway, and we envisage a two-pronged partnership strategy consisting of strong collaborative relations with a small number of strategic partners (two to five), complemented by an outreach strategy of two-way communication with a broader range of relevant partners. For some activities, strong and long-standing partnerships already exist; for others, explorations and discussions will be held in the first six months to better understand and identify strategic and relevant partners. Key partners already identified include: WHO FERG, WHO TDR, LIDC, Swiss Tropical and Public Health Institute (STPH), CSRS, and EMBRAPA. Mapping the partnership landscape will be an important initial activity.

Box 6. Existing collaboration efforts

The Aflacontrol project brings together scientists and economists from IFPRI, ICRISAT and CIMMYT with national research centers, universities, and non-profit partners to conduct risk analysis of aflatoxins in groundnuts and maize, in Mali and Kenya respectively. The research includes surveys of small-scale farmers, to ascertain their willingness to pay for the biocontrol technology under development by IITA. Further collaborative work is planned with ILRI to link those results with their analysis of the maize cattle-feed value chain.

The Systemwide Program on Integrated Pest Management is an initiative involving ten CGIAR Centers and two associated Centers, designed to develop innovative solutions to the contamination of foods, feeds, and the environment with pesticides and mycotoxins

6.3.5 Methods

The keystone of this component is agriculture research, bringing innovation to improve management of AAD and developing and testing technological, organizational, and social innovations. Epidemiology, with its focus on health in populations, has for long been the foundation on which public health decisions are developed, implemented, and evaluated (IOM 1988). Risk analysis is the gold-standard approach for addressing food safety as well as diseases of trade; it contributes to the conceptual framework of the impact pathway and will be a major research approach. Risk-based analytic approaches will need further development to better integrate considerations of participation and equity and to be a practical application for all levels of value chain actors (Grace et al. 2008). Behavioral analysis will help identify information approaches and market access incentives for farmers to adopt mitigation measures. Addressing the complex problems of AAD from farm to fork will therefore require contributions from many disciplines, including economics, sociology, gender studies, and ecology. Similarly, the development, testing, and dissemination of risk assessment and management tools and strategies will require the contributions of biology, genetics, molecular epidemiology, bioinformatics, food technology, communications, extension, and other specialties. The interface of human health and agriculture is a meeting ground for many disciplines and approaches, as illustrated in Box 7 and in each subcomponent.

6.3.6 Subcomponent 1: Improving Food Safety (initial priority)

Food-borne disease is one of the most important health problems in developing countries. Under this subcomponent we address three critical areas of agriculture-associated health risks.

1. Mycotoxins are fungal toxins that contaminate staple foods, animal feeds, and animal source foods in most of the humid tropics.
2. Biological hazards (including micro-organisms and parasites) cause the great majority of food-borne disease and appear to be increasing in recent years. Most arise from

contamination of foods (mainly livestock or fish source) with human pathogens or from food-borne zoonoses.

3. Plant toxins are natural substances in plants that can harm health; these include anti-nutritional factors in some legumes and cyanogenic glycosides in cassava. Chemical hazards from pesticide residues can also harm human health and affect trade in agricultural products.

Rationale, Objectives, and Research Questions

Mycotoxins: Rationale

Mycotoxins are produced as secondary metabolites by several pathogenic and food spoilage fungi. They affect almost one-quarter of global food and feed (Dohlman 2004). They are found in a wide range of foods, including certain cereals, legumes, root crops, spices, tree nuts, and dry fruits; if animals eat contaminated feed, they may also be present in animal source foods. The highest-risk crops are maize, groundnuts, and cottonseed. Aflatoxins are one of the most potent natural toxins, and the most potent carcinogens known today among mycotoxins (IARC 1993). Other mycotoxins, including fumonisins, are also widespread in tropical areas. Most are less well researched and their impacts less well understood than aflatoxins.

Mycotoxin contamination affects the long-term health of humans and animals. Chronic effects include growth retardation (Gong et al. 2004), immune suppression (Jiang et al. 2005), reproductive problems (Shuaib et al. 2010), and cancer. Consumption of high doses can result in acute illness and death: in 2004, more than 125 people died in Kenya. Mycotoxins also negatively affect nutritional status by interfering with protein-energy metabolism and by affecting the synthesis of vitamins A and D as well as zinc and selenium (Williams et al. 2004). However, more research is required to understand the interactions between vitamin A/iron/zinc deficiency, diarrhea, and mycotoxin exposure—conditions that frequently co-exist in children who lack access to adequate good food. Such an understanding will help in accurately mapping and measuring the mycotoxin health burden. Another important areas for multi-disciplinary research is the link between aflatoxins and stunting (Box 7).

Box 7. Links of aflatoxins and stunting

The affect of aflatoxin on retardation of growth and reduced productivity in livestock is well established (Williams et al. 2004; Hall & Wild 1994; Ubosi et al. 1985). However, the affect of aflatoxin on growth retardation and immune suppression among exposed human populations is less well established (Strosnider et al. 2006). The use of biomarkers that measure actual exposure to aflatoxin in the diet, enable a direct impact assessment of aflatoxin risk mitigation strategies as well as on health.

A number of studies in West Africa (Benin and Togo – Gong et al. 2004; Gong et al. 2002; Jolly et al. 2006) have demonstrated exceptionally high aflatoxin exposure among children using exposure biomarkers, showing a startling 2.5 fold increase in aflatoxin exposure among children at weaning when they are shifting from milk to solid foods. These studies show a significant association between aflatoxin exposure and stunting, although the mechanism remains unclear (Gong et al. 2004). Partnering the CG competencies on agricultural systems with researchers in health, nutrition and demography will be highly synergistic, allowing for further evidence on health impacts that will play an important role in convincing policy makers as well as consumers and producers to invest in strategies and regulatory systems to reduce aflatoxin exposure

Mycotoxin contamination also affects the agricultural economy through loss of produce, lost access to markets, and management costs (Shane 1994). Mycotoxins are also toxic to livestock, lowering production and productivity. Commercial food and feed sectors, large institutional buyers such as the

World Food Programme, and national food reserve agencies therefore all require mycotoxin-safe maize, which often means the exclusion of small farmers from this market.

Contribution of CGIAR. A number of strategies are currently being developed and evaluated to address the problem. These include pre- and post-harvest measures as well as dietary strategies:

- Development of mycotoxin-tolerant cultivars (especially maize and groundnut) (Gardner et al. 1987; Brown et al. 1999; Holbrook et al. 2008; Menkir et al. 2008; Waliyar et al. 2003)
- Competitive exclusion technology for biological control (Cotty et al. 2008; Atehnkeng et al. 2008)
- Dissemination of appropriate pre- and post-harvest technologies that reduce the risk of food/feed contamination (Hell et al. 2008; Waliyar et al. 2008a), including low-cost, effective storage interventions
- Various food processing practices (Fandohan et al. 2008)
- Development of simple diagnostic tools, including bio-markers, to raise an exposure alarm and indicate severity of contamination (Waliyar et al. 2008b)

A combination of some of these cost-effective strategies can reduce mycotoxin burden in vulnerable populations. Earlier work by IATA and partners identified local maize processing practices that can reduce mycotoxin exposure (Cardwell and Henry 2004). Integration of public health (Strosnider et al. 2006) and agricultural strategies (Menkir et al. 2008) is a promising strategy to reduce mycotoxin exposure in developing countries.

Priority research area. Priority will be given to aflatoxins in staple crops grown by poor farmers in Sub-Saharan Africa for household consumption, sale, and other uses. The key research challenge is to determine how cost-effective, pro-poor and appropriate risk management can be scaled out for wide-reaching impacts.

Biological hazards: Rationale

Food-borne disease is one of the most important health problems in developing countries, responsible for 4 billion annual episodes of gastrointestinal disease (UNEP 2010). As much as 70 percent of deaths among children under five is linked to biologically contaminated food and water (Unnevehr and Hirschorn 2000). In 2 to 3 percent of cases, severe and disabling long-term effects result, including joint disease, kidney failure, or cardiac, retinal, or neurological disorder (Lindsay 1997). These often permanent effects, though little noticed by policymakers, may well represent an even greater health and economic burden than the acute disease. Parasitic food-borne zoonoses (such as cysticercosis and echinococcosis), largely absent from rich countries, cause important losses in poor countries—in the range of millions of DALYs and billions of dollars in medical costs, lost productivity, and losses to the livestock sector (Maudlin et al. 2008).

In countries where detailed attribution data exists, the burden of food-borne disease is mostly due to pathogens (Thorns 2000), most of which are zoonotic in origin (Schlundt et al. 2004). Animal source food poses the greatest risk to human health (Adak et al. 2005; Lynch et al. 2006). In developing countries, much less is known about every aspect: causes of diarrhea, prevalence of food-borne diseases, high-risk foods, risk factors (including behavioral), or the cost and other impacts of illness (Kaferstein 2003).

As with other AAD, biological hazards in food can impose additional burdens on the agriculture and livestock sector and even the ecosystem itself. The economic impact in poor countries is largely unknown, but evidence from developed countries shows that costs can be very high. A US study estimates the total economic impact of food-borne illness at \$152 billion annually (Scharff 2010), while work from ILRI indicates that beef-borne disease alone costs Nigeria more than \$1 billion per year (Okike et al. 2010). Food safety policies and regulation can also carry a high cost, in excluding small-scale value

chain actors or shifting them to informal markets with higher risks and fewer gains (Kang'ethe et al. 2007).

Innovative risk-reduction approaches are needed. The use of polluted irrigation water, for example, supports the livelihoods of between 20 and 50 million farmers and feeds up to one billion consumers—while creating a risk of disease, when crops are eaten raw. In such instances, risk reduction and livelihood support have to be carefully balanced. Water pollutants can also impair the health of livestock and that of the consumers of animal products, within a complex system that includes links between waterborne and food-borne diseases.

Contribution of CGIAR. A number of approaches and strategies are being used to assess and manage biological hazards:

- Assessment of risk posed by biological hazards in food, combining a number of methods ranging from participatory epidemiology to stochastic modelling (Grace et al. 2007) as well as research into the association between gender and food safety
- Surveys, contingent valuation, and behavioral observation to assess willingness to pay for food safety: studies across seven countries demonstrate a 5 to 15 percent premium for safety-assured products (Jabbar et al. 2010)
- Training and certification of informal sector milk traders, and evaluation of the resultant risk-reduction and economic benefits (Kaitibie et al. 2008)
- Non-treatment interventions to reduce the risks of farming, trading, and consuming wastewater-irrigated vegetables
- Understanding the benefits of informal sector food to livelihoods, and the effects of food safety policy both on consumer safety and on the livelihoods of those in informal food production

Priority research area: The initial research focus will be animal-source foods in seven of the eight high-potential smallholder value chains targeted by CRP 3.7 (fish and pigs in Uganda, milk in Tanzania and India, pigs in Vietnam, sheep and goats in Ethiopia and Mali). The key research challenge will be to improve food safety while maintaining smallholder market access.

Plant toxins and chemical hazards: Rationale

Some common food crops are associated with plant toxins and anti-nutritional factors. Cassava contains cyanide; grass pea harbors β -ODAP (β -N-oxalyl-L- α , β -diaminopropionic acid); faba bean contains tannin, vicine, and convicine; yams have alkaloids; and most of the food legume crops contain phytate and raffinose family oligosaccharides. These plant toxins and anti-nutritional factors reduce the nutritive value of food crops, and if taken in large quantity over a long period cause serious health problems in humans and animals, while also lowering the bioavailability of dietary minerals and micronutrients (such as iron and zinc). Tens of thousands of people are affected by konzo and lathyrism, two toxico-nutritional neuro-degenerative diseases that persist exclusively among the poorest and most marginalized communities (Tshala-Katumbay and Spencer 2007). Similarly, overconsumption of grass pea in an unbalanced diet for a period of three to four months causes lathyrism in up to 6 percent of the population within its production zone (Spencer 1995). Favism is a medical condition caused by deficiency of the erythrocyte-located glucose-6-phosphate dehydrogenase (G6PD) that predisposes individuals to anemia as a result of consuming faba beans. The condition is most common in people who live around the Mediterranean, and it generally affects men more often than women. Similarly, presence of phytic acid in food legumes reduces the bioavailability of iron and zinc (Spear and Fehr 2007).

These crops are grown over significant areas: cassava, 18.7 m.ha.; grass pea, 1.50 m.ha.; faba bean, 2.67 m.ha. In most areas, they are irreplaceable by other crops. Cassava and grass pea are adapted to adverse agroclimatic conditions such as drought and waterlogging, and to the nutrient-deficient soils

which are frequent, widespread, and persistent in South Asia (SA) and Sub-Saharan Africa (SSA) (Kumar et al. 2010).

Chemical hazards from pesticides and from other agricultural inputs can also contaminate food, harming human health and affecting trade in agricultural produce.

Contribution of CGIAR: Over the past 25 years, in collaboration with NARS partners, CGIAR centers have developed safer grass pea and faba bean (ICARDA) as well as cassava (IITA).

- Centers are developing strategies that reflect particular challenges in SA and SSA, where the production of these crops is often dominated by marginal farmers, with women comprising much of the workforce.
- Pesticide-related health problems continues to be part of CIP's newly created program on complex systems.

Priority research area: The initial priority for plant toxin research will be the development and evaluation of low-toxin or toxin-free varieties of grass pea, cassava, and faba beans; multiplication of quality seeds, demonstration of improved agronomic practices; and training on food processing methods for poor farmers in South Asia and Sub-Saharan Africa. Work on chemical residues in food will be addressed through the integrated pest management research which seeks to reduce the use of pesticides in order to meet objectives of improving occupational health and food safety, decreasing input costs, protecting the environment and slowing the development of resistance.

Objectives

The objective of this component is to contribute to the assessment, prevention, and mitigation of the multiple burdens of food-borne disease in developing countries, through demand-driven, pro-poor research into agriculture, livestock, and agroecosystem research that builds on CGIAR's wealth of experience and expertise.

Research themes

Throughout the three subcomponents, the same set of research questions will support learning and transformation, to contribute to the overall impact pathway:

- **Prioritization and systems understanding:** Which hazards are of greatest concern for the poor in developing countries (in terms of health, loss of income, and livelihoods)? What is the relative prevalence risk? How can agriculture research and One Health/multidisciplinary approaches add value to risk reduction? How can they address the issues of gender, equity, participation, and ecosystem impacts? What partnerships, coalitions, and engagement are needed to influence actors in development and those in markets to better support risk management?
- **Risk and socio-economic assessment:** What is the epidemiology of transmission, exposure, and vulnerability? What are the social, gender, and environmental determinants of risk and disease impact? What are the impacts on agroecosystems? What are the risk pathways between hazard origin and human victim? What are the risk factors and control points for reducing each risk along the food chain from farm to fork? And how does this vary by ecological zone or size of producer? Finally, how can interventions at farm level and along the value chain protect consumers?
- **Innovation and risk-based management:** What has been learned about these hazards, and what are the key gaps? How is risk currently managed, and what surveillance is in place? Are there cost-effective methods to reduce the risk (to health, income, and livelihoods) without reducing productivity for small- and medium-scale producers? What new science-based diagnostics, technologies, breeds, biological control, animal vaccines, methodologies, and other innovations can improve the mitigation, surveillance and management of risk? How can

these innovations and technologies be developed, tested, evaluated (for both economic and social benefits), scaled-up, and disseminated? How can policy alternatives and implications be effectively conveyed to decision-makers?

Impact Pathway of the Subcomponent

The overall impact pathway follows the approach diagrammed in Figure 7: major activities include prioritization and system understanding; risk and socioeconomic assessment; and innovation and risk-based management. At the same time, the focus on three specific health risks under this subcomponent allows for a more targeted approach. For each health risk, research results will shape technological and other innovations as well as information for dissemination. These innovations will be systematically assessed, and the results will be fed back into the development of increasingly appropriate solutions in an iterative manner. This feedback approach allows for more permanent and sustainable solutions, as well as increased adaptive capacity for longer-term development

The outcomes of the research will be methods, approaches, innovations, and models tested and available to scale out to other communities. The adoption of these approaches in the targeted communities and beyond will reduce the risks to human health from mycotoxins, biological hazards, and plant toxins, while safeguarding or enhancing agricultural production and productivity. This will contribute to the ultimate impacts of improved health, nutritional status, and rural livelihoods.

Improving Food Safety: Activities, Outputs, and Outcomes

Table 11 provides detail of the activities, outputs, and outcomes for this subcomponent,. Refer to the key provided to identify the specific research area for each activity, output, and outcome. Annex X gives an expanded version of this table at a higher level of detail.

Table 11. Activities, outputs, and outcomes for subcomponent 1 (by research theme)

	Activities	Outputs	Outcomes
Prioritization	<ul style="list-style-type: none"> • Survey along value chains; assess contamination in key crops <u>across agroecological zones</u> • Assess multiple burdens of FBD • Develop and validate participatory approaches to prioritizing food-borne hazards 	<ul style="list-style-type: none"> • Risk maps for mycotoxins in key crops • Groundnut, maize, and sorghum value chains mapped • Metrics and assessments of multiple burdens of food-borne disease over producers and consumers • Risk-targeting decision support tools 	<ul style="list-style-type: none"> • Resource allocation better reflects risk and costs of food-borne disease. • Risk maps for different food-borne disease used for risk targeting. • Assessment of the impacts over producers and consumers
Risk & socio-economic	<ul style="list-style-type: none"> • Develop and test new detection methods • Assess mycotoxins in soil, crops, and livestock • Assess retention of toxins during processing • Implement exposure surveys • Develop and validate rapid tests for FBD • Test surveillance models and provide evidence for better surveillance of FBD 	<ul style="list-style-type: none"> • Elucidate link between mycotoxins and malnutrition in children • Mycotoxin exposure in human population • Evidence for policy influence • Novel rapid tests developed, tested, and shared • Surveillance systems and prediction models 	<ul style="list-style-type: none"> • Prediction models used by government agencies and national and international organizations. • New cost-effective detection tools used routinely by actors along the value chain, including exporters. • Better surveillance and reporting of food-borne disease.
Innovation and risk-based management	<ul style="list-style-type: none"> • Develop, test, and enable commercialization of atoxigenic strains of fungus • Develop and test control innovations, such as: improved diagnostics; alternate uses for contaminated grains; resistant cultivars; other biocontrol strategies; processing methods to reduce toxins; alternative uses for contaminated food • Improve epidemiological understanding of transmission, susceptibility, and control • One Health collaborations for on-farm risk reduction addressing equity, participation, & ecological aspects • Develop and test risk mitigation innovations and strategies • Evaluate low-toxin lines in target region, for farmers' participatory selection in SA and SSA • Evaluate preferred varieties with partners and NGOs • Seed multiplication of best varieties in selected areas • Safe alternatives to pesticides • Implement research on institutional arrangements and strategies to improve adoption and cost-effectiveness • Health, social, economic, and other impacts assessment 	<ul style="list-style-type: none"> • New country or region-specific strains for biocontrol identified • Database on current control strategies • Long-term: Simple, rapid technologies for mycotoxin detection at field level • Alternative uses of contaminated products identified and promoted • Improved varieties with low toxins • New trait-specific donors for traits associated with high nutritional value • Packages of management strategies tailored to different agroecosystems • Information approaches and market access incentives for farmers to adopt Aflatoxin cost-effective mitigation measures • Technological, organizational, and social innovations developed, tested, and shared • Evidence generated (reports, papers, database) 	<ul style="list-style-type: none"> • New strains promoted and commercialized • 10% farmers in selected areas adopt recommended management • Mycotoxin reduced by 70% and exposure by 80% in selected areas • Farmers adopt cost-effective measures to minimize exposure to plant toxins. • Evidence influencing policy in a pro-poor direction • Widespread adoption of improved management in the target regions • Value chain actors pay premiums for safer food. • Farmers' adoption of technologies to minimize overuse and misuse of harmful pesticides • Increased income from safer agricultural produce
Capacity and skills	<ul style="list-style-type: none"> • Build capacity of NARS and graduate students • Develop and test risk-communication strategies • Targeted dissemination to decisionmakers, private sector, NGOs, research community, donors and others • Community-based capacity building 	<ul style="list-style-type: none"> • Policy advocacy platform • Publication of peer-reviewed research articles, data sets, and learning materials 	<ul style="list-style-type: none"> • Shift in mindsets towards pro-poor and risk-based food safety policy an practice • Behavioral changes of value chain actors in high-risk areas • Enhanced access for the poor to safe food

Key: Underline: mycotoxin-specific; *italics*: biological hazard; **bold**: plant toxins and chemical hazards; normal: all food-borne hazards

Methods for Food Safety

Box 8 summarizes the various methodological approaches that will be drawn upon in implementing this component.

Box 8. Methodological approaches

A multidisciplinary approach, combining scientific research with innovative participatory and socio-economic research, is a key strength of this sub-component as it is for the entire component.

Epidemiology, with its focus on assessing health in populations and testing health solutions, is the foundation for understanding disease in populations and for informing, implementing, and evaluating public health decisions (IOM 1988). **Risk analysis** is the gold-standard approach for addressing food safety; effective implementation will require integrating participation approaches and equity considerations (Grace et al. 2008). A risk-based approach is more effective for mitigating health hazards in resource-poor countries, and it can also be a bridge joining food safety and livelihood concerns. Uptake of many risk-mitigation strategies in developing countries has been limited, and approaches need to be adapted to better meet stakeholder needs and improve adoption. ILRI is developing methods of Participatory Risk Assessment (PRA), helping to characterize risks associated with informally marketed food and suggesting new methods of risk management, based on indigenous risk-mitigation practices rather than external technology. Similarly, IFPRI is developing a risk analysis approach that integrates an assessment of producers' willingness to adopt, and to pay for, low-cost mitigation technologies, based on their knowledge, attitudes, and perceptions of risk. On health risks related to wastewater irrigated food, IWMI and partners will apply innovative risk assessments such as QMRA and QCRA, as complements to existing epidemiological methods.

Economic, sociological, gender, and ecological research bring essential perspectives and tools to address the complex problems of AAD; adoption will depend on effective communication, influence, and advocacy. Innovations in experimental behavioral economics can shed light on the effectiveness of risk communication strategies and other approaches for changing producer and consumer behavior, in the face of known hazards and reduced market access due to food safety problems; they can also guide policies for reducing information asymmetries. Economic and social assessments are essential for understanding the non-health impacts of disease. Moreover, assessments of cost benefit and cost effectiveness must accompany impact effectiveness. Gender roles are a major determinant of exposure to risk, health seeking behaviour and health burden. Moreover, women are often the custodians of family health and nutrition; as a result gender research is needed to address the different health issues for women and men and ensure equitable health results.

Innovation and technology: Agriculture research has a clear contribution to make in developing new technologies to better assess, manage, and communicate risk. At the heart of this component are the traditional strengths of the CGIAR, in laboratory and on-farm research: breeding for better disease control; and development of diagnostics, control, and prevention methods. Revolutions in genetics, molecular epidemiology, and bioinformatics will bring new tools to help solve the age-old problem of food-borne disease. New technologies applicable to informal markets (such as milk vessels with an antimicrobial coating) also offer promising solutions. Genomics, metagenomics, and bioinformatics can improve surveillance and pathogen tracking and provide insights into possible risk, transmission, and pathogenicity. To increase the likelihood that new technology is context-sensitive and will be adopted by stakeholders, it is essential to involve producers and consumers and other actors along the value chain in framing the research and setting priorities, as well as in risk assessment and evaluating improved technologies. The three principles of trans-disciplinarity, participation, and equity will underpin the methodological approaches. Likewise, a cost-effectiveness framework for innovative mitigation strategies is essential to ensure environmental sustainability and economic feasibility.

Scientific research into new and innovative technologies and diagnostic tools builds on the strengths of the CG and partner NARs. A further crucial component of this CRP will be the up-scaling and adoption of these innovations by farmers and other actors along the value chain. This aspect will require other partnerships, with public, private, and non governmental service and information providers, as well as innovative research through iterative processes to adapt existing technologies so they are socially and politically as well as technically feasible and cost-effective.

Partnerships for Food Safety

Mycotoxins

ICRISAT, CIMMYT, IITA, ILRI, and IFPRI are the main centers involved in mycotoxin research. Established partners include advanced research institutes (ARIs), universities, EMBRAPA and NARS. The component will facilitate linkages and synergies among partners to work together. The Bill and Melinda Gates Foundation have initiated a Partnership for Aflatoxin Control in Africa (PACA), bringing together many institutions, donors, and other stakeholders to reduce the aflatoxin burden in Africa. The partnership includes key regional actors in Africa, including COMESA and the AU, and is being promoted within the CAADP framework as a key issue in food security. The CG centers involved in aflatoxin-related research are playing a key role in shaping and informing this partnership and the priorities for research and action, together with African policy makers and research centers.

Biological hazards

ILRI, IWMI and IFPRI are the three centers most active in this area. WHO, FAO, and OIE all have mandates for food safety. WHO currently has a Reference Group working on attribution and burden of FBD and are seeking collaborators (FERG) as well as a strong water, health and sanitation program to which IWMI is closely linked. The World Bank has done some initial, largely qualitative work with the University of Guelph, on cost of compliance to meet increased private standards. ARIs in Europe and America are involved in ongoing projects.

Plant toxins and chemical hazards

Over the past 25 years, in collaboration with NARS partners, ICARDA and IITA have developed safer grass pea and faba bean (ICARDA) as well as cassava (IITA). Partners are NARS in target countries and ARIs in Belgium, USA, Spain, and China. Among development partners, NGOS, private sectors and national seed agencies in South Asia and Sub-Saharan Africa will be involved for transferring technologies. For policy and knowledge partners, WHO, FAO, and IFAD will be partnered for awareness, risk assessment, and communication. The CGIAR Centers, in particular IITA, ICRISAT, CIP and IRRI, have worked over many years with NARS, other International Associations of Research of Cancer (IARCs), and the private sector on alternative technologies to harmful pesticides to reduce risks of residues on agricultural produce and occupational hazards. To better coordinate their work, in 1996, the CGIAR Centers have established the Systemwide Program on Integrated Pest Management.

Examples of partnership arrangements for this component are presented in Table 12.

Table 12. Examples of partnership arrangements for food safety

Research theme	Enablers	Development implementers	Value chain	Research	CGIAR
Mycotoxins	WHO	PACA	Seed	EMBRAPA	ICRISAT
	CODEX	MoA	producers	NARS	CIMMYT
	DFID	MoH	Food & feed	ARIs	IITA
	Food regulators		industry		IFPRI ILRI
Biological hazards	WHO	WB	Food industry	NARS	ILRI
	FAO	MoA	SSAFE	ARIs	IWMI
	OIE	MoL		Developing country universities	IFPRI
	CODEX	MoH			
	WB				
Plant toxins	EU				
	Food regulators				
	WHO	MoA	Food industry	NARS	ICARDA
	FAO	MoH	Seed industry	ARIs	IITA
Chemical hazards	IFAD				
	Food regulators				
	WHO	MoA	Pesticide industry	NARS	IITA
	FAO	MoH			ICRISAT
	CODEX				CIP
	Food regulators				IRRI

6.3.7 Subcomponent 2: Zoonotic and Emerging Diseases (initial priority)

Rationale, Objectives and Research Questions

Zoonoses are an important cause of sickness and death in poor countries

Improving the health of the poor requires reducing the threat and burden of zoonoses (Perry and Grace 2009), since in least-developed countries, zoonoses (and diseases recently emerged from animals) account for 25 percent of the Disability Adjusted Life Years (DALYs)—much greater than the combined burden of malnutrition and food associated-toxins (WHO 2008). Around 60 percent of all human diseases are zoonotic (Taylor et al. 2001). Zoonoses are responsible for most of the burden of food-borne disease (Schlundt et al. 2004), and the majority (75 percent) of emerging diseases have jumped species from animal hosts. Of the 35 leading communicable causes of death, 15 are either zoonoses or have a zoonotic component (Ecker et al. 2005).

Dollars as well as DALYS: The multiple burdens of zoonotic disease

By definition, DALYs only measure the disutility to the individual of being ill. They do not capture medical costs of illness to the individual or society (including cost of medication and provision of health care infrastructure). Indirect costs include loss of production and productivity as the result of illness, as well as costs of averting hazards (for example, mosquito nets).

Zoonoses have resulted in significant economic impacts. A study by Roth et al. (2003) shows that, reviewing both private and public costs of human illness and costs borne by the livestock sector, only 10 percent of the benefits of control accrued to the public sector. Diseases emerging from animals, while probably costing less than endemic zoonoses, often have more discrete effects: the severe acute respiratory syndrome (SARS) cost an estimated \$50 billion, while a probable influenza pandemic could cost \$2 trillion (World Bank 2008).

Agriculture-based interventions are essential for the control of zoonoses

The successful control of zoonoses, whether tuberculosis in Ireland, rabies in continental Europe or brucellosis in Canada, has always relied on interventions at animal level—as well as, for zoonoses of livestock, intervention along the farm-to-fork production pathway. The lesson from these experiences was sometimes forgotten, until bird flu came as a wake-up call. Control of zoonoses is best managed by multi-sectoral initiatives grounded in epidemiological studies that identify the variables that influence disease emergence and transmission (Schelling et al. 2007). Effective interventions need to be contextually adapted to local conditions, on the basis of knowledge of disease transmission pathways.

Objectives

The objective is to contribute to the assessment, surveillance, control, and prevention of the multiple burdens of zoonoses, both actual and potential, through demand-driven, pro-poor research into agriculture, livestock, and agroecosystem research that builds on CGIAR experience and expertise.

Research questions and approaches

- A. What are the priority zoonotic and emerging diseases that constrain pro-poor development?
 - What is the prevalence and burden of zoonotic and emerging disease?
 - What are the risk factors and control points?
 - What are the options for control? What are the likely risk-risk trade-offs, costs and benefits, and cost-effectiveness of control?
- B. How to better predict, plan for, and prevent diseases emerging from agroecosystems?
 - How can surveillance, response, prevention, and preparedness systems be more effective, integrated, and sustainable?
 - Which response strategies can improve adoption of control strategies?
- C. How can agriculture-based interventions contribute to control of neglected zoonoses?
 - How to build and test multi-sectoral, integrated zoonoses control packages?
 - How to develop new technologies to meet current gaps in disease control?
 - How to promote uptake, adoption, and transforming knowledge into use?

Impact Pathway of Subcomponent 2

The impact pathway assumes that research will co-generate evidence, methods, and tools in collaboration with partners, who in turn will use the research outputs to improve policies, programs, and services for pro-poor management of zoonotic and emerging diseases. The major strands of activity follow the pattern previously set out (Figure 7): major activities are prioritization (burden assessment and investment opportunities around neglected Zoonoses); assessment (pathogen detection platforms and surveillance); management (disease control tools, methods, delivery); and capacity-strengthening and policy engagement, as cross-cutting processes. The outcomes delivered will contribute to a) better detection and surveillance of diseases, b) better prevention and control of zoonoses through integrated and multisectoral approaches, and c) more resilient ecosystems that reduce the risk of disease transmission and emergence. This will contribute to the ultimate impacts of better health, nutritional status, rural livelihoods, and ecosystem sustainability.

Activities, Outputs, and Outcomes

Table 13. Activities, outputs, and outcomes of subcomponent 2 (by research theme).

Activities	Outputs	Outcomes
Prioritization and systems understanding		
<ul style="list-style-type: none"> Review and rank the multiple burden and the control of zoonoses Work with international organizations to complement and ground truth ongoing studies 	<ul style="list-style-type: none"> Contributions to better assessment of the multiple burdens of zoonoses and intervention opportunities More detailed assessment of one or two known priority diseases 	<ul style="list-style-type: none"> Greater awareness of health partners of the importance of zoonoses and need for ag.-based interventions Funding opportunities developed to support intervention opportunities
Risk and socio-economic assessment		
<ul style="list-style-type: none"> Understand drivers and crucibles of disease emergence Develop pathogen detection platforms 	<ul style="list-style-type: none"> Surveillance and control options based on improved understanding of disease Diagnostics that take into account variants in circulation 	<ul style="list-style-type: none"> Tools and guidelines used by national and regional partners Shift in mindsets and policies towards ecohealth solutions
Innovation and risk management		
<ul style="list-style-type: none"> Understand the role and effectiveness of current institutions to monitor and control for zoonosis Develop partnerships Co-develop and test integrated zoonosis control for one or more priority diseases 	<ul style="list-style-type: none"> Evidence, tools, and methods for integrated zoonosis control tried by development partners 	<ul style="list-style-type: none"> Tools and guidelines being used by national and regional partners Shift in mindsets and policies toward one health solutions

Methods

An over-arching approach is One Health, a collaborative and multi-disciplinary approach, that recognizes the interdependence of human animal and ecosystem health. The research approach will integrate:

- epidemiology (risk analysis; risk factor studies; prevalence and incidence surveys; impact assessment; diseases modeling; participatory approaches)
- biotechnology (genomic and metagenomics; bioinformatics; development drugs, vaccines and diagnostics; transgenic; population genetics; manipulation of microbial genomes)
- economics (cost benefit and effectiveness analysis; value chain; behavioral economics)
- sociology (gender and social determinants of health; health-seeking behavior; innovation systems; uptake and adoption)
- environment (ecosystem health; one health/ecohealth; wildlife/livestock interface; natural resource management)

Priority research area: The initial priorities will be Rift Valley Fever as an exemplar of emerging infectious disease and cysticercosis as an exemplar of neglected zoonoses.

Partnerships for Zoonotic and Emergic Dseases

Zoonotic diseases is a complex area, and many actors and multiple partnerships will be needed around research, development and policy enablement. Key research partners include: CIRA, universities with veterinary, public health, and biomedical research (STPH, IGS, London-Royal Veterinary College [London-RVC], London School of Hygiene and Tropical Medicine [LSHTM], Oxford, Guelph, and

others), International Ecohealth Society and Alliance for Ecosystem Health; and national agricultural research, public health and bio-medical research institutes and universities. Development partners include: International NGOs (the International Union for Conservation of Nature [IUCN], the World Wildlife Fund [WWF], and Oxfam); private-sector companies; public-private partnerships (FIND, GALVmed); national NGOs; and the private sector. Knowledge and policy partners include: FAO, WHO (FERG), OIE, the United Nations Children’s Fund (UNICEF), regional organizations (such as the African Union Interafrican Bureau for Animal Resources [AU-IBAR], the Economic Community of West African States [ECOWAS], and WAHO); PROMED; the Joint United Nations Program on HIV/AIDS (UNAIDS); national governments.

Table 14 presents some examples of partnerships for zoonotic and emerging diseases.

Table 14. Examples of partnerships for zoonotic and emerging diseases

Enablers	Development implementers	Value chain	Research	CGIAR
WHO	IAH	FIND	NARS	ICRISAT
OIE	EAH	GALVmed	STPH	CIMMYT
FAO	ICUN		IGS	IITA
AU-IBAR	WWF		RVC	IFPRI
ECOWAS	Osfam		LSHTP	ILRI
			UO	
			UG	

6.3.8 Subcomponent 3: Other Health Risks in Agroecosystems

Rationale, Objectives, and Research Questions

Other important issues arise at the intersection of health and agriculture that are not high initial priorities: they are not currently a major focus of research investment (in terms of budget and personnel), and some are emerging issues that are newly being explored. Nevertheless, CGIAR Centers have ongoing research in these areas and have potential to expand, as further evidence and resources become available. Four such potentially significant areas are identified:

1. Water- associated diseases
2. Occupational health
3. Resistance to pesticides, antibiotics, and other agricultural chemicals
4. Agroecosystem provision of health services
5. Links of aflatoxins and stunting

Water-associated diseases

Contamination of irrigation water with domestic or industrial wastewater can introduce pathogens or chemicals that may affect farmers and enter the food chain. This important problem is considered along with subcomponent 1 on Food Safety (Drechsel et al. 2010). A second major risk is water-related diseases: malaria kills 1.1 million people annually; others include schistosomiasis and emerging diseases such as cryptosporidiosis, giardiasis, and buruli ulcer (Erlanger et al. 2005; Keiser et al. 2005a; Steinmann et al. 2006; WHO 2007). These diseases may be fostered by poorly designed or managed irrigation and water storage systems (Boelee and Madsen 2006; Diuk-Wasser et al. 2006).

Occupational health

People in developing countries bear more than 80 percent of the global burden of occupational disease and injury, and the agricultural sector is one of the most hazardous (ILO 2000). Further, according to International Labor Organization (ILO), the agricultural sector is one of the most hazardous to health worldwide (see also Loureiro 2009). Occupational hazards in agriculture range from simple conditions like heat exhaustion to complex diseases like respiratory disease, zoonotic disease, and poisoning from agrochemicals. It is estimated that 2 to 5 million people suffer acute poisonings related to pesticides annually, of whom 40,000 die every year; and there are 170,000 recorded fatal injuries in agriculture annually Cole (2006). In spite of such striking numbers, occupational health in general, and in agriculture in particular, remains neglected in most developing countries because of competing social, economic, and political challenges (Nuwayhid 2004).

Resistance to Pesticides, Antibiotics, and Other Agricultural Chemicals

Excessive use of pesticides can also lead to resistance in medically important insects, such as mosquitos. Malaria in particular, can no longer be handled only through existing means, as mosquitoes have become resistant to agricultural insecticides (Diabate et al. 2002), while the parasite itself is increasingly resistant to anti-malarial drugs. Hence the health sector has sought collaboration with professionals in the areas of water management and plant disease control (Townson et al. 2005). There is vast experience of relevant agricultural interventions that can help mitigate negative health impacts (Keiser et al. 2005b; McCartney et al. 2007).

Using antibiotics (especially growth-promoters) in farmed animals has been shown to generate resistance to antimicrobials of human importance that can spread to humans, with the potential to cause major harm. Resistance to other veterinary drugs, including insecticides, acaricides, and trypanocides, also has potential to affect human health.

Agroecosystem health provision and shaping agriculture for better health outcomes

Health risks are created by many activities whose primary aim is food production and that alter natural ecosystems. The most problematic practices involve wildlife, water management, land use, and animal husbandry:

- fragmentation of wildlife habitat, unsustainable harvesting of wildlife, and sale of wildlife in wet markets
- changes in the distribution and availability of surface waters, as through dam construction, irrigation, and stream diversion
- agricultural land-use changes, including proliferation of both livestock and crops and greater use of monocultures; uncontrolled urbanization and urban incursion into agricultural areas
- keeping animals in densely habited areas
- climate variability and change
- movement of people and animals, causing introduction of pathogens and pests

Objectives

The objective of this subcomponent is to assess emerging health risks related to agriculture that are currently less prominent or less studied, and to conduct and develop research to identify their multiple impacts and mitigate the multiple associated burdens, as appropriate.

Research Questions

The research questions include:

- How does agriculture influence the epidemiology of known and emerging diseases? What is the risk contribution of agricultural management relative to other risk factors for the same disease? Where are interventions most cost-effective?
- Which disease-reducing management interventions are effective, cost-efficient (also in reducing public health expenditure), and most suitable for labor-intensive mixed farming systems and intensifying agricultural systems?

Impact Pathway of Subcomponent 3

Research in this subcomponent will focus on the agriculture-associated diseases for which innovative partnerships and approaches can have the highest impact. These will build on and expand long-standing collaborations (for example, the agricultural health platform and history of IWMI as WHO Collaborative Center). These powerful partnerships have an advantage over individual organizations, both in applying innovative risk assessments and in contributing to Health Impact Assessments by developing practical recommendations for mitigation. Likewise, the partnerships draw on social marketing approaches to increase the adoption of risk-mitigation measures.

The research outcomes of more efficient programs, reduced exposure to water-associated disease, and healthier environments will lead to improved health not only for farming communities but also for rural and urban consumers affected by agriculture associated disease. Improved health in turn will contribute to improved livelihoods and more sustainable ecosystems.

Activities, Outputs, and Outcomes

As this subcomponent is designed as scoping work directed toward the longer term, the activities, outputs and outcomes shown in Table 15 are merely indicative; they will be developed over time, as the program rolls out.

Table 15. Activities, outputs, and outcomes for subcomponent 3 (by research theme)*

	ACTIVITIES	OUTPUT	OUTCOME
Prioritization	<ul style="list-style-type: none"> • Determine relative contribution of agriculture to disease burden associated with health risks of concern (compared to other environmental factors) • Improve risk prioritization and management by national partners 	<ul style="list-style-type: none"> • Quantified relative risk posed by agriculture 	<ul style="list-style-type: none"> • Increased knowledge of the role of agriculture factors in selected diseases • Better understanding of the role of CG research in health issues related to agriculture • Better targeted health strategies
Risk and socio-economic assessment	<ul style="list-style-type: none"> • Risk analysis for better managing diseases related to agroecosystems, including promoting appropriate levels of protection based on the multiple burdens of disease 	<ul style="list-style-type: none"> • Methodology and results shared with implementors for development of guidelines • Improved sectoral productivity analysis that integrates health burdens with health benefits of agricultural disease management 	<ul style="list-style-type: none"> • After 3 years: Risks and benefits assessment of agricultural water management interventions evaluated under CRP5 • Risk assessments for specified health risks with agricultural drivers, carried out and used by decisionmakers and implementers
Innovation & risk management	<ul style="list-style-type: none"> • Development and scientific evaluation of agricultural water management options that reduce risks of agriculture-related diseases and enhance health benefits of agriculture 	<ul style="list-style-type: none"> • Recommendations for cost-effective interventions to reduce health risks • Targeted uptake strategy to guide dissemination, initiated at project inception 	<ul style="list-style-type: none"> • Scientifically evaluated options for increasing human health through better management of agricultural health risks • Better collaboration between the public health and agricultural sectors; improved integrated disease control

* Specific activities, outcomes, and impacts related to malaria are shown in Figure 8.

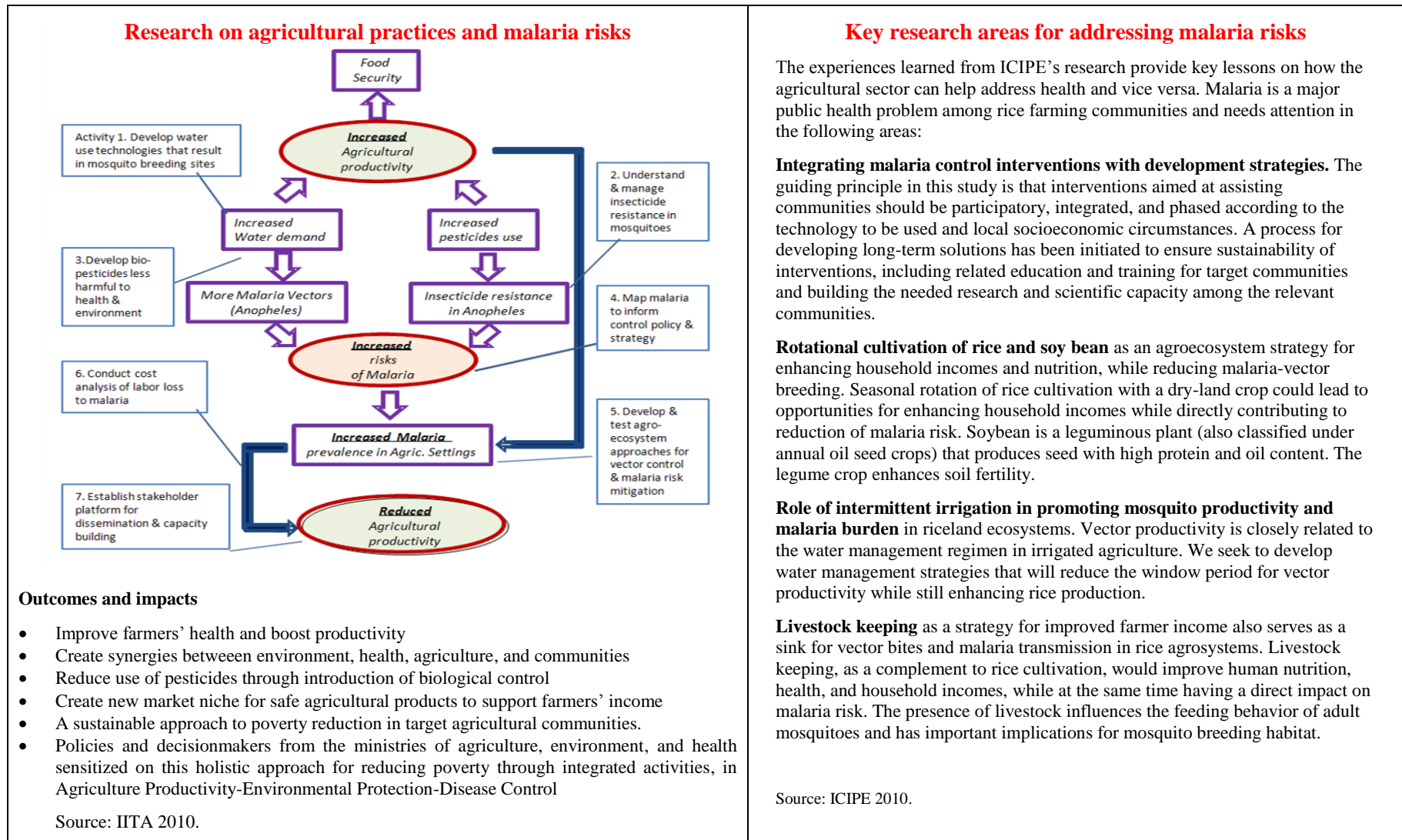
Methods

For water-associated disease and occupational health, there will be a strong emphasis on interdisciplinary and participatory Health Impact Assessments, complementary to existing epidemiological and biological methods. Participatory assessments are critical in developing practical recommendations for mitigation; in addition, innovative risk assessments such as Quantitative Microbial Risk Assessment (QMRA) and Quantitative Comparative Risk Assessment (QCRA) will be applied. Understanding drug resistance requires broad inputs from molecular epidemiology, modeling, ecology, and economics. Understanding agroecosystems will draw on ecosystem health and related disciplines.

Partnerships in Other Health Risks in Agro-Ecosystems

Alongside the CGIAR, there are a number of agricultural research institutes that are crucial for success, including icipe, CIRAD, the Institut de Recherche pour le Développement (IRD), LSHTH, LSTM, STPH, the International Technology Group (ITG), FAO, WHO, TDR, and UNICEF, as well as universities and NARS. In addition, several networks are relevant to research, dissemination, and up-scaling to the public health sector, as well as for capacity building. Indeed, for much of this research, the CG may be contributing relatively small inputs drawn from their specific areas of expertise to broader-based programs. We envisage linking to icipe, the Integrated Partnership for Malaria in Africa (IPMA), Tropical Diseases Research to Foster Innovation & Knowledge Application (TropIKA) (WHO), Malaria World, Access Initiative, IDRC and others.

Figure 8. Research on agricultural practices and malaria risks



6.4 Component 4: Integrated Agriculture, Nutrition, and Health Programs and Policies

This Consortium Research Program (CRP4) is rooted in the belief that integration of efforts in the fields of agriculture, nutrition and health—from planning through implementation—can result in cost-effective achievement of nutrition and health objectives. Component 4 is focused on maximizing delivery and impact, by fully integrating the efforts of individual sectors and by carefully fostering supportive policy and institutional environments.

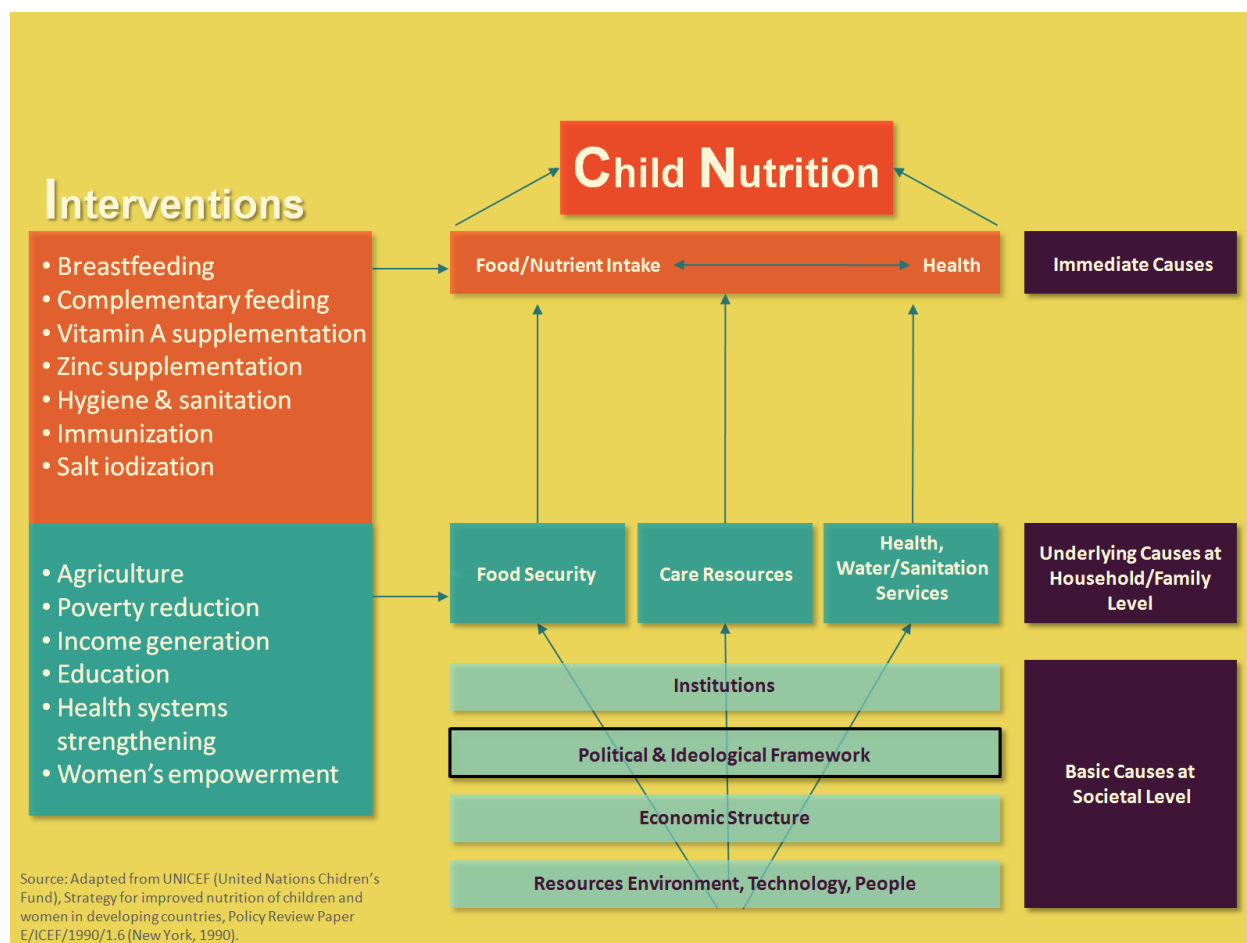
Integrated ANH programming and harmonized policymaking are viewed here as mutually reinforcing. On the one hand, integrated agriculture-nutrition-health program innovations can provide the evidence to incentivize and support the development of ANH-relevant policies and institutional arrangements. On the other hand, an “enabling” policy and institutional environment supports the necessary development and scale-up of effective ANH programs. Component 4 comprises these two interlinked domains: Subcomponent 4.1 focuses on programs, while Subcomponent 4.2 focuses on policies.

6.4.1 Rationale, Objectives, and Research Questions

Rationale

Many agricultural development programs fail to include specific interventions to assure nutrition, food safety, or health (Ruel 2001; World Bank 2007; Berti et al. 2004); often, programs operate under the assumption that improving agriculture productivity and income will automatically benefit nutrition and health (Diao 2007; Negin et al. 2009). Figure 9 shows that although agriculture can improve access to food and income, it contributes to only one of the three main pillars for improving child nutrition and health—that is, food security. The other two pillars involve providing adequate resources for child care and increasing access to health services and a healthy environment (UNICEF 1990). Thus, agriculture development programs must incorporate specific interventions that address the multiple needs of poor populations—for food, care, and health and other basic services. Among the new generation of agriculture programs, some have explicitly integrated nutrition and health goals, but few have been rigorously evaluated and carefully documented—especially with respect to operational issues, impact, and cost-effectiveness (Ruel 2001; Leroy et al. 2008; World Bank 2007). Even fewer have incorporated food safety as a component in their programs. Similarly, the community-based agriculture programs designed to improve human nutrition and health have rarely been scaled up successfully; an exception is Helen Keller International’s homestead food production program in Bangladesh (Iannotti et al. 2009). There is thus little empirical evidence regarding *what works* in an integrated ANH program, or how and under what circumstances such programs can generate the greatest benefits for the poor (Garrett 2008; World Bank 2007; Fanzo and Pronyk 2010).

Figure 9. Conceptual framework of the determinants of child nutrition and health



Source: Adapted from UNICEF 1990.

¹ The nutrition interventions in the green box (top left of figure) are those recommended in the Nutrition Lancet Series (Bhutta et al. 2008).

Objectives

The overall objective of Component 4 is to exploit and enhance the synergies between agriculture, nutrition, and health (ANH) through operational and policy research that permits a) more effective integrated community-level programming, and b) the cultivation and strengthening of an enabling policy and institutional environment to support relevant action.

Subcomponent 4.1: Integrated Programs. This subcomponent will build on existing programs and concepts to design new approaches and models to integrate ANH, by engaging CGIAR centers working in collaboration with development implementers.

- It will undertake research to understand and address the complexities of implementing such integrated programs in environments with vastly different diets, cultures, traditions, livelihoods, agroecosystems, vulnerabilities, exposures, and degrees of marginalization.
- It will use state-of-the-art research methods and tools to develop, test, monitor, evaluate, document, and scale-up integrated ANH programs.

- It will generate a critical body of evidence on these programs’ nutrition and health benefits and cost effectiveness—evidence that is urgently needed to stimulate investment to improve the nutrition and health of millions of poor, marginalized, and vulnerable households and individuals.

Subcomponent 4.2: Harmonized Policies. This subcomponent seeks to cultivate and sustain an “enabling environment”—an essential precondition for broad and sustainable success in addressing the underlying causes of malnutrition and agriculture-associated diseases. Such an environment requires a political and ideological framework, as well as supporting institutional arrangements and ANH-relevant policy frameworks and processes, that can foster decisionmaking that effectively harnesses the potential synergies among the agriculture, nutrition, and health sectors. (Figure 9 illustrates the central supporting function of the political and institutional framework.)

- This subcomponent will help scientists identify the researchable challenges where integration offers realistic benefits.
- It will develop information, processes, and decision support tools to help policymakers choose among feasible alternatives, based on effectiveness and efficiency considerations.

We recognize that not all ANH challenges require integrated solutions across sectors; in many cases, sector-specific actions may be most appropriate. Careful attention will ensure that policy research adds value to ongoing sectoral and cross-sectoral activities, while avoiding duplication of effort.

Research Questions

Examples of research questions that will be addressed by this component include the following.

- What design and implementation features make programs most successful in achieving their agriculture, health, and nutrition goals?
- What are the best approaches and targeting mechanisms to ensure that women are key participants and beneficiaries of such programs?
- What are the best tools to rigorously evaluate complex, multi-sectoral ANH programs and to generate the impact evidence needed for advocacy and to stimulate investments?
- How can an evidence base be created and sustained to support better investments in integrated planning across agriculture, health, and nutrition?
- What are the best practices in engaging policy and decisionmakers for cross-sectoral decisionmaking?
- What capacity is needed for cross-sectoral policy research and decisionmaking, and how can it be strengthened?

6.4.2 Impact Pathway, Outputs, and Outcomes

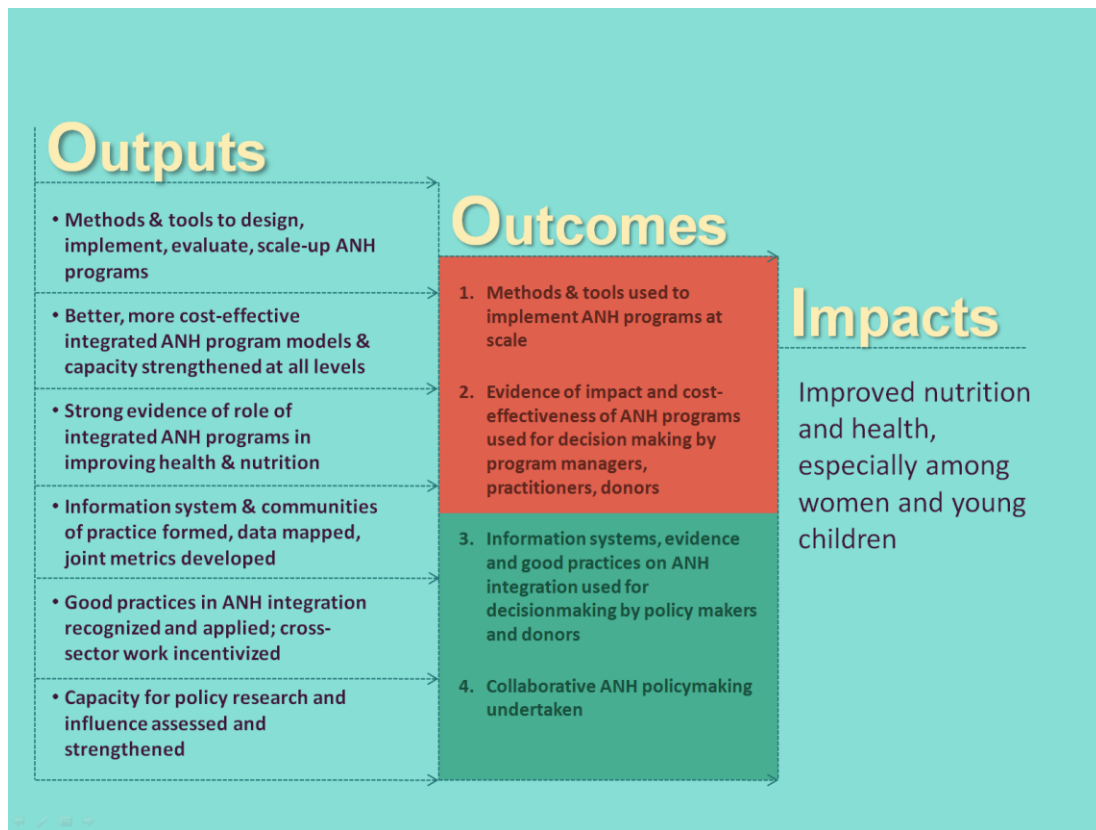
Of the three CRP4 impact pathways, component 4 focuses on the last two, the pathway for programs and the pathway for policies. Figure 10 illustrates the role of research in supporting the program and policy domains and the broad outputs, outcomes and impacts expected. There are important synergies to be gained in linking agriculture-nutrition- health development program implementation (on the left) and strengthening the enabling environment (on the right).

Component 4 seeks to strengthen such links and synergies, highlighting the importance of operational and policy research for maximizing the contribution of agriculture to nutrition and health outcomes and impacts. Methods and tools developed to design effective ANH will be used by decisionmakers in both governmental and nongovernmental development agencies, as will the evidence generated on the programs’ success and cost-effectiveness. Outcomes and outputs generated by the *program subcomponent* (4.1) can pave the way for success in the *policy subcomponent* (4.2), and vice

versa. Policy frameworks and processes can be made more favorable for ANH by demonstrating the potential benefits of effective ANH programs. In turn, the necessary program experimentation and innovation can be supported and incentivized by enabling policy environments.

Component 4, taken as a whole, will harness both the synergy of integrated programming and the potential for sustained policy commitment, to best realize the benefits of agriculture, health, and nutrition

Figure 10. Impact pathways of Component 4



6.4.3 Subcomponent 4.1: Integrated Programs

Rationale, Objectives, and Research Questions

Rationale

This subcomponent aims to maximize the nutrition and health benefits of agriculture while minimizing the risks of agriculture-associated diseases (AADs), through applied research to improve the design, implementation, and evaluation of community-based integrated ANH programs. It has five specific objectives, each related to specific research questions.

Objective 1.

Develop tools and indicators to design, implement, and evaluate agriculture programs that incorporate specific nutrition and health goals and interventions at the community level.

Research Questions

- What tools and methodologies can be developed to incorporate nutrition and health into community-based agricultural programs?
- What are the best tools and methods to rigorously evaluate the implementation, impact, and cost effectiveness of multi-sectoral programs such as integrated ANH programs? What process, impact, and cost-effectiveness indicators should be used?
- Are there simple, valid tools that can be adapted for rapid assessment, monitoring, or impact evaluation on key indicators?

Objective 2.

Rigorously evaluate the implementation, impact, and cost-effectiveness of integrated ANH programs in different communities, regions, and agroecological systems, using experimental or quasi-experimental methods for complex social programs.

Research Questions

- Do existing or new integrated ANH programs have an impact on nutrition and health outcomes? If so, how is this impact achieved and at what cost?
- Under what circumstances are impacts greatest? Which types of communities, households, and individuals benefit most? Where are the benefits greatest (in terms of region and agroecosystem)?
- Which packages of interventions achieve greatest benefits, and under which circumstances? What is the value added of specific interventions (such as behavior change communication)? What is the most effective intensity of exposure to interventions (for example, agriculture extension), in different contexts? Overall, what level of nutrition and health impact can be achieved through different modalities of integrated ANH programs?

Objective 3.

Generate evidence and document and disseminate lessons and best practices from research conducted under objective 4.1.2.

Research Questions

- How can implementation monitoring and evaluation results be used for advocacy?
- How should the learning be synthesized to inform practice and policy, in order to accelerate progress in improving nutrition and health globally? (links to subcomponent 4.2 on Policy)

Objective 4.

Explore and document mechanisms to successfully replicate, adapt, and scale up successful integrated ANH programs, and to ensure their sustainability.

Research Questions

- How can integrated ANH programs be adapted to different contexts and populations in different agroecological zones, and/or scaled up to increase coverage?
- What are the constraints and bottlenecks to replication, adaptation, and scaling-up?
- What capacities and skills need to be developed at community level and in government (district, provincial, and central level), with what approaches?

- What institutional mechanisms need to be defined and implemented to support integrated programs at the community level?

Objective 5.

Develop local capacity to design, implement, evaluate, and successfully scale-up integrated ANH programs.

This objective links to Objective 4. It seeks to work with other development partners to accomplish two broad aims: a) to better identify, measure, and monitor capacity constraints, weaknesses, and needs, relevant to scaling up ANH programming; and b) to develop approaches, tools, and methods for strengthening essential capacities for this purpose.

Impact Pathways

The applied research carried out by CGIAR centers and its partners to support better ANH programs will closely mirror the planning, implementing and evaluation cycle of partnering program implementers (governments, nongovernmental organizations, and other partners). This applied research—drawing from outputs in other CRP4 components as well as other CRPs—will contribute to three broad types of outputs (Figure 10):

1. Methods and tools to design, implement, and evaluate integrated ANH programs; the capacity to use these tools and to implement cost-effective ANH programs at local, regional, national, and international levels
2. Cost-effective program models that integrate agriculture, nutrition, and health and can be successfully scaled-up
3. A strong body of knowledge documenting the contribution of ANH programs to improved nutrition and health outcomes, to be used for advocacy and to guide policy and investments

The first set of outputs will be generated in Years 1-3, the second set in Years 1-5. The third set will start emerging subsequently, after tools have been developed and applied and after the first round of case studies have been concluded and fully documented (Year 5 and beyond).

It is expected that these outputs will be widely used by program implementers, development practitioners, and governments to scale-up ANH programs and to integrate agriculture, nutrition and health in national policies. The solid evidence generated by the research will stimulate greater investments by donors and implementers in successful integrated ANH programs and policies. These investments in turn will benefit the poor, helping to accelerate progress in improving the nutrition and health of vulnerable populations and individuals and reducing the risk of agriculture-associated diseases.

Activities, Outputs, and Outcomes

Table 16 sets out the activities, outputs, and outcomes for this subcomponent, with specific objectives and timeframes.

Table 16. Activities, outputs, and outcomes for the Integrated Programs subcomponent

Activities	Outputs	Outcomes
Objective 4.1.1. Develop tools and indicators to design, implement, and evaluate agriculture programs that incorporate specific nutrition and health goals and interventions at the community level (Years 1-3)		
Develop and test essential tools for program design: formative research, situation analysis, nutrient gap analysis (using linear programming), inventory of resources and services (and constraints to their use), program theory, and impact pathway development.	Optimal tools and methods for informing the design and targeting of integrated ANH programs.	Better designed and targeted integrated ANH program models are available for use by partners (NGOs, governments, and international organizations).
Develop and test methods to document program implementation, quality of service delivery, and impact pathways for complex, multi-sectoral ANH programs.	A set of tools, methods, and indicators to assess implementation of ANH programs; to identify and test solutions to identified implementation problems; and to identify and measure program impact pathways.	Program implementers have access to a set of tools, methods, and indicators to monitor and assess program implementation and to correct operational problems, ensure smooth implementation, and monitor program impact pathways.
Design and test a set of tools using program theory and experimental and quasi-experimental impact evaluation approaches, in order to document ANH program impact.	State-of-the-art tools and methods to evaluate the impact of multi-sectoral programs such as integrated ANH programs.	State-of-the art approaches are available to measure impact, implementation, and cost-effectiveness of integrated ANH programs.
Develop and validate a set of indicators (including gender-disaggregated indicators) to measure the impact of ANH programs on a range of outcomes (such as agricultural production, income, food security, diet quality and diversity, health symptoms, nutritional status, and women's empowerment).	A set of simple, valid indicators (disaggregated by gender as appropriate) to measure the impact of ANH programs on key ANH outcomes.	A set of indicators (disaggregated by gender as appropriate) is available for ANH program implementers, evaluators, and academics to document ANH impacts.
Develop and test a methodology to gather detailed program cost information and assess the cost effectiveness of integrated ANH programs.	A standard method to gather cost information and develop cost-effectiveness estimates of ANH programs.	ANH programs have available state-of-the art techniques to measure cost effectiveness.
Develop simple tools that can be used by program implementers for rapid assessments, monitoring, or simple impact evaluation of ANH programs on key outcome indicators.	A set of simple tools for use by program implementers to conduct rapid assessments, monitoring, or simple impact evaluation of ANH programs on key indicators.	ANH program implementers have available a set of simple tools to assess implementation and impact of their programs on key indicators.

Table 16. Activities, outputs, and outcomes for the Integrated Programs subcomponent (continued)

Activities	Outputs	Outcomes
Objective 4.1.2. Rigorously evaluate the implementation, impact, and cost effectiveness of integrated ANH programs using experimental or quasi-experimental methods for complex social programs (Years 1-5)		
Use tools developed in Objective 1 to carry out rigorous operational, impact, and cost-effectiveness assessments of existing, strengthened, or new models of integrated ANH programs—implemented in a variety of agroecological zones and targeting marginal populations with different vulnerabilities.	Research findings on impact and cost-effectiveness of integrated ANH programs implemented in different agroecological zones and targeted to marginal populations with different vulnerabilities.	<ul style="list-style-type: none"> – Body of evidence on the contribution of integrated ANH programs to improved outcomes in different contexts – Information on cost effectiveness of different program models in different environments – Lessons learned in implementing programs in various populations and agroecological zones
Objective 4.1.3. Generate evidence and document and disseminate lessons learned and best practices for designing (or strengthening) and successfully implementing cost-effective, integrated agriculture programs that incorporate specific nutrition and health goals and interventions at the community level (Years 5-10)		
Document and synthesize evidence generated in Objective 2; publish and disseminate findings to various audiences—academic, program implementers, and policymakers.	Evidence disseminated to relevant stakeholders, showing the impact and cost-effectiveness of integrated ANH programs on agriculture, health, and nutrition outcomes.	Increased knowledge and commitment to sustained investments in a new generation of integrated ANH programs.
Use evidence for advocacy among different stakeholders.	Advocacy done among relevant stakeholders.	
Objective 4.1.4. Explore and document mechanisms to successfully replicate, adapt, or scale up successful programs and ensure their sustainability (Years 5-10).		
Carry out research to understand, document, and address capacity and institutional constraints to replication, scaling-up, and sustainability of integrated ANH programs.	Information on constraints to replication, scaling-up, and sustainability of integrated ANH programs and on ways to address these constraints.	Better understanding of constraints to replication, scaling-up, and sustainability of ANH programs and of ways to address these constraints.
Participate in government policy dialogue and global initiatives to scale-up ANH programs and integrate ANH in policy.	Increased presence of policies and active ANH integrated programs.	National policies and global initiatives have the tools and momentum to implement integrated agriculture, health, and nutrition programs.
Objective 4.1.5. Develop local capacity to design, implement, evaluate, and successfully scale-up integrated ANH programs (Years 1-10)		
Train program implementers in the use of simple tools developed for assessments, monitoring, and simple impact evaluation of ANH programs and for scaling-up.	Program implementers trained in the use of tools to assess and scale-up ANH programs.	Capacity developed at program level to use tools to assess and scale-up ANH programs.

Priority setting and sequencing of activities

Priorities will be determined jointly with several partners, including CGIAR centers and program implementers.

In terms of timing and sequencing of activities, research will be undertaken on a subset of five to six programs in the first phase of CRP4 development (Years 1–5). Lessons generated from this round of

research will then guide the development of a new wave of programs (in Years 5-10) that use innovative approaches to more solidly integrate agriculture, nutrition, and health. The second phase of applied research will also have a stronger focus on addressing agriculture-associated disease risks at the community level—an area of increasing need, where experience on effective implementation is still limited.

Research Methods

This subcomponent has two main goals: to generate the hard evidence needed regarding the health and nutrition impacts and cost-effectiveness of integrated ANH programs; and to derive lessons learned on how to design, implement, evaluate and scale up such programs. Research in this subcomponent will focus on developing and using tools to strengthen program design, implementation, and evaluation, and on documenting and disseminating the learning to facilitate replication and scale-up of successful program models.

For these purposes, the research team will use state-of-the-art monitoring and evaluation methods, based on program theory and on well-defined program impact pathways. The team will use mixed methods drawing from quantitative as well as qualitative research tools, involve multi-disciplinary teams, engage local and implementation partners, and include simple tools and feedback loops to ensure that real time information is available and used by decision-makers at all levels.

Table 17 provides examples of methods that will be used for the program-relevant research, to be implemented in a selected set of countries and sites (case studies). The research will also develop a set of indicators for process, impact, and cost-effectiveness that will be used across case studies to allow valid comparisons and possible meta-analyses of research findings. An information management and learning system will be developed to link the different case studies and to generate learning across sites. (For more information on site and case study selection, see Section 5 on Partnerships.)

Table 17. Indicative research methods for the Integrated Programs subcomponent

Goal of research	Research Methods
Design effective programs	<ul style="list-style-type: none"> • Formative research to define program/intervention needs • Baseline surveys to characterize population and agricultural systems • Knowledge, attitudes, and practices surveys • Community and market surveys • Dietary surveys to identify food/nutrient gaps and food safety concerns • Social network census to identify how information is acquired and disseminated
Evaluate impact	<p><i>1. Evaluation designs</i></p> <ul style="list-style-type: none"> • Experimental designs with randomization and treatment and control (or other types of comparison) groups, including pre-post intervention data collection, wherever feasible • Quasi-experimental designs where experimental design is not feasible. Examples include: stepped wedge approaches (staged implementation); dose response (comparing different intensities of interventions); matching methods (regression discontinuity, propensity score matching, or matching individual or cluster by design) <p><i>2. Data collection</i></p> <ul style="list-style-type: none"> • Large surveys (cross-sectional, before/after, or longitudinal follow-up) • Qualitative research to document <i>how</i> and <i>why</i> impact did or did not occur • Community surveys, market surveys
Document impact pathways, quality of implementation	<ul style="list-style-type: none"> • Design an impact pathway framework, collaborating with program implementers. • Collect data on program implementation at different steps along the program impact pathway, to identify implementation failure and bottlenecks that may affect program quality, utilization, and impact. • Use operations research methods, combining methods to assess aspects such as fidelity of implementation, quality of service delivery, uptake and coverage, and perceptions of service providers and clients. • Synthesize information and feed it back in timely fashion to program implementers, to enable action to strengthen program implementation, quality of service delivery, and/or utilization.
Measure cost	<ul style="list-style-type: none"> • Adapt existing costing methodologies such as activity-based costing ingredients (ABC-I approach); collect needed cost data in an ongoing manner.
Measure cost-effectiveness	<ul style="list-style-type: none"> • Use cost and impact information to derive cost-effectiveness. Examples of effectiveness indicators include: for nutrition, anthropometric measurements (underweight, stunting, and wasting) and select micronutrient status indicators (such as vitamin A, iron, and zinc); and for health, cases of illness prevented.
Replicate and scale up	<ul style="list-style-type: none"> • Data collected (especially on impact pathways and implementation) will be used to generate lessons learned for replication and scale-up. • Research will also be conducted to understand and document capacity and institutional constraints for scaling up successful programs.

Partnerships

CGIAR centers will work collaboratively with research partners and development implementers to carry out the applied program-relevant research of this component. All research and capacity-strengthening activities will be conducted jointly with partners, taking advantage of the strong international and local networks of CGIAR centers. Bioversity, CIP, ICRAF, IFPRI, ILRI, and World Fish have already invested in this type of research and will be actively involved in this component. Other centers may also contribute, as they develop new program activities at the intersection of agriculture, nutrition, and health. The set of example case studies presented in Appendix 3 shows the large number of existing partnerships between CGIAR centers and implementing partners.

The research program will also partner with academic institutions in training and capacity strengthening; examples of academic institutions that have indicated their interest and commitment; the University of Pretoria in South Africa, Colombia University (with the Millennium Villages project), Cornell University (especially around work on agriculture and nutrition in partnership with the Tata

Foundation), the Leverhulme Center for Integrative Research on Agriculture and Health (LCIRAH) and the emerging University Network on Agriculture, Nutrition and Health for Development it is coordinating, the University of California at Davis, and the Public Health Foundation of India. The program will also partner with FAO on the development of tools and methods, and for capacity strengthening on the ground. Partnerships with the private sector (such as Land O'Lakes) will provide technical support for the development of tools and approaches, and facilitate engagement with networks of farmers, cooperatives, and processors. In Africa, partnerships with the African Union and with NEPAD/CAADP processes will be established to work on joint programs and to strengthen nutrition and health in CAADP pillar 3.

Priority setting and selection of case studies

In the first phase of the project (Years 1-4), the CGIAR and implementing partners, such as local and international nongovernmental organizations, governments, and UN agencies, centers involved will agree on priority case studies. Five to six case studies will be chosen through a rigorous process, beginning with an open call for nominations, and selection will be based on a comprehensive set of criteria:

- demonstrated interest and commitment to designing and implementing multi-sectoral ANH programs
- innovation in program model and willingness to face new implementation challenges
- potential of program model to have an impact on poor and vulnerable households and individuals
- commitment to research partnership
- willingness to adapt implementation to the needs of research, as feasible (for example, by implementing different packages of interventions to build comparison groups; investing time and human resources in research partnership and in developing a joint research agenda; and showing interest in learning and in building staff capacity).

Finally, the case studies will be selected to represent a broad set of nutrition and health issues and programming models, as well as diversity in geographic focus and agroecological systems.

Summary of CGIAR engagement with integrated ANH programs

Appendix 3 presents examples of case studies that could be good potential candidates for the applied ANH research of this component, focusing on those that CGIAR centers have been involved in. Those case studies are summarized in Table 1. All the case studies are community-based and agriculture-focused and they address at least one other sector, such as health, nutrition, environment, animal health, markets, hygiene, or water and sanitation. All the programs have health and/or nutrition goals, and most have a strong gender component: targeting women as program beneficiaries, focusing on improving women's income and control over income, and/or addressing the obstacles women face in achieving good health and nutrition for themselves and their families.

All of these case study implementers have identified ways in which a partnership with CRP4 could help fill existing and foreseen gaps in research and programming or in documenting evidence. Applied, program-relevant research can help strengthen program design, implementation, and effectiveness in several areas: monitoring and evaluation; policy formulation and communication; program design, implementation, and scaling-up; and documentation and dissemination of lessons learned.

A critical criterion for engaging with a given program will be a commitment to work on the integration of *all three sectors*—agriculture, nutrition, and health—rather than only two of the sectors. Past programs have usually focused more narrowly, on either agriculture and nutrition *or* agriculture and health.

6.4.4 Subcomponent 4.2: Harmonized Policies

Rationale, Objectives, and Research Questions

Success in strengthening policy environments will depend on persuading leaders to demand a more integrated approach in each of the three sectors. As each sector identifies areas where important objectives can be achieved cost-effectively through cross-sectoral collaboration, these opportunities will need to be championed in appropriate policy-making fora with evidence-based arguments.

There are three specific objectives within this subcomponent.

Objective 1. *Provide a continuously updated and relevant **evidence base**, from an agricultural and cross-sectoral perspective, that adds value to ongoing initiatives by supporting better investments in integrated planning across agriculture, nutrition, and health.*

Transdisciplinary research will explore what areas of information, knowledge, and evidence are needed to support more effective decisionmaking. (See Appendix 4 for examples.) An enhanced information and knowledge base will not only support research planning and design and development decisionmaking, but will also be an invaluable resource within CRP4 for prioritization, monitoring, and evaluation as well as impact assessment.

Research questions

- Given existing evidence on the effectiveness of integrated ANH collaboration at the sub-sectoral level (from subcomponent 4.1), what additional evidence is required to persuade leaders in the three sectors to embrace integrated planning and programming?
- What are the specific challenges in cross-sectoral development for marginal and vulnerable peoples? How can emergency and aid programs be transformed into effective longer-term efforts for integrated and sustainable agriculture, nutrition and health improvements?
- What specific emerging ANH policy and decisionmaking issues, relating to dynamically changing agrifood systems, can be better addressed with strategic foresight and research?
- How can nutrition and health objectives be incorporated within a multi-criteria approach to agricultural investment planning?
- How can ideas, data and information, analysis, and recommendations be brought together to improve policy and decisionmaking? How can this be done in a way that enhances the demand for more evidence-based decisionmaking?
- How can existing data be made more relevant for decisionmaking? At the national level, ministries collect information at different scales and time frames, and they process it in ways that may not be useful to other ministries. What steps can be taken to make the data serve cross-sectoral needs and to make it available for real-time decisionmaking?
- What capacity is currently lacking in the agriculture, nutrition, and health sectors to enable work that is more trans-disciplinary and collaborative? How can this institutional and individual capacity best be strengthened?
- What models and studies can be recommended to partners looking for agricultural contributions to resolving nutrition and health problems?

Objective 2. *Assess and document **good practices** in engaging policymakers and decisionmakers for cross-sectoral decisionmaking.*

These good practices will take into account the hierarchy of decisionmaking, from the local to the global. This objective will address the need to bridge the three main sectors as well as other important

sectors—for example, those dealing with gender and capacity development, as well as planning, investment, and finance.

Research Questions

- What global trends in agriculture, nutrition, and health frame the problems that partners face at national and local levels? How can CRP4 bring these effectively to the table?
- What type of governance and institutional arrangements shape actual or potential links among the ANH sectors, and where are the opportunities and entry points for strengthening integration? How can this be supported by capacity building?
- How does one effectively bring an integrated message to ongoing policy and planning processes?
- What boundary-spanning organizations or individuals can bring agriculture, nutrition, and health together to engage policymakers and implementers? What are examples of good practices or cross-sectoral institutional arrangements?
- What are the particular information and analysis needs of policymakers, funding sources, stakeholders, and the general public—and how can these needs be met?
- Programs that cut across ministerial or agency boundaries present a number of special public finance issues. What public finance issues need to be resolved so that cross-sectoral collaboration is made attractive to decisionmakers in separate ministries? How are costs of integrated programs to be allocated among participants? What role do user fees, earmarked taxes, and targeting of beneficiaries play in the decisionmaking process?

These and similar questions will be particularly relevant for such larger policy and decisionmaking support efforts as the Comprehensive African Agricultural Development Program (CAADP) (see Appendix 5). This information will also be critical to planning and implementing the partnership, communications, and advocacy elements of this program.

Objective 3. *Assess and strengthen capacity for cross-sectoral policy research and decisionmaking*

This capacity development objective seeks, first, to work with partners to assess the capacity of relevant stakeholders to carry out policy research and advisory functions, and, second, to develop and implement resulting capacity-strengthening recommendations. Key outcomes include quantifiable targets relating to

- training by discipline
- level of training recognized in human resources development plans
- investment as share of budget and staff qualification ratios

Impact Pathways

The theory of impact underpinning this component assumes there is potential or actual demand for research to support policy and investment decisionmaking, in areas where agriculture, nutrition, and health intersect. This demand can be satisfied by different combinations of three types of research outputs: ideas; data and information; and evidence-based recommendations. At times of crisis, *ideas* reach people faster and travel farther than data and information. Ideas are thus important to catalyze new actions, to bring people together around an innovation, and to suggest a course of action when complete information is not available. Subsequently, *data and information* may serve to reinforce decisions taken, to provide a basis for adaptive or corrective action, or to engage partners with independent analytical capacity. Finally, transparent analysis of credible information will provide the basis for *recommendations* that can inform broader actions in an objective way. The needs of decisionmakers will therefore determine the form of information, the sequence in which it is used, and how it is used.

Subcomponent 4.2 seeks to achieve better cross-sectoral policy and decision-making; well-functioning knowledge and information systems; and improved capacity for cross-sectoral collaboration in the three sectors. It will achieve impact along three broad avenues:

1. through the generation of knowledge, evidence of impact, and improved communication to appropriate users
2. through the assembly of information, data, and tools to support decisionmaking
3. through an improved understanding of the institutional arrangements and processes that promote collaboration

Intermediate users of the outputs of CRP4 will be researchers, implementers of development programs in government and NGOs, and policymakers and decisionmakers in the cross-sectoral space between agriculture, nutrition, and health. The other three components of CRP4 will work closely with a range of partners on value chains, scientific research, integrated community-level programming, and control of agriculturally associated diseases. Component 4, in its synthesis and communication role, will help partners gain access to the knowledge generated and raise it to the policy level.

Activities, Outputs, and Outcomes

In the following discussion, we present the pathway from activities to outcome for three objectives, over two time periods: an initial start-up period (Years 1–3); and a medium-term period (Years 4–10).

Timing and sequencing of activities

In the first three years of the CRP, this component will have a relatively small role, though this role will be central to the evolving coherence and direction of the program. In the medium term (4–10 years), we assume there will be increased demand for evidence-based advice, as well as more sophisticated tools for providing it. This component will work across the other three CRP4 components in real time to document current best practices and to reinforce the effectiveness of their efforts through increasing sophistication of the tools. By the tenth year, this component, together with the three others, will have refined the tools and approaches needed for formal problem identification, for prioritizing among alternative investment choices, and for monitoring and evaluation. By Year 10, agriculture for improved nutrition and health investment will be based on benchmarked data; will better leveraged on disease problems and better targeted to the most affected; and will support more productive agricultural programs, as measured both by income and by combined income-nutrition-and-health metrics. Table 18 shows an indicative set of activities, outputs, outcomes, and impacts, highlighting the expected time period for different activities.

Table 18. Activities, outputs, and outcomes of the subcomponent on Harmonized Policy

Activities	Outputs	Outcomes
Objective 4.2.1. Develop/enhance information tools and systems, and provide continuously updated evidence base		
Create operational information system: networking among sectors, information sharing, joint development. (Years 1-3)	1. Community of practice (CoP) is established of agriculture-nutrition-health specialists in information systems. 2. Data sources are mapped. 3. Systems are reviewed by partners.	1. Inventory of data sources categorized by scale, metrics, quality, and potential for merging with other data. 2. Owners of data participate in CoP with view to sharing data.
Refine information for planning and monitoring; increase depth of analysis. (Years 4-10)	1. Progress in agriculture for improved nutrition and health system is monitored. 2. Indicators for health and nutrition are developed. 3. Trends in funding and quality of human resources are tracked.	1. Funding and staffing targets are benchmarked. 2. National progress is compared with similar neighbors at macro level.
Adapt or develop fit-for-purpose tools for planning, monitoring, and evaluating activities. (Years 1-3)	1. Limitations of existing metrics are reviewed. 2. New metrics are developed to relate agriculture, health, and nutrition.	1. New tools are piloted by planners and component leaders. 2. Staff of national partners are trained in use of tools.
Evaluate activities in integrated agriculture for improved nutrition and health. (Years 4-10)	1. Metrics are adapted to benchmarks. 2. Benchmarks are established for measuring component research.	Use of formal tools for planning and evaluation becomes the established norm.
Objective 4.2.2. Assess policy processes and governance environment, and document good practices in engaging policy and decisionmakers for cross-sectoral decisionmaking.		
Conceptualize the cross-sectoral “system” at the interface of agriculture, health, and nutrition (Years 1-3)	The goals, components, resources, and management of the “agriculture for improved nutrition and health” system are elaborated and promoted in policy fora.	1. Consensus is achieved on need for integrated planning. 2. Decisions are made to take action. 3. Boundary-spanning mechanisms are put in place.
Assess institutional and governance arrangements and systems; identify and engage policymaking structures in agriculture, health, and nutrition (cf. CAADP process). (Years 1-3)	1. CRP4 component services and outputs are recognized as useful to policymaking bodies. 2. Integrated approach is understood by technical and advisory leaders. 3. Immediate and low-cost steps to greater integration are identified. 4. Action is taken. 5. Directions for long-term improvement are charted.	1. Policy hierarchies view CRP4 as a valued source of knowledge and advice. 2. Support for pilot integrated action is obtained (on a limited domain). 3. Mechanisms and resources for cross-sectoral problem identification and program planning are approved by policymakers in all three sectors.
(Years 4-10)	1. Analysis of institutional impediments to cross-sector work leads to solutions being identified. 2. Boundary-spanning activities and actors are identified. 3. Policy options and investment alternatives are based on transparent and rigorous evidence.	1. Understanding of immediate and low-cost steps to greater integration lead to guidelines for long-term improvement. 2. Policy recommendations by national advisors become cognizant of true opportunity costs of actions.

Table 18. Activities, outputs, and outcomes of the subcomponent on Harmonized Policy (continued)

ACTIVITIES	OUTPUTS	OUTCOMES
Objective 4.2.3. Assess and strengthen capacity for cross-sectoral policy research and decisionmaking		
Jointly with partners, assess the capacity to carry out policy research and advisory functions. (<i>Years 1-3</i>)	1. Comparable cross-country data are generated to serve as benchmarks for monitoring. 2 Training needs at national level are identified.	Quantifiable targets for training by discipline and level of training are recognized in human resources development plan.
Implement capacity-strengthening recommendations. (<i>Years 4-10</i>)	Investment plans for capacity strengthening are implemented based on estimates in Years 1–3.	Quantifiable targets for investment are monitored as share of budget, staff qualification ratios, and retention of staff.

Gaps in existing knowledge

An important early step will be to identify the available information and knowledge on the broader “agriculture for health and nutrition system,” as well as the information gaps that can potentially be addressed by this program. Several networks, communities, and institutions engaged in activities to improve health and nutrition are in fact integrated with agriculture at the local level. Some have relevant information, and they welcome collaboration with the program because rigorous evaluation of their information will help improve their own programs while offering analysis across a wide scale of operation. The other four components of the program will work closely with a range of partners focusing on key parts of the national system, i.e., value chains, scientific research, integrated programs at the community level and control of agriculturally associated diseases. Component 5, in its synthesis and communication role, will help partners gain access to this knowledge and raise it to the policy level.

When it comes to national-level data on ANH expenditures, the emphasis will be on adding value to currently available information and helping national partners link information across sectors. However, cross-sectoral information on financing of interventions will be difficult to obtain. In addition, there are major differences among the ANH sectors in the way interventions are financed—through user fees, ministerial budgets, and cross-sector subsidization. They may differ as well in their primary objectives and basis for assessment, as in the distinction between animal and human health.

Although there are many international and regional reporting systems for disease and malnutrition, they have critical gaps in information about certain neglected areas. They also lack information about the prioritization of efforts, benefits, and risks of specific interventions in relation to livelihoods, agricultural productivity, and tradeoffs in health and nutritional outcomes.

A final gap in knowledge lies in understanding the decisionmaking process, including the inevitable use of incomplete data for making critical decisions in emergencies and under time constraints. A compelling idea may catalyze initial action, and subsequent data collection may then lead to better ways to manage the problem. In agricultural research, for example, the agricultural research intensity ratio (as a target for investment in research) began as a notional target drawn from the industrial sector. Several decades of measurement and analysis have resulted in detailed analytical content with clear insights for public finance. Similarly, targets for public expenditure, such as CAADP’s investment target of 10 percent of budgets, are galvanizing action and analysis. Refinement of targets and clearer understanding of the structure of public finances will follow, as a necessary part of improved planning.

Public health leaders and epidemiologists must often make judgment calls about when and how to intervene, weighing the costs of postponing a decision to await better information versus the costs of possibly making a wrong decision through early intervention. For example, in the control of Rift Valley fever—an important zoonose that occurs sporadically—decisionmakers would benefit from a phased decisionmaking approach: breaking down the decisionmaking process into smaller steps can help

decisionmakers have more confidence in expensive mass vaccination and quarantine decisions, by refining the uncertainties and expected costs and benefits in a sequential manner as more surveillance information becomes available.

Research Methods

This subcomponent seeks to cultivate and strengthen enabling policy and institutional environments for more effective integrated ANH programs and interventions. A range of established and state-of-the-art methods will be used to analyze current policy environments, institutional arrangements, and capacity, and to evaluate changes over the course of CRP4 as well as the impact of research on these changes. Novel research methodologies are also likely to be developed in the course of this CRP.

An assessment of the current state of policy and institutions will provide a baseline level of information to assess changes. Common indicators will be developed for tracking change over time, and various methods will be used to document change. Evaluation of impact will be based solidly on established theories of change, as recommended in the recent guidance for assessing the impact of research, advocacy, and communication on policy and practice (Shiffman 2007; Shiffman and Smith 2007; Clark 2002). Stakeholder, network, and influence mapping (including the NetMap⁹ method) will assess and monitor awareness of and commitment to integrated ANH policymaking. Country case studies will identify current good practices as well as barriers to best practice in different contexts. Tools and principles developed for capacity assessment will be used to audit institutional capacity in policymaking and integration (Gillespie 2001, Pelletier et al. 2011).

It is notoriously difficult to attribute specific policy impacts to specific research inputs. Where this is not possible (and to complement any impact studies), research will assess contribution and influence. Several methods will be used to generate learning about how evidence reaches, and influences, different stakeholders and to document research uptake; those methods include uptake logs, citation analysis in policy-relevant documents, RAPID Outcome Assessments (ROA), and episode studies, aiming to understand forces, events, and decisions relevant to policy change (Jones 2011). As well as documenting actual policy changes, research will keep track of the process of change, including documentation of formal and informal policy processes and actors.

Partnerships

Partnerships to deliver this initial program might include:

- Collaboration with FAO, WHO, and OIE to provide data and information on patterns of disease occurrence and risk associated with changes in agrifood systems, to inform surveillance and alert systems.
- Direct engagement with national governments and policymakers at all levels.
- Collaboration with universities and research institutes on metrics and evidence for cross-sectoral decision-making. Existing partnerships with the University of London LICRAH program and development of other research partnerships will be further developed.

⁹ Net-Map is a participatory interview method that combines social network analysis, stakeholder mapping, and power mapping. Net-Map helps people understand, visualize, discuss, and improve situations in which many different actors influence outcomes. By creating Influence Network Maps, individuals and groups can clarify their own view of a situation, foster discussion, and develop a strategic approach to their networking activities. It can also help outsiders understand and monitor complex multi-stakeholder situations. More specifically, Net-Map helps players to determine: what actors are involved in a given network; how they are linked; how influential they are; and what their goals are (see http://netmap.files.wordpress.com/2008/04/netmap_brochure.pdf for more information).

- Support for joint planning and program implementation of public and private human health services, veterinary services, and agricultural services to control zoonoses and improve food safety regulations and practices.

Many of the key skills to support policy and decisionmaking, to establish knowledge and information systems, and to evaluate and improve institutional capacities and arrangements are well established in the CGIAR (for example, the Consortium on Spatial Information, Priority Setting, and Institutional Learning and Change). In this component, the CGIAR Centers involved will also build on their individual experience in coordinating policy and decisionmaking processes. For example, component 4 will benefit greatly from the experience of ReSAKSS (Regional Strategic Analysis of Agricultural Support Systems), a program that provides timely analysis to policymakers in Africa, coordinated by IFPRI, with regional nodes hosted by ILRI, IWMI, and IITA. IFPRI's involvement with the University of Minnesota, in Harvest Choice, also provides a link to rigorous research evaluation and priority setting.

7. GENDER RESEARCH STRATEGY

Throughout much of the world, women are the guardians of household food security and nutrition (see Box 9). At the same time, cultural factors can put women and girls at particular risk of undernutrition, micronutrient malnutrition, and poor health. Good ANH programming must therefore account for gender issues at all stages of the project cycle, from participatory assessment and analysis through surveillance, implementation of interventions, monitoring, and evaluation.

Box 9. Why focus on women to improve children's health and nutrition?

There is substantial evidence that households do not act in a unitary manner when allocating food and nonfood resources (Alderman et al. 1996); males and females within households do not necessarily pool resources, and they often have different preferences on how to use resources. A number of studies demonstrate the different ways men and women use resources and, correspondingly, the benefits of investing in women

Increasing women's control over assets—such as land and other physical and financial assets—has been shown to improve child health and nutrition and to increase allocations toward education (Quisumbing 2003; World Bank 2001).

In Bangladesh, a higher share of women's assets is associated with better health outcomes for girls (Hallman 2000).

A study by Smith et al. 2004 using cross-country data found that increases in women's education (investment in human capital) have made the greatest contribution to reducing the rate of child malnutrition, responsible for 43 percent of the total reduction.

Research from IFPRI finds that equalizing women's status would lower child malnutrition in South Asia by 13 percent (13.4 million children) and in Sub-Saharan Africa by 3 percent (1.7 million children) (Smith et al. 2003).

These findings indicate that an investment in women is also an investment in the food security, nutrition, and overall health of their children.

The central gender-related questions in this program are two: How can decisionmakers reach and involve millions of women with integrated ANH interventions that provide health and nutrition benefits to them and their families? And how can women be protected from the potential risks associated with agriculture, given their greater health and nutrition vulnerability, especially during the reproductive period? Several gaps in knowledge exist with respect to these key research questions.

- To what extent are women and girls unable to meet their nutrition and health needs over the life cycle, and what are the most promising approaches and best practices to meet these varying needs? How can agriculture play a bigger role in protecting women's and girls' nutrition and health status?
- What is women's exposure to agriculture-related disease and occupational health hazards, at different stages of the production to consumption cycle? What interventions can be designed to reduce this?
- What are the best approaches to engage women in integrated ANH programs? How to ensure that they benefit through gaining greater access to resources, and protecting their own health and nutrition and that of their children?
- How can behavioral change communication be used to intervene in intrahousehold food allocation patterns that disfavor women and girls? What are the best delivery platforms for such interventions—agricultural programs, social protection programs, reaching girls in schools, or other approaches?

To address these questions, CRP4 will focus on the following broad areas.

1. **Gender analysis of needs and differential exposure to risks:** Men, women, girls, and boys have different nutritional needs and different risks of undernutrition and disease. Tools for risk analysis, surveillance, and household and community nutritional assessments need to be gendered to capture these differences. Based on the results, gendered interventions will be integrated in each of the components.
2. **Women’s participation in and benefits from ANH programs:** Women are key mediators of household nutrition, and their participation in integrated ANH programs will be crucial. While the health and nutrition sectors have often integrated gender concerns, the agriculture sector has not been as successful, despite evidence that agriculture interventions that address gender issues are better able to achieve nutritional objectives (Berti et al. 2004). This is a key element of Component 4.
3. **Increasing access to assets and empowering women:** In most countries, women play key roles in food and nutrition security both as agricultural laborers—sometimes sole breadwinners—and as household caregivers. To play these key roles effectively, however, women need access to and control over assets and other means of production. Evidence suggests that ANH programs could enhance their outcomes by investing in increasing women’s assets and decisionmaking power. All components of CRP4 will work with CRP2, CRP3, and CRP5 to identify and test approaches to reduce the asset gap between women and men and to empower women to protect the food, nutrition, and health security of their family members.
4. **Intrahousehold food allocation and consumption:** Intrahousehold consumption patterns of foods—especially those considered high-value “prestige food”—often favor men, in many developing countries. These prestige foods are also usually the nutrient-rich foods that young children and women need the most for growth and reproduction, and are the foods targeted by CRP4. Through behavior change communication, CRP4 will increase awareness of how production and productivity choices affect nutrition and equity issues. Through linkages with CRP3, research will be conducted on the variable dynamics of intrahousehold food allocation, as well as on interventions to increase the consumption of nutrient-rich foods especially by women, children, and other vulnerable groups (such as people living with HIV/AIDS).
5. **Technology development and delivery systems:** Involvement of both men and women in technology development is crucial to the uptake of such technologies. Women are very often constrained in access to services and inputs, such as improved seeds for nutritionally enhanced crops. Approaches such as participatory plant breeding and community seed systems and business enterprises can improve their level of access. Women also play a critical role in post-harvest handling and processing of food, an important focus of CRP4. They will therefore be incorporated as one of the key actors in the work on value chain for enhanced nutrition (Component 1).
6. **Capacity building and policy interventions:** Women need to be involved in dialogue on policies that affect agriculture, nutrition, and health. However, most organizations involving local women are weak and unable to influence policy. Capacity building and organizational development can go a long way in ensuring that these organizations play a role in influencing relevant policies.

As well as forming an over-arching theme in CRP4, gender will also be mainstreamed into work on each of the components of CRP research in the following ways.

Component 1: Value Chains for Enhanced Nutrition and Health

Value chains are inherently gendered, reflecting several broad factors: the different roles that men and women play across the spectrum of value chain activities; the preferences of men and women for different value chains; and different levels of engagement of men and women in specific value chain components and activities. This component has a strong focus on women, relating to the opportunities for income generation for women along the value chains as well as their critical roles in the production and marketing of nutritious foods. Some key areas of focus include:

- Understanding and influencing (where needed) intra-household decisionmaking processes on the production, marketing, and consumption of nutrient-rich foods in the context of the value chains.
- Identifying the roles, constraints, and opportunities of men, women, and other defined groups as potential agents of change to improve nutrition along the value chain, especially as related to improving women's access to better processing technologies, capacity building, or organizational capacity.
- Developing innovative tools, methods, and approaches (including social marketing tools) for increasing access to information and promoting behavior change in men and women; evaluating the effectiveness of these approaches on both genders.
- Developing a model for strengthening women's capacity for improved decisionmaking on production, marketing, and consumption of nutrient-rich commodities.

Component 2: Biofortification for Improved Nutrition and Health

The design and implementation of this component (and both subcomponents) were shaped to take account of unequal access to resources and the different responsibilities of women and men in earning income and raising families, as well as their different biological requirements for nutrients. Some specific examples from HarvestPlus (Subcomponent 2.1) illustrate gender considerations.

- Micronutrient requirements are higher for women than men, reflecting their different reproduction requirements. HarvestPlus selects its target combinations of crop, nutrient, and country to yield maximum potential savings of disability-adjusted life years (DALYs), based on estimates of the current micronutrient status of women (and preschool children) and the estimated nutrient adequacy of their diets.
- Target nutrient-density levels, set for breeders to incorporate into high-yielding, high-profit varieties, are by design based on the nutrient requirements for women of reproductive age; bioavailability and efficacy assessments are done in this same group (as well as in preschool children).
- Marketing and messaging related to HarvestPlus crops and their nutritional value is designed to convey information specifically to primary caregivers (almost always women, normally mothers). Extension programs and messaging related to HarvestPlus crops also take into account women's and men's contrasting perspectives and roles in farm production.
- Assessment of HarvestPlus programs examines the specific roles of women and men in several areas: adoption of biofortified crops, food purchases, food preparation, and intra-household distribution of food.

With respect to a biofortified food basket for Latin America (Subcomponent 2.2), gender is integrated in the following ways:

- Women are among the intended beneficiaries.

- At least one-third of targeted farmers will be women in projects to disseminate biofortified seeds to farmers, in partnership with government programs and NGOs.
- When working with the private sector to develop food products, at least one product per country will be preferentially consumed by women (per industry's market research); this will also necessitate involving women in product development.
- Nutrition impact studies will focus on women (and children).

Component 3: Prevention and Control of Agriculture-Associated Diseases

Exposure to agriculture-related hazards differs by gender. For example:

- Women doing laundry in canals may be more at risk from schistosomiasis, while young men are at more risk from neuro-lathyrism.
- Women are responsible for feeding households and thus play a crucial role in managing food-borne disease. Special attention will be given to empower women to use risk-reducing technologies.
- Women are frequently the caretakers for sick family members and animals, resulting in greater exposure to disease and higher burdens, but also giving them a key role in disease management and prevention.

Gender considerations will therefore be integrated in all the components of this research. Data on exposure and risk factors will be collected separately for various gender and age groups, with a view to

- a. identifying the differential exposure of men, women, boys, and girls to risks; and
- b. enhancing the involvement of both men and women in the surveillance and management of risks.
- c. developing interventions to reduce AAD targeted specifically to women or other vulnerable groups.

Component 4: Integrated Agriculture, Nutrition, and Health Programs and Policies

As the over-arching component of the project, Component 4 will pay particular attention to the program's gender-related impacts:

- by developing and using a set of gender-disaggregated indicators to assess the impact of ANH programs, and
- by documenting and disseminating the impact of ANH programs on women's social, health, and nutritional status.

Sub-component 4.2 (Policy) will ensure that gender-disaggregated data are used in an integrated way to highlight nutrition and health issues facing women and children. Within the relevant cross-sectoral processes, ministries responsible for gender will be engaged. Finally, part of the process monitoring of CRP4 will be mainstreaming gender within cross-sectoral planning and implementation.

8. INNOVATION

CRP 4 is an important new departure for the CGIAR. CGIAR Centers have had specific programs in various areas of agriculture-nutrition and agriculture-health, and a number of Centers have collaborated in an agriculture and health research platform together with external health and nutrition partners. CRP4 represents a much larger and more systematic approach by the CGIAR to engage with the human nutrition and health communities to meet a new and explicit system-level goal of expanding agriculture's contribution to improving nutrition and health.

Bringing together agriculture, nutrition, and health is not a new idea. In what ways will CRP4 be innovative?

8.1 New Understanding and Global Commitment

There is a growing appreciation globally that something different needs to be done to address the massive malnutrition and disease burdens in developing countries. It is also recognized that joint efforts of the ANH sectors will be critical to designing solutions and achieving impacts. At the IFPRI 2020 conference in February 2011, "Leveraging Agriculture for Improving Nutrition and Health," this sentiment was summarized by Prime Minister Manmohan Singh of India:

"Leveraging agriculture for improving nutrition and health . . . is particularly important in developing countries, where agriculture is also the mainstay of a very large number of people".

This strategic view is increasingly shared at operational levels as well. Implementers of development programs understand that food-based solutions offer important opportunities to improving nutrition, and that agricultural food safety and zoonotic disease control initiatives are an essential part of public health efforts to reducing infectious disease burdens. CRP4 will come into operation at a time when there is tremendous interest, understanding, and commitment to better linking agriculture, nutrition, and health.

8.2 New Ways of Working: New Types, and Stronger Partnerships

CRP4 will foster new partnerships to ensure that agriculture, nutrition, and health are integrated and delivered—at the community level, in large development programs, and in policymaking. A major area of this research program (Component 4) focuses on creating, and responding to, demand from program implementers and community organizations for better evidence, knowledge, and technologies and methods for learning and adapting. It will also respond to the demands from policymakers and investors for better evidence on priorities, knowledge gaps, and good practices.

Within its new strategic results framework, the CGIAR has committed to making agriculture research accountable for improving human health and nutrition—and CRP4 is its main mechanism for achieving this strategic goal. A key design element of CRP4, enabling translation of research into development outcomes and impacts, is its firm grounding in well-defined, practical delivery pathways: value chains, development programs, and policymaking.

The vision of the CGIAR, in developing CRP4, allows for the development of a larger coordinated research program that can serve as a platform for bringing together the critical mass of multi-disciplinary research expertise needed to tackle priority ANH challenges. The unique nature of the CGIAR, as a multilateral and independent research organization, makes it a natural convenor and an interesting partner for nutrition and health research as well as development organizations. The CGIAR already has very positive commitments from its ANH partners to work together, expressed in partners'

meetings as well as in the IFPRI 2020 conference. These commitments will be further specified and operationalized in the first year of CRP4, around key research topics linked to the large development initiatives that are highlighted in other sections of this proposal.

8.3 Innovative Research to Meet Emerging Challenges

Dramatic increases in population and urbanization are changing the relationships between agriculture and food, especially in the developing world. In this changing social landscape, there is little understanding of how improving knowledge and information might influence consumer behavior for better nutrition and health options, or how this opportunity might relate to changing agricultural production and supply. This area of international agricultural research is seriously under-invested.

The dynamic changes in agriculture in the developing world have included dramatic intensification of agricultural practices as well as ecosystem change, resulting in big changes in disease pathogen distribution and transmission dynamics, both in natural systems and along food chains.

CRP4 will have the ability to convene research on these and other emerging social and biological issues. It will work with partners to design mechanisms for enhancing nutrition along the agricultural value chain and to apply new molecular biology tools informed by population biology and social research, to improve our understanding of how agricultural intensification can be more sustainably managed.

New Tools and Approaches to Build the Evidence Base

Research is needed to provide standardized ways of measuring, providing and communicating evidence that can guide good practices for joint ANH actions. Policymakers, investors, and development implementers receive an array of information from different sectors—on return to investments, on cost-benefit and cost-effectiveness figures, and on health and nutrition outcomes measured using various indicators, such as DALYs, disease burden, or number of food-insecure or undernourished people. For these different prioritization and performance indicators to usefully guide policy and practice across sectors, shared tools, indicators and vocabulary will be critical. While some efforts have begun on useful cross-sectoral metrics and assessment methods, much faster progress can be made when sufficient funding becomes available to assemble a critical mass of expertise, as through CRP4.

9. INTERACTIONS WITH OTHER CRPS

CRP4 is the primary CGIAR program for delivering the system-level objective of improving nutrition and health. This CRP is intended to link with and influence other programs in the CGIAR research portfolio to enhance the contribution of agricultural research for improving nutrition and health. There are accordingly numerous potential interactions between CRP4 and other CRPs, as shown in Appendix 6. The major interactions are described below, for each of CRP4's three impact pathways.

9.1 Value Chain Impact Pathway

In most cases, CRP4's value chain research will be pursued within the value chain work in the other CRPs. CRP4 will interact with agricultural commodity research in the key area of strategic plant breeding for improved nutrition and health traits—for example, micronutrient-rich biofortified staple crops, and crops with reduced levels of harmful toxins—building on the successful work of the past several years in mainstreaming nutrition and health objectives into plant breeding programs. Under CRP4, this work will be expanded to look at nutritional quality and food safety throughout food value chains beyond production, through post-harvest, processing, storage and beyond. CRP4 will rely on CRP2 for value chain analysis, to identify opportunities along the value chain for improving nutritional quality and food safety. CRP4 will also work closely with the agricultural commodity CRPs in thematic area 3, to improve nutritional quality and food safety along value chains. Nutritional quality can be enhanced either through improving the nutritional quality of staple crops (CRP 3.1/2/3/4/6) or through making accessible foods of higher nutritional value, such as animal source foods (CRP3.7), legumes (CRP3.5) and fruits (CRP6). The latter will be the main focus of CRP4. Food safety research, too, will require joint actions, primarily around aflatoxins and for animal source foods.

Beyond the nutritional and food safety analyses provided by CRP4, there will also be a major contribution from its consumer-level studies on diet preference, risk and other behaviors. This increased consumer focus will be critical as food production by and for the poor evolves from primarily subsistence and local informal markets to more formalizing markets and supply to poor urban consumers.

9.2 Development Program Impact Pathway

The integrated ANH programs in Component 4 will draw on the research findings from other CRPs relating to agricultural intervention, technologies, and innovation. In particular, there will likely be important links between CRP4 and research undertaken in the CRPs under thematic area 1 (drylands, humid tropics, and aquatic and coastal systems). These interactions will involve nutrition and health inputs from CRP4, and inputs from thematic area 1 CRPs on understanding agricultural biodiversity, livelihoods, and agricultural program options in different agroecological and regional settings.

The elements of CRP4 linked to public health and nutrition programs will also have strong links to other CRPs. For example, CRP4's science-based evidence and technologies can inform food safety and veterinary public health programs, especially CRP 3.7 (relating to production technologies, food processing techniques, diagnostics, and vaccines). Other potential health links include: CRP5 – water-associated diseases; CRP6 – indigenous technical knowledge for health; and CRP7 – the effects of climate on food production opportunities and the nutrient content of crops, as well as changing patterns of disease risks associated with climate change in various systems.

9.3 Policy Impact Pathway

CRP4 will have strong links with all major components of CRP2—policies, institutions, and markets. CRP4 will use many common analytical frameworks and research methodologies as well as sharing monitoring and evaluation methods with CRP2. Shared research approaches will extend to cross-cutting

issues such as social protection policies, risk management, and gender policies. There will also be strong links to CRP3.7 around risk management and public health metrics and policies.

10. CROSSCUTTING ISSUES

10.1 Capacity Strengthening

Capacity strengthening is a crucial element for CRP4's longer-term and more sustainable impacts, essential for program scale-up and sustainability. The CGIAR and its research partners have long experience in supporting developing-country research organizations and researchers, through collaboration in programs and enhancing the capacity of development implementers and enablers.

Implementing CRP4 will require adequate capacity for translating research methods and outputs into adopted technologies and institutional and policy changes. Just as important, it will mean developing *cross-disciplinary capacity* at various levels, including government and development agencies as well as educational and research institutions. At present, the higher education systems in most CRP4 countries lack any training in multidisciplinary expertise: programs designed for the development professional have a single disciplinary focus with no opportunities for cross-disciplinary learning. As a result, government professionals — with a wealth of experience in their own fields — have very limited capacity to reach out to other disciplines, due in part to a lack of tools to address joint objectives. Similarly, researchers working on promising innovations lack the training or the incentive to work across disciplines or sectors.

Renewed interest in the integration of agriculture and food systems with health and nutrition outcomes presents an opportunity to develop a truly multidisciplinary capacity and outlook. Research teams working on CRP4 will undertake, as a preliminary step, comprehensive assessments of capacity gaps and needs in targeted countries and institutions, to develop an appropriate capacity development strategy.

Capacity strengthening will be carried out at four levels: individual, group, organizational, and policy.

Individual Level: Individuals involved in all program areas will be targeted for individual skill-building with a multi-disciplinary perspective. Capacity strengthening approaches will include: one-on-one collaboration, hands-on experience to learn new research and analytical methods, mentoring collaboration with researchers, graduate student supervision, postdoctoral and visiting-scientist placements, on-the-job training, and short courses. Approaches will be adapted as needed, based on the assessment exercise. This interdisciplinary experience will better prepare these individuals to take on scientific and leadership roles in advancing integrated ANH programs.

Group Level: CRP4 will encourage enhanced networking among its direct and indirect partners. Networks of scientists, policy analysts, educators, program designers, and evaluators will develop to share and exchange innovations and experiences. Networking will be facilitated by the use of modern information technology, including social media, and by active efforts to encourage engagement at all levels. For example, an educational network can bring together universities in the North and South to exchange course content incorporating research and methods generated by CRP4.

Organizational Level: Six types of organizations will be included in capacity strengthening efforts.

1. *Research organizations* need capacity support particularly in the areas of research planning and management, institutional development, resource mobilization, and scientific writing. A networking approach will enable more isolated institutions to pool resources, including personnel. Systematic mentoring will be complemented by well-targeted training of senior managers and scientists.
2. *Teaching and training organizations* provide the mechanism for recruitment and formation of new scientists, technicians, practitioners, and managers. These organizations include technical schools, universities, and training centers, as well as education networks in agriculture and natural resources management. CRP4 will engage with a range of training organizations—

technical schools, universities, and training centers, as well as education networks in agriculture and natural resources management—to facilitate incorporating new knowledge generated by CRP4 into training and education curricula, and to develop relevant learning resources. Student researchers will be involved in various components as part of thesis research, with supervision and mentorship by the researchers.

3. *Organizations designing policies and programs* provide the essential bridge to widespread adoption and scaling up. In these organizations, capacity will be needed for (1) developing national strategies and programs capable of implementation and funding, and (2) program monitoring and evaluation. These organizations will also provide a forum to bring together professionals from various disciplines, to contribute to policy and program solutions in an integrated and multi-disciplinary manner.
4. *Organizations implementing intervention programs* have a crucial role to play. Local government organizations, civil society organizations (CSOs), international and local nongovernmental organizations (NGOs), community-based organizations (CBOs), and a range of private organizations will all be key in designing and implementing intervention programs that emanate from CRP4. CRP4 will work with such bridging organizations to strengthen their capacity to design, manage, use, and evaluate research outputs, through extensive brainstorming sessions, special short courses, participatory workshops, and other special training events.
5. *CGIAR Centers* themselves will gain important capacity to integrate nutrition and health considerations into their research programs, incorporating health and nutrition goals and interventions where appropriate. Capacity development will be mainly through joint research, as well as advocacy based on evidence generated by this CRP. CRP4 will also support creation of a learning platform to strengthen capacity for research across the five components of CRP4 (and across other CGIAR CRP programs doing research on nutrition and health-related activities), by sharing knowledge and information, analytical assessment tools, methods, participatory research strategies, specialized expertise, best practices, and feedback. The platform will include tools including indicators for needs assessment, monitoring, and evaluation. Based on needs assessment, the learning platform will sponsor online training courses or e-learning materials on methods and multi-stakeholder processes.
6. *Other international and regional organizations*, such as UN agencies, will also benefit from capacity development through individual and institutional partnerships, engaging in joint research planning and analysis as well as publication of research findings and targeted dissemination of research outputs.

Policy Level: CRP4 will support capacity creation in policy research programs at the regional and sub-regional levels, with the lead CGIAR Centers providing methodological and analytical support to universities, policy institutes, and national and international policymakers and government officials. In Africa, for example, CRP4 will support processes such as NEPAD/CAADP, ASARECA’s Policy Analysis and Advocacy Program, and FANRPAN (Food Agriculture and National Resources Policy Analysis Network), drawing on IFPRI and ILRI leadership in ReSAKSS (Regional Strategic Analysis and Knowledge Support Systems). Similar policy analysis networks will be implemented in the South Asia region.

Appendix 7 presents an impact pathway for the capacity strengthening activities of CRP4, as implemented at different levels.

Special attention will be paid in all research and capacity strengthening activities to create opportunities for women and members of marginalized groups. Pilot sites will be selected that represent different agroecological and socioeconomic conditions. Local and international graduate students will be engaged in research questions designed to create models that can serve as international public goods.

Special briefings and trainings will be organized for policymakers, especially on issues related to promoting cross-sectoral support, financing, policies, and institutional developments.

At the national level, leadership and managerial skills will be required to manage cross-sectoral collaboration. National food security and nutrition taskforces will be engaged in a series of policy dialogues to identify capacity gaps and to encourage incorporating the results of research into national policies and strategies.

Appendix 8 presents a description of capacity strengthening activities for each component of CRP4.

10.2 Communications and Advocacy

10.2.1 Rationale

The CGIAR Research Program on Agriculture for Nutrition and Health places priority importance on establishing a strong communications function from the beginning of the program. Cross-sectoral collaboration requires nurturing; an effective communication strategy will help a) establish the focus of the program for both external and internal audiences; b) provide a unifying voice for the program; and c) reinforce mainstreamed messages relating to such factors as partnership behavior, gender inclusion, and integrated planning around shared goals.

Upon approval of the program, the management team will create a task force drawing on expertise from center and partner organizations, to develop a communications strategy for the start-up and development phase of the CRP.

10.2.2 Start-up phase: Elements of the Communications Strategy

During the first years of the program, the communications goal will be to unify participants, Consortium members, and donors around the goals of the program—improved health and nutrition through integrated planning with agricultural research and development. The messages may be targeted in different ways to different audiences to make them more accessible. The basic message will accomplish the following: 1) establish a common vocabulary for expressing the program’s objectives and expected impacts; 2) demonstrate how the integrated program builds on the strengths of the lead organizations and partners but stands on its own, as a focused program with responsibilities and the resources to fulfill them; and 3) establish a basis of core principles for managing cross-sectoral collaboration. This third function can include formal statements of partnership principles (see Section 10.1) and even reference materials on desirable behaviors.

The program will also create a web portal providing an accessible and searchable archive of the documentation, statements of principle, and decisions establishing the program. The evidence base underlying the creation of the CRP will reinforce the value of an integrated approach. It will also provide potential partners with the resources they need to explore new collaboration. In addition, cross-sectoral and multi-institutional collaboration involves negotiations, and occasionally conflict resolution. The ability to go back to first principles and to the record of initial discussions will facilitate the development of mutual trust. Finally, the principles and practices for managing a multi-stakeholder program—drawing on the experience of international organizations and NGOs—will be posted for continuous reference.

The program website will also be a port of entry for potential collaborators and a reference for potential donors exploring the match between their objectives and those of the program.

The strategy for the start-up period will identify the targets and the venues for presenting such messages. Component 5 (Section 9) underlines the importance of ideas, data, and information, as communication tools that can be used in different fora to reach different targets. Appendix 5 on implementation partnerships describes the impact pathway for policy that uses tailored messages for the following purposes: 1) presentations in regional and national policy fora (for example, CAADP and sub-regional organizations); 2) getting agriculture on the agenda of national strategic planning exercises in

health and nutrition (and vice-versa); 3) getting integrated health, nutrition, and agriculture into National Poverty Reduction Strategies and into National Agricultural Research Fora, where they exist.

10.2.3 Development Phase: Communication Strategy for Public Awareness and Reaching End Users

The Communications Strategy will move quickly from establishing the program to consolidating support for its activities, recruiting new collaborators, and ensuring use of its knowledge. Public goods are freely accessible to all, but serious efforts are required to get them into the right hands.

Targeting research outputs to particular users is a professional skill. This CRP will enhance the productivity of its scientists and partners by having specialized communications professionals work with scientists from project design onward to ensure the transfer of knowledge to users. Researchers will be helped to identify target groups for research outputs and to plan the particular format of outputs to meet their needs.

The Program Management Team will benefit from having a formal Communication and Advocacy Strategy that balances the need for scientific rigor and credibility with the need for a stream of public awareness materials that highlight the potential impact for advocacy purposes. The Communications Strategy will 1) formalize policies to ensure high standards of professional quality in CRP outputs, through peer review and editorial assistance; 2) assist researchers to maintain the value of their intellectual property while maximizing shared use and credit by partners; and 3) identify the policy and advocacy channels to be cultivated, in close association with researchers and partner organizations.

10.2.4 General lessons: communications in cross-sectoral collaboration

From the beginning, the communication focus will be on the integration of agriculture, health, and nutrition as the special characteristic of this program. Success will depend on the recognition by decisionmakers in each sector that there are real and tangible economic gains from integration of effort. Fiscal and budgetary arrangements can be specifically designed to make collaboration attractive to cross-sectoral partners. A synthesis of the economic evidence showing the benefits of integrated programming, highlighting experience from other cross-sectoral activities, will be an important element in maintaining the collaborative commitment, and a stream of new evidence will help to reinforce it.

11. MANAGEMENT ARRANGEMENT FOR IMPLEMENTATION

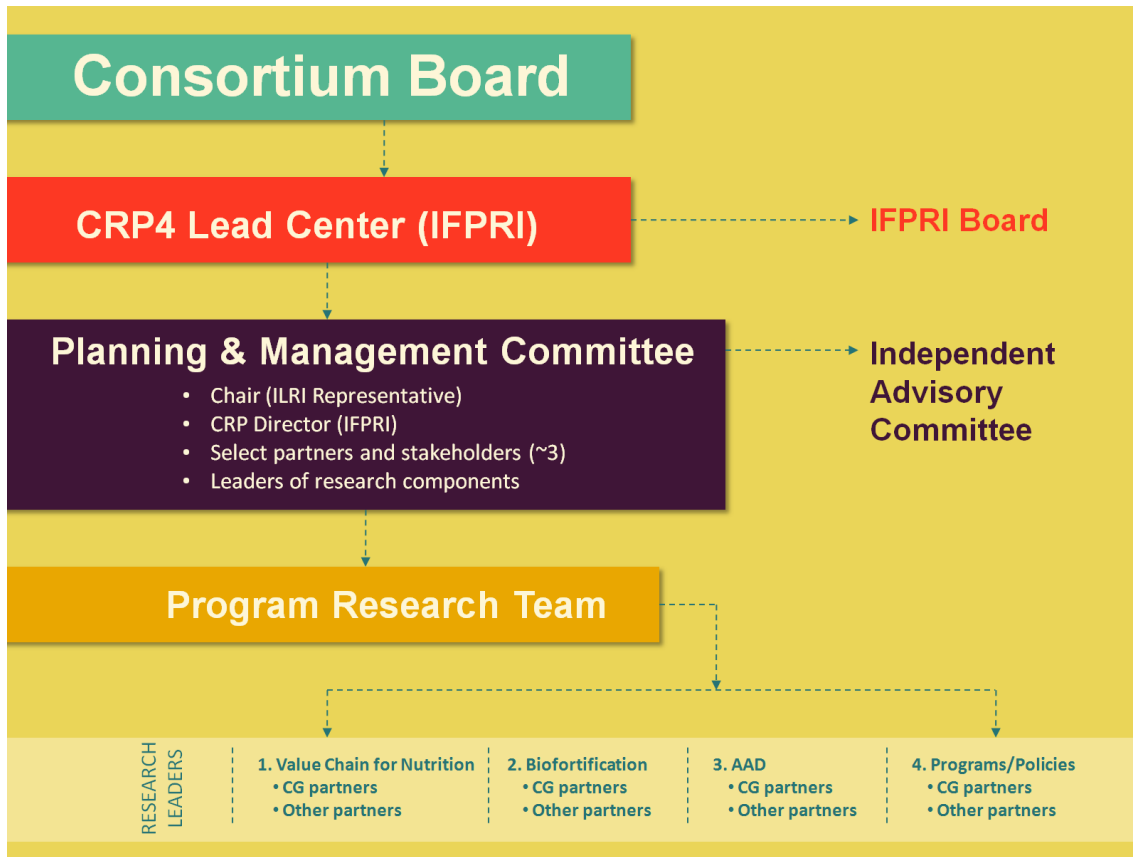
11.1 Governance and Management Arrangements

The governance and management arrangements for CRP4 follow the guidelines set out in the CGIAR Strategic Results Framework. The Lead Center is IFPRI, which will have overall fiduciary and operational responsibility for the implementation of CRP4. To enhance synergies across the ANH components of the program, the Consortium Board has requested that ILRI, which currently manages two-thirds of the health-related research in the CGIAR, play a strong support role. ILRI will provide the Chair of the Planning and Management Committee for the first two years of CRP4; will be specifically consulted on the recruitment and performance evaluation of the Program Director; and will lead the implementation of Component 3 on agriculture-associated diseases.

The Board of Trustees and Director General of IFPRI are accountable for the overall execution of CRP4 and for the effective engagement of the different partners. IFPRI will be responsible for the overall reporting relative to its Program Implementation Agreement with the Consortium Board, and accordingly shall require program participants to operate this CRP in accordance with the PIA and flow-down provisions which will be reflected in contracts between IFPRI and the partner entity. Responsibilities will then cascade to participating CGIAR Centers and partners. ILRI, in executing its responsibilities in the implementation of Component 3, will consult closely with IFPRI and the CRP4 Director.

The overall management structure of CRP4 is outlined in Figure 11.

Figure 11. CPR4 Management structure



The main elements of this management structure include:

Planning and Management Committee (PMC): The PMC will oversee the planning, management, implementation, and monitoring and evaluation of the CRP. It will review and approve the program workplans, milestones and budgets. The PMC will discuss and approve the strategic directions of the program and new funding initiatives, and will advise on the development, implementation, monitoring and evaluation of the program, including strategic linkages and partnerships.

The PMC will be convened by the Program Director, supported by the Program Management Unit (as secretariat, see description below), and chaired by one of the Center representatives. In the first two years of the program, an ILRI representative appointed by ILRI Director General will serve as Chair of the PMC, as requested by the Consortium Board. It is expected that a rotating system for chairmanship will be established by the PMC once it is formed. PMC members will include three representatives from key CGIAR Centers and implementing partners, and the four research component leaders. It is anticipated that the PMC will have face-to-face meetings twice per year and more frequent meetings and decisions will be made by consensus. As needed, the Director General of IFPRI, supported by the PMC Chair and Program Director, will consult with the Director Generals of participating CGIAR Centers to resolve any contentious matters.

Independent Advisory Committee: A six-person Independent Advisory Committee will be formed to support the development of collaborative, efficient, and effective science and management. It will consist

of three scientists to cover the range of science and disciplines in the program, two representatives of development partners (development implementers, policy/investment stakeholders), and one member of HarvestPlus Program Advisory Committee. This panel will be complemented by additional ad-hoc advisors for specific or emerging issues, as needed. The Independent Advisory Committee will provide advice to the Management Committee and the IFPRI Director General on research program performance, research priorities and focus, and management and partnership issues. Nominations will be actively canvassed from participating centers and partners by the Management Committee to ensure broad acceptance. The slate of candidates will be proposed to the IFPRI Director General for confirmation by the IFPRI Board. The Independent Advisory Committee will have one face-to-face meeting annually at the time of one of the PMC meetings and will be consulted for advice at other times by the Program Director. The PMC, through IFPRI and the Program Director, will be required to formally respond to the Independent Advisory Committee recommendations.

Given the importance of partnership engagement in this CRP, it is proposed to hold a partner and stakeholder meeting biennially, in association with the GCARD meeting. It will be an open forum, and sponsored participation by key partners may be budgeted into component activities. Program Management will be led by the Program Director supported by a Program Management Unit. The key management positions envisaged are as follows:

Program Director. CRP4 will be managed by the Program Director, who will be appointed by IFPRI in consultation with ILRI and will report to its Director General. The Program Director will be responsible for ensuring the implementation and delivery of all aspects of the CRP, according to the obligations of the Performance Implementing Agreement. Responsibilities include: leadership of the CRP including communicating and modelling a shared vision of the CRP among participating centers and partners; ensuring integration across agriculture, nutrition and health; coordinating work plans, budgets, reporting, monitoring, and evaluation; setting priorities for funding and for broader communications and resource mobilization; representing the CRP externally and supervising the program management unit.

Program Management Unit. This unit will consist of a small number of staff who will support the implementing Centers and partners in the implementation of the CRP. The program management unit positions include the following:

- *Research Coordinator* – This position will focus on supporting research strategy across the CRP and the development of high quality standardized methods and metrics for data and evidence. The research coordinator will provide intellectual leadership in research.
- *Program Manager* – This position will provide management and monitoring and evaluation support to program research teams in implementing the CRP. This will include support on cross-cutting issues such as gender and capacity building, development of proposals and agreements, and monitoring and evaluation (M&E) and reporting requirements.
- *Senior Administrative Assistant.* This position will offer administrative support to the Program Director and the Management Unit staff in planning, budgeting, and reporting.
- *Research Assistant.* This position will provide some basic research assistance to the Program Director and PMC.

Program Research Team: A small program research team will be formed, comprised of the Program Director and the four *Research Leaders* from each of the research components. This team will operate informally but will meet regularly (virtually) as well as face-to-face twice a year, in the context of the PMC meetings. Their role will be to coordinate research and to ensure intra- and inter-CRP coherence, focus, collaboration, and effective partnerships. The cost of these activities will be embedded in the research components.

11.2 Program Implementation

Once this proposal is approved by the Fund Council, an Operational Plan will be developed by the PMC, with assistance from the Program Management Unit. The components of the Operational Plan will be agreed with the Consortium Office and will include specific elements outlined elsewhere (such as the M&E plan). An essential component of the Operational Plan will be financial planning to support the priority research and development areas, and how funding can be raised through the Fund Council or other investors. Financial planning will be discussed with partners in order to stimulate joint proposal development and appropriate sharing of resources in key priority areas.

Implementation of components and sub-components will be the responsibility of research leaders. Research leaders will be selected from CGIAR centers or partners that have a significant resource stake. Funds from the Fund Council through the Consortium Board will be managed as subcontracts to the institutions involved.

12. TIMEFRAME AND MILESTONES

CRP4 will be fully operationalized with the signing of the Program Implementation Agreement between the Consortium and IFPRI as the Lead Center of CRP4 (as per the CGIAR Strategy and Results Framework).

The main initial task will be to develop a five-year operations plan with the active participation of CRP4 centers and partners. This will include further elaboration of the impact pathways, outcomes and impacts, partnership and human resource arrangements, and detailed plans of work and budget for different components and subcomponents.

The overall thrust of CRP4 is relatively new for the CGIAR. It combines some ongoing research with other well-established areas of research (such as biofortification of staple crops, nutritional assessment of programs, and zoonoses research), as well as some smaller-scale activities that can benefit from greater coordination and resources (such as food safety), along with some areas of innovation that still need to be developed (such as quality and safety of foods along value chains, evidence and metrics for priority setting, and assessment of cross-sectoral ANH interventions).

Some important milestones for the first five years are listed in Table 19. As a relatively new joint-research area for the CGIAR and its agricultural partners, and with new collaborations being established with partners in health and nutrition, the first three years will be devoted to establishing basic metrics and evidence as well as principles and practices for joint research linked to the value-chain, program, and policy implementation pathways. Also in the initial three years, existing research and funded projects will be aligned within a more comprehensive program that takes into account the research and development needs of the nutrition and health communities as well as those of the CGIAR agricultural research partners.

Important early efforts in communication and partnership are planned, in order to build on the notable enthusiasm generated in the proposal development stage and in related CGIAR center initiatives. This enthusiasm will need to be translated quickly into tangible research results to guide priorities, partnerships, and investments.

Table 19. Timeframe and milestones

Milestone	Year 1	Year 2	Year 3	Year 4	Year 5
Institutional arrangements for CRP operations among partners agreed and contracted	X				
Management Committee established and meets	X	X	X	X	X
Appointment of Staff	X				
Center and Partner meetings	X	X	X	X	X
Science Advisory Panel established and meets	X	X	X	X	X
Detailed work-planning for components and subcomponents	X	X			
M&E plan developed	X				
Communication and resource mobilization strategies and planning for components and subcomponents	X	X			
Establishment of value chain partnerships for nutrition and food safety	X	X	X	—————→	
Bio-fortification (on-going milestones plus exploration of new regions)	—————→				
Data and evidence for prioritization and assessment of nutrition and health interventions	X	X	X	X	X
Identification and establishment of program partnership case studies	X	—————→			
Cross-sectoral metrics development and testing	X	X	X	X	X
Priority setting and strategy refresh					X

13. OPPORTUNITIES AND RISKS

The opportunities presented by this program are enormous, flowing from a groundswell of demand for integrated ANH research—as seen by the tremendous level of participation and interest in IFPRI 2020 Conference in New Delhi. The networks and collaborations proposed (and that in some cases are already functioning) provide opportunities for enhancing dissemination and uptake of research outputs, presenting a real opportunity to influence both debate and practice in this area. The program also provides the opportunity to leverage additional funding and commitments from donors and stakeholders, expanding this area of research into a potentially world-changing force.

With such an ambitious program there come challenges and risks. The unavoidable challenges need to be tackled to achieve innovative impacts; the serious risks need to be mitigated or avoided, as potentially detrimental to the work—and not all of those risks can be anticipated. *Challenges* flow from the inherent difficulties in bringing different research disciplines together, exacerbated by the current tendency to work in isolated sectors. Differences in assessment tools, guidelines, and methodologies will certainly complicate implementation, coordination, evaluation, and interpretation of findings. Another critical challenge is the current lack of capacity and expertise in implementing cross-sectoral work on the ground, and this is addressed in CRP4 through a well-defined capacity-strengthening strategy.

Risks fall into two categories. They may be *internal* to the program and its partners, or they may be *external*, stemming from the immediate political, social, or institutional environment.

External risks are tolerable and normal challenges that CRP4 will face squarely; some may even provide unanticipated opportunities to move forward in a new way. The main priority in risk management will be to minimize the *internal risks*—especially those that are both high probability and potentially high-impact. The challenge of bringing together multiple partners from multiple sectors, with the attendant challenges in coordination and management, presents risks flowing from potential gaps in communication and credibility. This may particularly affect coordination with the health sector, where the CGIAR has few existing partnerships.

The assessment, monitoring, and management of these internal risks will be the responsibility of all partners. Open communication about potential risks (and responses) will be not only encouraged but also built into monitoring, evaluation, and management systems. The challenges related to managing the large number of partners involved in this CRP will be addressed directly by designating a CRP staff member to partnership management (see Section 5 on Partnerships). Within each component of the program, moreover, specific opportunities and risks have been assessed (as discussed below); these will be further elaborated in the form of a management plan.

13.1 Component 1: Value Chains for Enhanced Nutrition and Health

The diversity of partners assembled for this component represents a highly strategic opportunity for interdisciplinary synergy and cross-sectoral ANH cooperation, and coordination of joint research activities and partners will require careful attention. Close cooperation will be established with existing international agricultural frameworks (such as GFAR, NEPAD, and ECOWAS/WAHO), as a way to minimize such risks and to reinforce self-sustaining collaborative approaches.

13.2 Component 2: Biofortification

Biofortified crops are increasingly recognized as important new tools that will complement existing nutrition interventions. Bringing a public health lens to the marketing of an agricultural commodity presents unique opportunities for advocacy and for the diffusion of an agricultural innovation to serve public health. Quick wins are possible in this area, in the form of readily visible results, even while making a sustainable contribution to reducing malnutrition over large populations. Committed donors are now investing at unprecedented levels toward food security.

This very welcome infusion of global interest merely reinforces the continuing substantial and unwavering commitment of key donors to biofortification. Sustainable partnerships have been developed (largely by CGIAR) across sectors and continents, with substantial research results. With the current interest in linking agriculture to nutrition and public health, the time has arrived to build a strong platform for developing and delivering nutritious staple crops that are relied on daily by the most nutritionally vulnerable populations around the world.

The biofortification strategy is nevertheless not without risks and limitations. Anticipated risks include the following:

- Limitations on nutrient bioavailability, along with the presence of naturally existing inhibitors, may reduce the absorption of minerals (in particular) and thus their impact on human health.
- Absent or weak commercial seed industries in target countries may fail to produce and market biofortified seed and food products in sufficient amounts to ensure access by the poor and undernourished.
- Behavior change communications approaches may fail to educate the population regarding the nutritional benefits of biofortified crops (especially if they are more expensive and/or have distinguishable traits), reducing willingness to pay and incentive to consume.
- Lack of political will, whether internal or external to the CGIAR, may mean failure to prioritize nutrient content as a breeding objective.
- Climatic extremes or other natural phenomena may interrupt or delay some activities or affect the results (for example, the nutrient density of crops).

13.3 Component 3: Prevention and control of Agriculture-Associated Diseases

New and transformational thinking is emerging in the field of health for development, as major players increasingly recognize the need for multi-disciplinary, multi-sectoral, integrated, and participatory approaches are needed. This component adopts a One Health/Ecohealth/multi-disciplinary approach to address the complex questions around food-borne, zoonotic, and other agricultural health problems. By bringing to bear a socioeconomic and ecological understanding of the existing constraints to adopting technological solutions, the component will identify opportunities for interventions that can realistically be evaluated, implemented, and adapted contextually by partners. Nevertheless, while One Health multidisciplinary approaches are conceptually attractive, they have proven difficult to operationalize, and there is a risk that sectoral inertia may be difficult to overcome. CRP4 will develop tools to create and maintain incentives for multi-sectoral approaches.

13.4 Component 4: Integrated Agriculture, Nutrition, and Health Programs and Policies

CGIAR centers have well-established capacity and experience to work collectively with implementing partners, providing a unique opportunity for research on implementation and delivery. Quick results are possible by working with established programs with expertise in integrating AHN (summarized in Appendix 3). Several of these programs offer solid implementation on the ground, as well as strong capacity and engagement of numerous partners; the CGIAR can play an important role in strengthening the design and evaluation of such programs and in generating and documenting learning for replication, adaptation, and scaling-up. These opportunities also feed into the policy level, generating significant learning about approaches to improving health and nutrition outcomes through coordination with agriculture.

Linking research to implementation will require extensive investment in communication, dialogue, information sharing, internal education, and advocacy. Developing generalizable findings across agroecological zones will be complicated by the wide diversity of the target populations, with large

variations in food production, diets, cultures, degree of marginalization, and type and magnitude of vulnerabilities. The main risk in this area is the possibility of insufficient funding: a failure to integrate CPR4's findings and lessons for cross-sectoral collaboration would perpetuate the existing divisions between program areas—leaving promising results partially developed and limited to their own sub-sectors.

14. MONITORING AND EVALUATION SYSTEM PROPOSED

With support from the Program Management Unit, the CRP4 Director and the Management Team will have the primary responsibility for designing the overall M&E framework of the CRP. They will also coordinate and support the monitoring of progress by the research teams under each component and subcomponent. The M&E framework will be used by all CRP4 research teams and cover the needs of all CRP4 partners to report on program activities and outputs, track progress, and take corrective action as needed, and to assess program influence on outcomes and impact. Monitoring and evaluation indicators for tracking and assessing achievements will be constructed according to the SMART framework—*specific, measurable, achievable, relevant, and time-bound*—allowing for clear, results-based management of the CRP.

All M&E will be kept as simple and pragmatic as possible. Two main objectives will underpin the M&E strategy. The first objective is to have a *systematic process* to monitor performance in achieving milestones and outputs, both for the program overall and for each participating institution and program component/subcomponent. The second objective will be to provide *indicators and lessons* that can be used to support institutional and programmatic learning about what makes research effective in achieving program outcomes and impacts. Approaches will be tailored to the three key CRP4 impact pathways (value chains, programs, and policies). For all three pathways, the M&E framework will be developed and implemented in close collaboration with the partnership director and the research teams. Subcomponent 4.2 on Harmonized Policies will undertake specific research to develop tools, methods, and indicators to assess, track, and document changes in policy and institutional capacity for cross-sectoral ANH outcomes and impacts. These research outputs will be incorporated and used for monitoring and evaluating CRP4.

In Year 1, a workshop of key partners and stakeholders will be convened to develop a detailed M&E plan. This plan will be grounded in the overall impact pathway strategy and linked to the partnership strategy, which will also be developed during the inception phase of the project. The overall M&E plan will focus on monitoring and tracking key activities, outputs, and outcomes, as well as partnership quality and performance in achieving outcomes and impacts. It will also focus on analyzing how new knowledge and evidence, planned in early stages of the program, will inform subsequent priority setting, program design, and institutional arrangements.

14.1 Performance Monitoring

A monitoring and evaluation plan will be developed under each component and subcomponent. The plans will provide a framework to track both the process of implementation and the attainment of interim targets. They will include milestones for activities, outputs (such as publications, datasets, training materials, and training activities), communication, dissemination, and networking (to ensure appropriate uptake of project outcomes). Plans will also specify corrective actions to be taken if milestones are missed. As well as tracking in real time CRP4 functioning to allow for flexible and adaptive management, these milestones will provide the basis for retrospective evaluations of the use of project outputs and their influence in subsequent years. Using the process-monitoring milestones, regular process evaluations of program content and scope will be established for CRP4, including tracking quality of implementation and partnership performance; these evaluations will show to what extent the program has been implemented as planned and will identify strategic lessons for future management. Given the importance of partnerships for the success of CRP4, social network analysis tools will be used to describe and evaluate the science and development networks that emerge from the work of CRP4. The new CRP4 website, due to come online in time for the start of CRP operations, will provide a repository for all CRP4 outputs and allow researchers and CRP4 partners to track output milestones.

14.2 Ensuring Uptake: Translating Outputs into Outcomes

High-quality research outputs are not enough by themselves to achieve impact. They must be taken up and used. The pathways to impact, however, are often long and complex; it is much easier to assess the contribution of researchers to *outcomes*—how the intended clients of research have improved their performance using research outputs. The outcome strategy of CRP4 will be guided by three key objectives that define the relevance of research findings to decisionmaking: *salience*—findings are relevant to the problems at hand; *credibility*—findings are authoritative and believable; and *legitimacy*—findings are perceived as fair (Cash et al. 2002). Cash et al. also highlight the importance of boundary-spanning organizations that can link the providers and users of the information. While outcomes will be beyond the control of the researchers, good program design can increase the likelihood that outputs are translated into outcomes:

- Increase salience by working with prospective research clients (such as governments and NGOs) to identify the most relevant questions and problems to address.
- Increase legitimacy by working with appropriate partners.
- Increase awareness and credibility of the findings, and the likelihood the results will be applied, by publicizing the project activities and research results in a variety of fora and trusted media.

Researchers should also ensure that findings are published in a form and an outlet that is accessible to the intended users. For example, if other researchers are the intended users, publications in a prestigious scientific journal may be effective, but if government policymakers are the intended users, policy briefs translated into appropriate languages are more important. CRP4 research projects will therefore pay particular attention to publishing research results in outlets that will reach their intended audience, either directly or through boundary-spanning organizations. While publication in high-impact peer-reviewed journals will be prioritized, weight will also be given to other forms of publication and outreach offering impact.

Each component of CRP4 will participate in monitoring uptake in its own area.

- Within each component, and in consultation with the CRP4 scientific advisory committee, key performance indicators will be identified for gauging the quality and quantity of outputs and outcomes.
- Components will be required to report not only on what was produced, but on measures of uptake by different stakeholders; process approaches and indicators, such as outcome mapping (Smutylo 2005) and participatory impact pathway assessment (Douthwaite et al. 2008), can document whether these strategies are increasing the likelihood of project outcomes.
- CRP4 will also use stakeholder feedback and surveys of knowledge, attitudes, and practices (KAP) to provide indicators of outcomes and influence. Novel techniques such as NetMap will be used to map the influence and uptake of outputs as well as stakeholder satisfaction with deliverables.
- Uptake logs and citation analysis in policy-relevant documents will document the influence of research findings; episode studies will assist in understanding the forces, events, and decisions relevant to policy changes (see subcomponent 4.2: Harmonized Policies).
- Qualitative analysis can be backed up by quantitative analysis of product usage statistics, such as downloads and citations of publications, downloads and uses of databases and films (including uses in student theses or training courses), and follow-up evaluations of training courses or materials.

- For a specific set of priority outcomes, a formal assessment will be conducted using a standardized tool, such as the outcome reporting tool developed for the previous CGIAR performance indicators.

14.3 Impact Assessment

The aims of impact assessment are (1) to *enhance the success* of CRP4 in achieving its stated goals, and (2) to *generate learning*, by measuring the potential and actual effects of the project on the intended beneficiaries, using tangible intermediate and final impact indicators. Both ex-ante and ex-post impact assessment methods will be used, as shown in Table 20. Moving from outcomes to impacts requires triangulation among quantitative and qualitative methods to identify how research has influenced performance along the three principle impact pathways—value chains, programs and policies—and how those changes have, in turn, affected the nutrition and health of target populations.

The detailed M&E plan developed in Year 1 will include a plan for impact assessments to be conducted over a five-year period. In the initial three years of the program, important efforts will be focused on collecting information and evidence to guide priority setting. Some ex-ante impact assessments will be conducted in Year 3 based on this information, as part of a priority setting refresh. Two to three ex-post impact evaluations will be undertaken each year beginning in Year 2. Initial ex-post evaluations will be built on ongoing work by the CRP4 participating centers and will focus on understanding the size, nature, and determinants of impacts. In Year 5 and beyond, ex-post impact assessments of the program are envisioned, later to include policy and value chain work initiated within the CRP.

The ex-post assessment of impacts in CRP4 will be designed according to the impact pathway. For value chain impact pathways, value chain analysis frameworks will be used, including a mix of quantitative measures (such as income, quantity and nutrient content of products, level of nutrition and food safety awareness and knowledge among key value chain stakeholders, accessibility of nutrient-rich and safe foods for the poor) and qualitative measures (participatory impact indicators, as well as value chain stakeholder coordination). For program impact pathways, ex-post studies will be planned with implementing partners in conjunction with the program case studies selected in Subcomponent 4.1 (programs). Assessment relating to policy impact pathways will rely on the methods and tools designed and used under Subcomponent 4.2 (Harmonized Policies). Policy changes will be documented as well as policy *processes* and changes affecting key stakeholders. Three types of methods will be used.

1. *Impact narratives* can document cases where research has led to policy changes and impact on the ground. These will be reported by project teams and independently verified through interviews with key stakeholders to document the mechanisms through which research contributed to changes.
2. *Ex post impact assessments* can document the impact of a particular change in policy, institutions, or markets on the ultimate objectives of improved nutrition and health. These studies play an important role in documenting the value of policy-oriented research, as well as in examining *how the implementation of* a policy affects the ultimate impact.
3. *External reviews of the body* of completed research work will assess its effect, as well as provide lessons for other research on how to achieve impact. Within an agreed timeframe, regular external reviews of the entire CRP4 will be commissioned by the Independent Evaluation Arrangement *of the CGIAR on behalf of* the Fund Council. These independent *evaluations will* provide an external perspective on research relevance and performance, and will serve as an important input into the periodic revision of the CRP.

Table 20. M&E Plan: Elements, timing, and scope

	2012	2013	2014	2015
Priority assessment Including some use of ex-ante impact assessment (IA) from data and evidence in first 3 years	CRP			CRP
Performance monitoring – milestones (management and program) at CRP level; outputs from components/subcomponents and partner activities (self reporting)	CRP/C/SC	CRP/C/SC	CRP/C/SC	CRP/C/SC
Annual Program Review (Science Advisory Panel) Review would cover science focus and quality across all components and subcomponents as well as management issues	CRP	CRP	CRP	CRP
Outcome assessment – evaluated using a standard outcome tool (for example, outcome reporting in previous CGIAR performance indicator systems)	C/SC	C/SC	C/SC	C/SC
Partnership assessment – combining indicators for partnership arrangements (based on outcome mapping (Smutylo 2005) and participatory impact pathway analysis (Douthwaite et al. 2008) as well as partnership surveys.		CRP/C/SC		CRP/C/SC
Ex-post Impact assessment – a 5-year plan for impact assessments will be developed in year 1, with 2-3 ex-post impact assessments conducted annually from year 2.		C/SC	C/SC	C/SC
External reviews (program and management)				CRP
CRP – overall CGIAR Research Program level				
C/SC – focus is at the component level, including within subcomponents where relevant				

15. BUDGET

As described above, the impact potential for improving human nutrition and health through agricultural interventions is enormous. CRP4 proposes a major scale-up of the CGIAR efforts to this end. As a relatively new area of CGIAR emphasis, it should be expected to grow relatively quickly once the key partnerships and research programs are developed.

The indicative scale of CRP4 is reflected in the budget below, which projects \$59M in activity for 2011, and rising to \$69M in 2013. This captures cost associated with the collaboration among ten CG Centers, and the HarvestPlus Challenge Program, and a host of global partners. Personnel and partnership cost represent 24 percent and 44 percent, respectively, of the total 2011 budget.

The overall program represents 6-7 percent of the current CGIAR expenditures. Of this, approximately 70 percent is for nutrition and 30 percent is for health.

One of the pillars of the CGIAR reform process is to provide greater assurance of longer term and sustainable funding. Donors contributing to the new Trust Fund are encouraged to contribute to Windows 1 and 2 to maximize coordination and harmonization. While donors are strongly encouraged to channel their resources through the fund, bilateral funding continues. In cases where such funding is provided, it should be consistent with the agreed Strategy and Results Framework. The accompanying financial projections assume that current bilateral funding will gradually be replaced by grants through the Fund. Thus in 2011, \$17M is assumed to be from the Fund or 29 percent of total funding. In 2013 the ratio of CGIAR Fund income is projected at \$44M, or 63 percent of total funding. Component 2, Biofortification, includes the HarvestPlus Challenge Program.

Budget figures are stated at conservative levels and do not include upside or overly optimistic estimates. First year budgets are based largely on financial data from each center's Medium Term Plan (MTP) on a full cost recovery basis and are comparable to 110 percent of actual expenditures for 2009. This is in fact a modest base given the increased interest in health and nutrition in the past two years from stakeholders and donors as the scale of the issues is recognized. Years following the base year show a modest cost increase of 8 percent in 2012 and 9 percent in 2013. Given the demand from stakeholders and Donors for these research topics, the budget illustrates a clear and achievable transition to a CRP financing structure that supports a rapid deployment of CRP4 during 2011.

The accompanying tables provide a breakdown of costs on an overall program (Table 1) basis and also by the five main components (Tables 2 – 4):

1. Nutrition – Sensitive Value Chains
2. Biofortification
3. Control of Agriculture-Associated Diseases
4. Programs and Policy
5. CRP Management

15.1 Budgets for 2011

For all CRPs, 2011 is a year of transition and at the time of submission we are in the second quarter. Therefore, figures for 2011 include allocations made by participating Centers in their respective Board approved Budgets for CRP4.

The proportions of funding by individual Centers from CGIAR Consortium Funds and bilateral sources varies significantly as shown in Table 5. In the case of the HarvestPlus Challenge Program almost all of the funding is from bilateral sources and there is an allocation of \$5.6M from the Consortium Windows, which includes previous funding from the World Bank to the Challenge Program.

Only four Centers have Budgets in excess of \$3M in 2011 for CRP4 (Bioversity \$3.5M; CIAT \$4.0M; IFPRI \$12.7M; and ILRI \$9.7M).

15.1.1 Budget Analysis

As reflected in the table below, CRP4 partnership cost as a percentage of total operating costs is 47 percent compared to 16 percent for the CGIAR as a whole. The Biofortification component comprises 51 percent of the total CRP4 budget over the three year period and 78 percent of total partnership cost. HarvestPlus represents 69 percent of the Biofortification component budget and its culture of extensive collaboration is woven into CRP4’s research activities as evidenced by the sizable budget for partnerships. CRP4’s research agenda is highly participatory—engaging a wide mix of partners, harnessing the expertise of CG centers, universities, local and international NGO’s, and private companies. The cost ratio of partner activity is significantly higher than personnel costs. This is indicative of the commitment to an integrated, inclusive research solution which is aligned with the SRF objective of strategic partnerships.

Other than office space (captured under operating expenses) to accommodate research staff, policy research requires a relatively modest level of investment in property and equipment. Research outputs are facilitated by information and knowledge management systems, thus computers and information technology and services are the primary components of capital investments supporting policy research. Table 1 illustrates the low capital investments for IFPRI and CRP4 compared to the CGIAR which includes centers that conduct research requiring significant investment in infrastructure, laboratories, and vehicles.

Table B1: Budget categories for comparison

Description	CRP4	Biofortification	CGIAR
Personnel costs	29%	16%	42%
Partnership/Collaborators	47%	70%	16%
Operating expenses (including training & workshops)	19%	11%	30%
Travel	4%	3%	7%
Capital and other equipment for project	1%	0%	4%
Total	100%	100%	100%

15.1.2 Indirect Costs Institutional Overhead

The overall Institutional Overhead Budget of \$22.9M over the three year Budget is 13.6 percent of total Direct Costs. This is an aggregation of the costs for each of the participating Centers calculated in accordance with approved CGIAR Financial Guidelines. The rate includes 4 percent for pass-through funds, the rate which has been used by CGIAR system-wide initiatives and Challenge Programs.

15.2 Sources of Funding

For year one, assumed to be 2011, a total of \$58.8M funding is budgeted of which \$42M is from bilateral sources. \$25M is from bilateral sources for the Biofortification component, mainly from CIDA and the Gates Foundation. In years 2 and 3, assumed to be 2012 and 2013, there is an assumption that donors supporting the Biofortification work will begin to shift their funding to the Consortium Windows 2 and 3.

The “rate of shift” is not possible to predict with any degree of accuracy. IFPRI, as designated Lead Center for the CRP, has assembled the costs necessary to do the work, but cannot be expected to predict with great accuracy the delineation of funding sources between Consortium Windows and bilateral funding sources.

Tables 3-5 show the total costs by component by years 2011 to 2013, which in aggregate are:

	<u>\$M</u>	<u>%</u>
1 Nutrition Sensitive Value Chains	20	10%
2 Biofortification	97	51%
3 Control of Agriculture-Associated Diseases	40	21%
4 Programs and Policy	30	16%
Total Direct Research	187	98%
CRP Management	4	2%
	<u>191</u>	<u>100%</u>

15.3 The Budget Cycle

Once the overall CRP has been approved, the Budget proposals for 2012 have to be further refined to ensure the full cost recovery principles embodied in CGIAR Financial Guideline Number 5 are effectively made operational. As Lead Center, IFPRI has operated project-based full cost assumption costing principles for many years. The partner Centers are committed to following these principles and identifying the appropriate cost drivers.

Detailed Budgets for 2012 will be prepared and evaluated by the Planning and Management Committee in September/October 2011 to ensure that the CRP and the individual participating Centers achieve Budget harmony for 2012.

Table B2: Breakdown of costs on an overall program basis

Project Cost 000's

Cost group	Description	2011	2012	2013	Project Cost
		Amount (US\$)	Amount (US\$)	Amount (US\$)	Amount (US\$)
1	Personnel Cost	14,218	16,557	18,063	48,838
2	Travel	1,944	2,146	2,365	6,455
3	Operating expenses	8,748	9,620	10,571	28,939
4	Training / Workshop	1,074	1,230	1,299	3,603
5	Partners / Collaborator / Consultancy Contracts	25,527	25,703	28,047	79,277
6	Capital and other equipment for project	347	336	356	1,039
7	Contingency	112	123	136	372
	Total	51,971	55,715	60,836	168,521
8	Institutional Overhead (as a % of Direct project cost)	6,829	7,694	8,355	22,879
	Total Project Cost	58,800	63,409	69,191	191,400

Project Funding

Description	2011	2012	2013	Project Cost
	Amount (US\$)	Amount (US\$)	Amount (US\$)	Funding (US\$)
Funding				
CGIAR Fund	17,176	32,849	43,606	93,631
Current Restricted Donor Projects	41,201	30,225	25,328	96,754
Other Income	423	336	257	1,015
Total Funding	58,800	63,409	69,191	191,400

15.4 Costs by Component and Year

The following Tables (3-5) provide a breakdown of costs by component for each year.

Table B3: Breakdown of costs for five main components for 2011

Project Cost 000's		2011					Total
Cost group	Description	Component 1	Component 2	Component 3	Component 4	CRP Management	
		Nutrition-sensitive value chains	Biofortification	Control of agriculture-associated diseases	Programs and Policy		
1	Personnel Cost	1,833	4,183	4,004	3,450	748	14,218
2	Travel	317	646	473	417	91	1,944
3	Operating expenses	965	2,365	3,420	1,853	144	8,748
4	Training / Workshop	210	411	124	254	75	1,074
5	Partners / Collaborator / Consultancy Contracts	1,094	20,520	1,881	1,933	100	25,527
6	Capital and other equipment for project	110	114	60	62	-	347
7	Contingency	30	33	34	15	-	112
	Total	4,559	28,271	9,997	7,985	1,158	51,971
8	Institutional Overhead (as a % of Direct project cost)	858	2,447	1,937	1,415	171	6,829
	Total Project Cost	5,417	30,718	11,935	9,400	1,330	58,800

Project Funding

Funding							
	CGIAR Fund	2,427	5,651	4,181	3,587	1,330	17,176
	Current Restricted Donor Projects	2,860	24,951	7,656	5,735	-	41,201
	Other Income	131	117	98	77	-	423
	Total Funding	5,417	30,718	11,935	9,400	1,330	58,800

Table B4: Breakdown of costs for five main components for 2012

Project Cost 000's		2012					
Cost group	Description	Component 1	Component 2	Component 3	Component 4	CRP Management	Total
		Nutrition-sensitive value chains	Biofortification	Control of agriculture-associated diseases	Programs and Policy		
1	Personnel Cost	2,433	4,753	4,869	3,723	778	16,557
2	Travel	375	741	506	433	91	2,146
3	Operating expenses	1,230	2,795	3,535	1,916	144	9,620
4	Training / Workshop	285	441	165	264	75	1,230
5	Partners / Collaborator / Consultancy Contracts	1,460	19,820	2,296	2,027	100	25,703
6	Capital and other equipment for project	110	107	60	59	-	336
7	Contingency	34	36	37	17	-	123
	Total	5,927	28,693	11,468	8,439	1,188	55,715
8	Institutional Overhead (as a % of Direct project cost)	1,095	2,723	2,197	1,504	176	7,694
	Total Project Cost	7,021	31,415	13,665	9,943	1,364	63,409

Project Funding

Funding							
	CGIAR Fund	3,021	17,220	5,619	5,624	1,364	32,849
	Current Restricted Donor Projects	3,904	14,086	7,975	4,259	-	30,225
	Other Income	96	108	72	60	-	336
	Total Funding	7,021	31,415	13,665	9,943	1,364	63,409

Table B5: Breakdown of costs for five main components for 2013

Project Cost 000's		2013					
Cost group	Description	Component 1	Component 2	Component 3	Component 4	CRP Management	Total
		Nutrition-sensitive value chains	Biofortification	Control of agriculture-associated diseases	Programs and Policy		
1	Personnel Cost	2,695	5,478	5,137	3,943	809	18,063
2	Travel	424	858	538	455	91	2,365
3	Operating expenses	1,337	3,326	3,723	2,015	169	10,571
4	Training / Workshop	297	476	177	272	75	1,299
5	Partners / Collaborator / Consultancy Contracts	1,590	21,831	2,406	2,119	100	28,047
6	Capital and other equipment for project	116	116	63	61	-	356
7	Contingency	37	40	41	19	-	136
	Total	6,496	32,125	12,086	8,884	1,244	60,836
8	Institutional Overhead (as a % of Direct project cost)	1,202	3,059	2,318	1,592	185	8,354
	Total Project Cost	7,698	35,184	14,404	10,476	1,429	69,190

Project Funding

Funding						
CGIAR Fund	4,193	23,932	7,061	6,991	1,429	43,606
Current Restricted Donor Projects	3,441	11,152	7,295	3,440	-	25,328
Other Income	65	101	47	44	-	256
Total Funding	7,698	35,184	14,404	10,475	1,429	69,190

Table 6 indicates the anticipated breakdown of funding for 2011 between the CGIAR Fund and bilateral sources.

Table B6: Allocation of CRP4 Budget among participating Centers and funding sources (\$000)

	Component 1	Component 2	Component 3	Component 4	CRP Management	Total 2011 Budget	2011 Funding Source		
	Nutrition Sensitive Value Chains	Biofortification	Control of Agriculture Related Diseases	Programs and Policy			CGIAR Fund	Restricted and Other Funding	CGIAR Fund %
BIOVERSITY	2,282	25		1,167		3,474	1,933	1,541	56%
CIAT		3,994				3,994	1,399	2,595	35%
CIP	433	559	88	516		1,595	1,032	563	65%
HARVESTPLUS		20,493				20,493	1,500	18,993	7%
ICARDA			906			906	565	341	62%
ICRAF	546			182		728	317	411	44%
ICRISAT	363	726	545	182		1,816	1,362	454	75%
IFPRI	945	3,758	1,872	4,781	1,330	12,686	3,767	8,919	30%
IITA	528	1,084	563	481		2,656	2,192	464	83%
ILRI			7,722	1,930		9,652	3,067	6,585	32%
WORLD FISH	320	80	240	160		800	42	758	5%
Total	5,417	30,718	11,935	9,400	1,330	58,800	17,176	41,624	29%

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APPENDIXES

Appendix 1. 2010 Status of Micronutrient Density in HarvestPlus Crops under Development

[expressed as increases in parts per million (ppm)]

<i>Crop</i>	<i>Nutrient</i>	<i>Baseline average in crop</i>	<i>Desired increment increase</i>	<i>Progress in germplasm currently in crop development at the CGIAR (cumulative increase ppm)</i>	<i>Current progress in germplasm in GXE trials out in target NARES (cumulative increase ppm)</i>	<i>Projected initial release genotype nutrient level</i>	<i>Projected year of first release</i>	<i>Target Countries</i>
Rice	Zinc	16	8	8	3 <i>in Bangladesh</i>	24	2012 <i>accelerated breeding</i>	Bangladesh India
Wheat	Zinc	25	8	6-8	GxE trials 2010/2011 cycle	31-33	2013	India Pakistan
Maize Hybrid	Provitamin A	0	15	8-12	Data available June 2010	5-8	2012-13	Zambia
Maize OPV	Provitamin A	0	15	4-5	Data available June 2010	4-5 6-8	2011 2015	Zambia
Cassava	Provitamin A	0	15	14 <i>pre-breeding CIAT</i>	9.5 <i>total carotenoids</i>	9 <i>total carotenoids</i>	2013 <i>accelerated breeding</i>	Nigeria DR Congo
Pearl Millet Hybrid	Iron	47	30	N/A	Data available Feb 2011	67	2012 <i>fast-track hybrids</i>	India
Pearl Millet OPV	Iron	47	30	50 <i>in progeny lines</i>	30	77	2011	India
Bean	Iron	50	44	30	20	74	2010-11	Dr Congo Rwanda
Orange Sweet Potato	Provitamin A	0	30 <i>= approx. 110 on dry matter basis</i>	200-360 <i>dry matter basis</i>	360 <i>dry matter basis</i>	360 <i>dry matter basis</i>	2009-10 <i>First variety released 2007</i>	Uganda Mozambique

Appendix 2. From Component 3 (AAD)

Appendix 2, Table 1. Detailed activity to impact plan for initial priority areas (food safety and zoonoses)

Activities	Outputs	Outcomes	Impact
Mycotoxins: (1) Measurement and detection methods			
<ul style="list-style-type: none"> • Survey along value chains; assess contamination in key crops across agroecological zones • Initiate development of new detection methods in collaboration with ARI partners • Conduct food consumption and mycotoxin exposure surveys with health experts • Analyze mycotoxins in crops, strain composition in soil, and environmental variables to develop prediction models for mycotoxins. • Assess the retention of these toxins during processing; modify processing methods 	<ul style="list-style-type: none"> • Risk maps showing magnitude of mycotoxin contamination in groundnut, maize and other key crops • Groundnut and maize value chain mapped with critical control points in different agroecological zones • Survey results showing mycotoxin exposure in human population • Long-term: Diagnostic relationship between aflatoxin levels in blood and nutritional status of children • Surveillance systems for adoption by regulatory agencies • Prediction models for occurrence of mycotoxins 	<ul style="list-style-type: none"> • Prediction models used by governments agencies and national and international organizations • New cost effective detection tools used routinely by actors along the value chain, including exporters 	<ul style="list-style-type: none"> • Reduction in aflatoxin incidence resulting from effective government policies
(2) Identify intervention opportunities and their costs; understand behavioral issues affecting their adoption			
<ul style="list-style-type: none"> • Identify and test new atoxigenic strains of <i>A. flavus</i> and other new biocontrol agents for maize and groundnut • Develop and test novel aflatoxins control • Test aflatoxin mitigation technologies in farmers' fields (maize and groundnut) • Assess farmers' willingness to pay for pre- and post harvest management options • Assess cost effectiveness (CEA) of control measures; analyze cost and benefits (CBA) to producers of technologies' adoption • Develop alternate pathways to channel contaminated products for non-food uses to reduce human exposure • Promote processing methods to reduce retained plant toxins 	<ul style="list-style-type: none"> • New strains for biocontrol of <i>A. flavus</i> identified • Appropriate pre- and post harvest aflatoxin management packages, based on CBA and CEA, targeted to specific farming systems • Long-term: Simple, rapid technologies for mycotoxin detection at field level • Alternative uses of contaminated products identified and promoted • A publicly accessible database on mycotoxins and relevant technological interventions 	<ul style="list-style-type: none"> • New strains for biocontrol of <i>A. flavus</i> promoted • 10% of farmers in selected countries adopt relevant technologies by 2015 • On-farm management practices (using biocontrol and resistant cultivars from MP3s) reduce levels in target countries by 70% • Risk of exposure to mycotoxins reduced by 80% in pilot sites • New biocontrol agents adopted by farmers in selected countries 	<ul style="list-style-type: none"> • Improved rural livelihood, health, and nutritional status of the targeted community as a result of reduced aflatoxin contamination

(3) Capacity building and information			
<ul style="list-style-type: none"> • Train NARS on detection tools • Develop flyers and videos in local languages to increase awareness at different levels • Develop a database of levels of mycotoxin contamination and relevant technological interventions 	<ul style="list-style-type: none"> • Policy advocacy platform to share information on risk associated with mycotoxins and their impact on livelihoods • Greater awareness of mycotoxins and associated health risks, among research collaborators, farmers, and consumers 	<ul style="list-style-type: none"> • Farmers and consumers in high-risk target regions have knowledge of mycotoxins and associated health risks, and methodologies / technologies for minimizing contamination. • Farmers and consumers are willing to adopt risk reduction measures. • Consumers are willing to pay a price differential for products with guaranteed low risk of mycotoxin exposure. 	<ul style="list-style-type: none"> • Improved rural livelihood, health, and nutritional status of the targeted community
Biological hazards			
<p>Activities</p> <ul style="list-style-type: none"> • Contribute to assessment of the multiple burdens of FBD. • Develop and validate participatory approaches to prioritizing food borne hazards • Develop and validate rapid tests for food –borne pathogens • Test surveillance models and provide evidence for better surveillance of FBD • Develop One Health collaborations for on- farm risk reduction which address equity, participation & ecological aspects • Improve epidemiological understanding of transmission, susceptibility and control • Develop and test risk mitigation innovations and strategies • Develop and test risk communication strategies • Assess the impact of innovations and strategies 	<p>Outputs</p> <ul style="list-style-type: none"> • Risk targeting decision support tools • Metrics and assessments of multiple burdens of food borne disease • Evidence and influence for more appropriate policy • Novel rapid tests developed, tested and shared • Novel technologies, developed tested and shared • Strategies for risk management • Surveillance system guidelines and models • Risk communication to multiple stakeholders using multiple channels and mediae 	<p>Outcomes</p> <ul style="list-style-type: none"> • More rational allocation of FBD resources reflecting broader societal concerns including • Better detection and reporting of FBD • Better management of FBD 	<p>Impact</p> <ul style="list-style-type: none"> • Improved livelihood, health and nutritional status of the targeted community

Plant Toxins			
(1) Measurement and detection methods			
<ul style="list-style-type: none"> • Evaluation of low toxin lines in target region, for farmers' participatory selection in SA and SSA 	<ul style="list-style-type: none"> • Research reports that inform stakeholders of the potential risk of plant toxin lines. 	<ul style="list-style-type: none"> • Policy makers use information and institute regulations 	<ul style="list-style-type: none"> • Enhanced agricultural production, reduced malnutrition, and better health
(2) Identify intervention opportunities, their costs, and understand behavioral issues effecting their adoption			
<ul style="list-style-type: none"> • Evaluate farmers' preferred varieties through partners and NGOs • Seed multiplication of farmers' preferred varieties in each partner country 	<ul style="list-style-type: none"> • Improved varieties with low toxins (ODAP in lathyrus, cynide in cassava, vicine and tannin in faba bean, phytate and raffinose family oligosaccharides in most legume crops) • New trait-specific donors for traits associated with high nutritional value • Adoption of improved varieties and production technologies in the target regions 	<ul style="list-style-type: none"> • Farmers' adoption of cost effective measures to minimize exposure to plant toxins 	<ul style="list-style-type: none"> • Enhanced agricultural production, reduced malnutrition, and better health
(3) Capacity building and information			
<ul style="list-style-type: none"> • Community based capacity building on maintaining genetic purity of adopted varieties, production of quality seeds, agronomic practices, and food processing methods to manage risk of plant toxins 	<ul style="list-style-type: none"> • Enhanced capacity of NARS in conventional and molecular breeding, crop management, and seed production technologies • Policy briefs/dialogues/advocacy to promote cultivation through proper infrastructure and seed support, value-addition, and linkage with markets at local level • Publication of peer-reviewed research articles, data sets, and learning materials 	<ul style="list-style-type: none"> • Enhanced access for the poor to safe food 	<ul style="list-style-type: none"> • Enhanced agricultural production, reduced malnutrition, better health, gender equity, and strengthened NARS capacity

Pesticides and residues:			
(1) Measurement and detection methods			
<ul style="list-style-type: none"> Analyze the market structure of pesticide use in developing countries, including fraud incidence Understand the intensities of use and common practices across different regions Conduct food consumption and pesticide exposure surveys with health experts 	<ul style="list-style-type: none"> Research reports that inform stakeholders of the potential risk of excess pesticide use 	<ul style="list-style-type: none"> Policy makers use information and institute regulations 	<ul style="list-style-type: none"> Improved health from reduced acute and chronic exposure
(2) Identify intervention opportunities and their costs; understand behavioral issues effecting their adoption			
<ul style="list-style-type: none"> Evaluate cost of compliance with private food safety standards for various size producers Evaluate cost-effective feasible strategies to reduce exposure to pesticides arising from consumption of produce, use by producers, and handling and disposal Understand consumers' willingness to pay for products with certified low risk; identify institutional mechanisms to certify produce as safe in terms of pesticide use 	<ul style="list-style-type: none"> Research reports to inform policies that minimize the crowding out effect of private food safety standards Mechanisms identified to improve agricultural practices Identify cost effective ways to maintain productivity with reduced exposure to pesticides 	<ul style="list-style-type: none"> Reduction of crowding out effect Farmers' adoption of cost effective measures to minimize exposure to pesticides 	<ul style="list-style-type: none"> Improved health from reduced acute and chronic exposure
(3) Capacity building and information			
<ul style="list-style-type: none"> Research and evaluation in support of harmonization of minor use registration of agrochemicals to increase availability in developing countries. Develop cost-effective decision support tools for pesticide applications such as improving integrated pest management to reduce pesticide use (particularly of highly toxic pesticides) especially in peri-urban areas adapted to resource-poor farmers 	<ul style="list-style-type: none"> Policy recommendation for harmonization of minor use registration of agrochemicals to increase availability in developing countries. Maintain or enhance the poor's markets access and improve their profitability and food safety 	<ul style="list-style-type: none"> Policies implemented to harmonize minor use of registration of agrochemicals. Enhance access to the poor of safe food. 	<ul style="list-style-type: none"> Improved health from reduced acute and chronic exposure Improved access for the poor to markets with better health practices
Measure and map the multiple burdens of zoonoses and consequences			
Activities 1. Review the impact (disease and economics) & control of zoonoses 2. Work with international organizations to complement and ground truth ongoing studies	Outputs 1. A global assessment of the multiple burdens of zoonoses and intervention opportunities, 2. More detailed assessment of 1-2 known priority diseases	Outcomes 1. Greater awareness of health partners of the importance of zoonoses and need for ag. based interventions 2. Funding opportunities developed which reflect intervention opportunities	Impact 1. Zoonoses control activities partly attributable to shift in awareness funded and delivering health and livelihood benefits to poor people

Predict, plan for, and prevent disease emergence from agro-ecosystems			
<ul style="list-style-type: none"> 1. Understand drivers and crucibles of disease emergence 2. Develop pathogen detection platforms 	<ul style="list-style-type: none"> 1. Surveillance and control options based on improved understanding of disease 2. Diagnostics that take into account variants in circulation 	<ul style="list-style-type: none"> 1. Tools & guidelines being used by national and regional partners 2. Shift in mindsets and policies towards ecohealth solutions 	<ul style="list-style-type: none"> 1. Improved detection & reporting of EID reducing threats to health and livelihoods 2. More resilient ecosystems reducing risk of EID
Better control of neglected zoonoses			
<ul style="list-style-type: none"> 1. Understand the role and effectiveness of current institutions to monitor and control for zoonosis 2. Develop partnerships 3. Co-develop and test integrated zoonosis control for one or more priority diseases 	<ul style="list-style-type: none"> 1. Evidence, tools and methods for integrated zoonosis control tried by development partners 	<ul style="list-style-type: none"> 1. Tools & guidelines being used by national and regional partners 2. Shift in mindsets and policies towards one health solutions 	<ul style="list-style-type: none"> 1. Integrated zoonoses control delivering health and livelihood benefits to poor people and addressing needs of poor (including women and other vulnerable groups)

Appendix 3. Examples of Integrated Agriculture, Health, and Nutrition Programs that Could Be Included in the First Phase of Research under Component 4.1

Helen Keller International and IFPRI (South Asia and West Africa)

The Enhanced Homestead Food Production (E-HFP) program, supported by Helen Keller International (HKI), has been ongoing in a number of countries in Southeast Asia, including Bangladesh, Cambodia, Nepal, and the Philippines. It is now being tested in select African locations. HKI has also worked closely with the International Potato Center (CIP) in introducing orange-fleshed sweet potatoes (OFSP) in a number of countries in Africa; OFSP is one of the products being promoted in E-HFP in that region.

Goal: The program model is expected to improve maternal and child nutrition outcomes through a number of program impact pathways, including: household-level production and consumption of high quality foods; increasing income through the sale of food surpluses; improving knowledge, attitudes and practices in regard to nutrition through the behavior change component; strong linkages with local health systems to improve uptake of essential services; and empowering women through increased knowledge, control over income, and program components that address gender equity issues.

Interventions: HKI works with local partner NGOs by first creating Village Model Farms (VMFs). Each VMP serves approximately two groups of 20 households each; these are reached through contact groups comprising primarily female farmers (known as “mothers groups”). These groups are provided with valuable production inputs, including seeds, seedlings, saplings, improved animal breeds, and feed and medicine for poultry and livestock, as well as improved cultivation techniques. Within the mothers groups, nutrition education is integrated into the agricultural program activities, thus encouraging women to adopt optimal dietary practices using the foods produced. The active involvement of local health staff in the program helps to reinforce key messages promoting optimal nutritional practices and extends the reach of the nutrition education component far beyond the members of the mothers groups.

Target population and reach: Since HKI launched the E-HFP program over two decades ago, over 5.5 million people have been directly reached (representing about 950,000 families), through work with more than 200 NGO partners in Bangladesh, Cambodia, Nepal, and the Philippines. Many millions more have indirectly benefited from spillover effects arising from the surplus of nutritious foods entering the local marketplace.

Early evidence of what works: Evaluation results have shown that E-HFP has increased production of nutritious crops and animal-based foods, improved dietary diversity, and increased income (especially under control of women), while it has increased female empowerment in family decisionmaking. In some countries, anemia prevalence was decreased in target children (6–59 months old) and non-pregnant women, and night blindness was reduced in children 12–59 months old. Evaluations show that the effects of the program survive long after HKI involvement has ended. The E-HFP model has received international awards as a *proven program* for addressing hunger and malnutrition at scale. In 2009, HKI’s E-HFP program in Bangladesh was selected as one of 27 case studies out of 250 applications for *Millions Fed: Proven Successes in Agricultural Development*, an initiative of the International Food Policy Research Institute (IFPRI) funded by the Bill and Melinda Gates Foundation.

Gaps in the program: An overarching gap is the need to evaluate the model’s impact on child nutrition, particularly on growth, as well as to deepen our understanding of the various program pathways. In addition, cost effectiveness, including the scalability of the model, needs to be better documented. Another gap relating to program design pertains to addressing specific deficiencies in local dietary patterns through appropriate horticultural and small animal production strategies. We also need to explore the feasibility of adapting the current Asia Pacific model to address the food and nutrition security needs of the ultra-poor and the landless. Another high priority is how to adapt the model to Sub-Saharan Africa, where severe constraints relating to water availability, weak government infrastructure, and few nongovernmental partners.

How CG can help: The CG centers can bring state-of-the-art knowledge in several areas: crop breeding (for enhanced nutritional value, drought and pest resistance, yield), livestock management and improvement (with a focus on poultry and small ruminants), integrated pest management, and water management systems. The system-wide Gender and Diversity program will provide valuable input for overall gender analysis and development of strategies for empowering women. IFPRI will play a key role in developing the monitoring and evaluation framework that will be necessary for mainstreaming these programs. The CG centers' credibility with the agriculture and food policy communities will be key in repositioning the E-HFP model, creating a strategic opportunity to harness agricultural programs to improve nutrition and livelihoods.

'Realigning Agriculture to Integrate Nutrition' (RAIN) Concern and IFPRI (Zambia)

With the support of a grant from Irish Aid for 2010, Concern Worldwide and the International Food Policy Research Institute (IFPRI) are working together to develop an innovative project, Realigning Agriculture to Integrate Nutrition (RAIN). The program reconceptualizes traditional livelihoods and food security programs, focusing on preventing stunting in children under the age of two years.

Goal: This new project will be implemented on an agricultural platform to reduce maternal and child undernutrition. The project is to generate evidence and inform policy at national, regional, and global levels, exploring how agricultural projects can contribute to the reduction of childhood stunting.

Interventions: The RAIN project will examine the combined potential of a targeted agricultural project that incorporates support for home/community food production and small animal husbandry, together with a strong nutrition and health intervention package.

Target population and reach: The project will be implemented in Mumbwa District, Central Province, in Zambia. Activities will address agricultural and nutrition practices of approximately 3,000 households with pregnant and/or lactating women and children below the age of two years. The project will be implemented in very close collaboration with the two key line ministries, the Ministry of Agriculture and Cooperatives and the Ministry of Health, at both national and local levels. This is to ensure sustainability from the beginning by involving necessary stakeholders, as well as to develop a feasible project model that can be replicated in other areas.

Early evidence of what works: As the project is still in the design phase, there are no indications yet. However, the design of the project takes into account evidence generated in other projects in related areas: homestead food production, infant and young child feeding practices, women's empowerment, and programs addressing micronutrient deficiencies using a food-based approach.

Gaps in the program: The project will be set up specifically to monitor and evaluate the impact pathway from agriculture to nutrition. It will concentrate on activities around this pathway and the additional health and nutrition package, especially the behavior change communication component). It will not emphasize other pathways, such as strengthening of the health system, water, sanitation and hygiene, and treatment of HIV (ART).

How CG can help: Technical expertise from various CG centers could greatly benefit the project, especially IFPRI (as project partner). Also valuable will be links with ILRI, World Fish, and IITA, as well related institutes and programs such as HarvestPlus and the World Vegetable Center. As a route for publication and dissemination of findings, the CG system will likely add weight, positioning the resulting model for adoption beyond the country of implementation.

Millennium Villages with Bioersivity and IFPRI (Sub-Saharan Africa and example of humid tropics)

The Millennium Villages Project (MVP) is a 10-year rural development project which involves the coordinated delivery of scientifically-proven interventions in agriculture, health, infrastructure, education, and business development. Millennium Village project sites are drawn from hunger "hot-spots," with an estimated underweight prevalence of at least 20 percent. Village clusters averaging approximately 40,000

people were selected to represent the major agroecological zones and farming systems in Sub-Saharan Africa, presenting a range of challenges relating to income generation, food security, disease ecology, infrastructure, and health system development.

Goal: The aim of the MVP is to accelerate progress towards the Millennium Development Goals (MDG) targets: MDG 1—to eradicate extreme poverty and hunger and eliminate undernutrition; MDG 4—to reduce by two-thirds the under-five mortality rate; and MDG 5—to reduce by three-quarters the maternal mortality ratio.

Interventions: The villages are demonstration and testing sites for the integrated delivery of science-based interventions in health, education, agriculture, and infrastructure. Within the project, hunger and undernutrition are being addressed with an integrated food- and livelihood-based model that delivers a comprehensive package of health and development interventions.

- Community-wide interventions support food and livelihood security: subsidized seed and fertilizer to increase agricultural productivity; the introduction of high-value and nutritious crops; agro-processing initiatives; and microfinance programs to stimulate small-business development.
- A community health worker program promotes exclusive breastfeeding and locally appropriate complementary feeding, home-based fortification, and proper food storage techniques.
- Clinical interventions focus on persistent macro- and micronutrient deficiencies in children, including vitamin A supplementation, treatment of severe acute malnutrition, and regular growth monitoring.
- For cases of moderate malnutrition, families receive InstaFlour (the United States Agency for International Development [USAID]) or locally made nutrient-rich flour consisting of millet, soybean, sorghum, cassava, and groundnuts.
- Basic maternal health interventions such as antenatal care and institutional delivery are supported by efforts to promote adequate weight gain, along with iron and folic acid supplementation.

Target population and reach: Millennium Villages are located in Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania, and Uganda. These countries were chosen to reflect a diversity of agroecological zones, representing the farming systems found in over 90 percent of Sub-Saharan Africa.

Early evidence of what works: Three years after the start of this 10-year project, the risk of stunting among children under two-years-old was reduced by 55 percent, with corresponding improvements in household food security, child care practices, and infectious disease control across rural sites in nine African countries.

Gaps in the program: The use of historical controls, the uniqueness of project settings, and the multi-factorial determinants of undernutrition limit definitive causal statements and impact assessment studies.

How CG can help: CG can bring new tools and methodologies for AHN implementation research, strengthen evaluation to establish causality, document lessons learned and impact pathways, formulate scaling-up strategies and comparison of impact and cost effectiveness to other programs, and serve as an effective partner in local and national capacity building.

Agriculture Diversity for Nutrition, McGill University, Kenyatta University, National Museums of Kenya, Université de Abomey Calavi, and Bioversity (East, West, and Southern Africa)

Goal: This project investigates the factors underpinning the persistent rise in malnutrition in communities in Kenya, Benin, and South Africa. The project assesses existing strategies based on targeted single or multi-nutrient interventions—exploring how interventions based on local ecosystems and human resources can provide sustainable solutions to hunger and malnutrition, identifying the actual and potential contributions of local biodiversity to diets, and appraising the impact of ecosystem degradation on nutrition and health status. The research is also attempting to identify and mobilize biodiversity

resources and biodiversity stakeholders by working with local communities as well as drawing on outside expertise in health, agriculture, environment, and development, in order to achieve transdisciplinary strategies for better health. These research results and outcomes may also serve as models in similar ecosystems and environments in Africa and other developing regions.

Interventions: The interventions targeted increasing the biodiversity within the study communities' food systems and then studying the effects of the increased agro-biodiversity and food availability on nutrition and health outcomes of under-five children. To ensure increases in the diversity of foods in communities' food systems, collaborating local food producers were provided with seeds of local but neglected food crops and were trained in mixed cropping systems.

Target populations and reach: Women farmers and children under five years of age in rural agriculture systems of Kenya, Benin, and South Africa.

Early evidence of what works: The experience from the first phase of the project affirmed the need for a comprehensive evidence base for designing coherent interventions to conserve and utilize food biodiversity, adapted to a wide range of situations, food systems, and ecosystems. Results to date have made important contributions to national and regional policies, through the wider recognition of the strong links between agro-biodiversity conservation, food, and nutrition.

Gaps in the program: Experience from the first phase also demonstrated the need for more data, and for further empirical demonstration of the contribution of biodiversity to positive health outcomes, to justify and guide policy changes and program implementation, and to shape specific nutritional interventions that build on local biodiversity resources.

How CG can help: This project needs to be scaled-up and tested in other food systems, in order to provide convincing empirical evidence of whether (and how) local food systems and biodiversity affect child nutrition and health outcomes.

Catholic Relief Services (Asia, Africa, and Latin America)

CRS has a strong integration component in its relief and development activities across all sectors.

Goal: Within the organization's current Agriculture and Environment Strategy (2009–2014), the pillar on Agriculture for Nutrition focuses on delivering improved nutrition and clean water.

Interventions: CRS conducts a huge number of programs in agriculture, nutrition, and health globally, including:

- Kitchen and community gardens;
- Education on labor-saving techniques, such as trench and keyhole gardens for the elderly and sick, including people living with HIV;
- “Baby-friendly farms” for breastfeeding women;
- Silos and other food-storage buildings;
- Junior Farmer Field Schools for orphans and vulnerable children affected by HIV and AIDS;
- Local production and marketing of vitamin- and mineral-rich foods like sweet potatoes and beans;
- Education in nutrition, diet diversity, sanitation, and food-handling practices; and
- Identification of social, physical, or cultural barriers that prevent people from using healthy behaviors, such as washing hands before preparing food, or breastfeeding exclusively during an infant's first six months.

In addition, CRS has put increased resources toward integrating water and sanitation interventions with agricultural programs to improve the health of vulnerable populations. Several models are used to conduct this work, such as the Hearth model and Participatory Hygiene and Sanitation Transformation (PHAST), which focus on community participation and leadership.

Target populations and reach: Due to the scale of CRS global operations, CRS can offer this partnership numerous projects of varying focus, scale, and geographic location, ranging from several thousand to several hundred thousand households, located in Asia, Africa, and Latin America.

Early evidence of what works: M&E indicators—such as improved agriculture production, change in crops grown, dietary diversity, reduction in stunting and underweight in children, change in behavior of mothers and caregivers—have been used to monitor and document the successes of projects over the last 10–15 years.

Gaps in the program: The Agency would be very interested in increasing the visibility of its work to a more general audience, through additional reports, case studies, and in-depth project evaluations.

How CG can help: CG can provide in-depth analysis of different technical approaches in the field to evaluate what works, where, why, and how; it can also support data analysis, peer review, and report and article production. Recent approaches and innovations from the CGIAR and universities (e.g., varieties from HarvestPlus) might be incorporated into our work and scaled up.

Projects Working with Unique Agriculture Systems with the Integration of Nutrition and Health

Food for Progress Project and ICRAF (North and Northwest Regions of Cameroon)

Fifteen years ago, ICRAF initiated the *Food for Progress Program* as a development project in the north and northwest provinces of Cameroon to address the loss of the nutritious foods formerly gathered from forests, and the potential importance of trees to restore soil fertility. In 2010 the project was awarded USAID's Equator Prize.

Goal: The project aims to empower smallholder farmers to lift their households out of poverty, malnutrition, and hunger, while at the same time creating more environmentally and socially sustainable farming systems.

Interventions: Using participatory approaches, community tree nurseries are created to domesticate selected indigenous fruits and nuts, which before deforestation were gathered for foods and medicines. Rural Resource Centers (RRCs) provide training and mentoring at the village level. These RRCs have spun off 123 satellite tree nurseries in surrounding communities, supported by NGOs, CBOs, etc. New skills are developed at the community level through training and capacity building: restoration of soil fertility by planting nitrogen-fixing trees and shrubs alongside food crops; tree propagation and nursery management; tree domestication using simple, low-technology horticultural techniques; group dynamics and community project management; marketing, business skills, and management; and the use of microfinance.

Target population and reach: Currently the project is working with 7,095 farmers and about 50 entrepreneurs in 485 widely-dispersed communities across the region, centered around 7 RRCs located in lowland rainforest and in the denuded Bamenda Highlands. There have been many positive and few negative outcomes.

Early evidence of what works: Villagers have identified 31 positive impacts, including: substantial income generation; the creation of employment and business opportunities in value-adding processing; retention of youths in the villages; doubled or trebled crop yields; diversified and more balanced diets (fruits and nuts, vegetables, meat, and honey); delivery of potable water piped in from hillside springs (and other infrastructure improvements), due to community-level planning and development; reduced workload for women (allowing more time to attend to family needs); and improved health of community members (Tchoundjeu et al. 2008; Asaah et al. 2010).

Gaps in the program: Currently the impacts on the nutrition and health of the participating communities are not being quantitatively assessed. Nor is there any work in progress to develop this project as a model

for “Transformed Agriculture”—focusing on the use of agriculture to promote improved health and nutrition.

How CG can help: The application of the research agenda of CRP4 Component 3 within the project communities should generate important information about the nutritional value of traditional and underutilized foods, providing critical evidence of the importance of domesticating these once-plentiful species as components of farming systems. The available timeframe (1–14 years) will offer opportunities to capture the dynamics of nutritional and health changes.

East Africa Dairy Development Project, ILRI, and Emory University (East Africa and example of agro-pastoral system)

Goal: The project is a large-scale intervention with the objective of doubling the dairy income in poor agro-pastoralist communities. The Bill and Melinda Gates Foundation, which funds the project, is also interested in ensuring the project provides additional welfare benefits, specifically improved child nutritional status.

Interventions: The project establishes dairy hubs organized around dairy farmer business groups to provide a steady market for the farm households, together with input and service provision through business development services.

Target populations and reach: The target populations will be 135,000 poor agro-pastoral households with indigenous cattle in Kenya, Uganda, and Rwanda.

Early evidence of what works: In collaboration with Emory University, ILRI is conducting a qualitative assessment of the potential pathways for dairy intensification to influence nutritional outcomes, including assessing the potential negative effects of livestock-associated health risks. The study is expected to raise awareness of the need and value of nutrition and health interventions to enhance nutritional outcomes.

Gaps in the program: Because the project was not originally designed to serve nutritional objectives, there is no component assessing opportunities for enhancing nutritional benefits.

How CG can help: The qualitative assessment is likely to suggest that a clear, positive nutritional impact would require additional measures to enhance the benefits (e.g., nutrition education) and to mitigate the risks (e.g., control of zoonoses). This could create an opportunity for undertaking a more holistic approach that also links to nutritional benefits through better crop diversity and quality.

KARI, PATH, and CIP (Western Kenya)

Vitamin A deficiency accounts for 6 percent of all deaths of children under five years of age and 5 percent of the total disease burden of children in this age group (as measured in disability-adjusted life years). Orange-fleshed sweet potato (OFSP) is an important source of energy and beta-carotene, which is converted into vitamin A in the body. Only 125 grams of most OFSP varieties supply the recommended daily allowance of vitamin A for children and non-lactating women. Evaluations of food-based approaches using OFSP undertaken in Mozambique and Uganda have shown significant impacts on Vitamin A intake and status (Low et al. 2007; HarvestPlus, July 2010).

Goal: In two HIV-affected Districts in Western Kenya, CIP and partners now want to provide solid evidence that it is possible to improve the health and nutrition of pregnant women and children up to age 2 years by integrating OFSP with health service delivery serving pregnant women.

Interventions: The intervention will include two intensity levels. The high-intensity intervention will use community health workers in conjunction with standing health facilities. It will also include community-based peer support through pregnant mothers’ clubs. The low-intensity intervention will take place only at prenatal programs in standing health facilities. It will provide pregnant women with nutritional information on vitamin A-rich foods and young child feeding within existing programs, with no agricultural component. Almost all countries have prenatal programs, many of which provide nutritional

advice to mothers. The low-intensity intervention constitutes a “minimum package” that most Sub-Saharan African countries could adopt and expand to scale, should it prove effective.

Target populations and reach: The target is to reach 900 pregnant women and their households during the intervention period of three and a half years. Two major expected impacts are: significant increases in consumption frequency of vitamin A-rich foods; and utilization of mother-child health care services. Partners include: the Program for Appropriate Technology in Health (PATH); the Kenyan Agricultural Research Institute (KARI); local government stakeholders; and two NGO partners—Community Research in Environment and Development Initiatives (CREADIS), and Appropriate Rural Development Agriculture Program (ARDAP).

Early evidence of what works: Although the program only started in May 2010, PATH has found that one of the first facilities to distribute vouchers, Tamlega Dispensary, reported a 30 percent increase in first-time visits by pregnant women in their first and second trimesters, compared to the past three months. If this occurs in many other clinics, the voucher program may be a tool that helps antenatal care nurses serve more women earlier in their pregnancies, giving the pregnant women information they need to adopt healthy practices during pregnancy and, eventually, to ensure that their babies’ nutrition and health care is good.

Gaps in the program: A major area for investment, still needing funding, is to study the effectiveness of linking OFSP distribution to de-worming efforts in community or school programs. Theoretically, improving intake of vitamin A while simultaneously lowering losses due to helminthic infections should substantially increase the effect on vitamin A status, above either intervention alone. The approach could also be extended as part of community-based nutrition programs, in addition to the use of health facilities as the entry point.

How CG can help: Test integration of additional crops (e.g., Traditional African Vegetables and fruit trees and their respective seed systems) and/or small-stock or poultry into the approach.

WorldFish (Bangladesh and example of aquatic system)

Fish and fisheries are important for the livelihoods, food, and income of the rural population in Bangladesh. However, increased rice production and changing agricultural patterns have resulted in a large decline in inland fisheries. Implementation of carp pond polyculture has been very successful, whereas little focus has been given to the commonly consumed small indigenous fish species, some of which are rich in vitamin A and minerals (such as calcium, iron, and zinc) and are an integral part of the rural diet. The program addresses an important element impairing the nutritional status of the rural poor: the decline in accessibility, increase in price, and decrease in intake of small indigenous fish species, as well as the increased intake of silver carp—the most commonly cultured fish species—which is poor in micronutrients and not preferred for consumption (Roos et al. 2007). An integrated approach was conducted jointly by Bangladeshi and Danish institutions, linking human nutrition and fisheries.

Goal: The overall objective of the research and capacity-building activities is to increase the production, accessibility, and intake of nutrient-dense small indigenous fish species, in particular mola, in order to combat micronutrient deficiencies.

Interventions: Activities include: food consumption surveys; laboratory analyses of commonly consumed fish species; production trials of carp-mola pond polyculture; teaching, training, and dissemination of the results.

Target populations and reach: Rural Bangladesh, in areas with inland fisheries resources in households with small, seasonal ponds, as well as poor communities with access to wetlands.

Early evidence of what works: No decline in carp production (and thus in income) was found with the inclusion of mola, and increased intake of mola has the potential to combat micronutrient deficiencies.

Teaching and training of graduates and field staff have led to increased awareness of the role of small indigenous fish species for good nutrition, resulting in the promotion of carp-mola pond polyculture and research in small indigenous fish species. The successful linking of human nutrition and fisheries to address micronutrient deficiencies has relevance for other countries with rich fisheries resources, such as Cambodia and countries in the Lake Victoria region of Africa.

Gaps in the program: Incorporation of behavior health communication with respect to nutrition and health education; strengthening of marketing and processing to increase utilization of nutrient-dense fish; and linkages to other rural development sectors, including health and education.

How CG can help: Influencing policy at the national level, building up a regional program with other Asian countries, dissemination at global, regional and national levels, assisting in getting funding for research and field activities.

Human and Animal Health Research Unit at the Swiss Tropical and Public Health Institute (One Health Model)

Goal: The human and animal health unit aims to contribute to health of humans and animals by identifying and applying synergistic potential of closer cooperation between human and veterinary medicine, known as “one health.”

Target groups and the coverage area: The focus is primarily on the health of mobile populations and their animals, and secondly on the control of zoonoses in developing countries. Many of these activities are in the framework of larger international networks such as the European Union Framework Program 7 (EU FP-7), connecting research institutions in the north and south. Target groups are livestock keeping communities and consumers of livestock products in developing and transition countries: East Africa (Kenya, Ethiopia); West Africa (Chad, Mali, Côte d’Ivoire, Mauritania); and Central Asia (Kyrgyzstan and Mongolia).

Interventions: Mixed research teams, from the health and agricultural sectors, research topics ranging from molecular epidemiology to trans-sectoral economic assessment. Nutritional studies in pastoral communities of Chad (e.g., significant association between vitamin A/B-carotene content in milk consumed and serum retinol; higher proportion of malnutrition among mobile pastoralist women than sedentary women of the same region).

Early evidence of what works:

- Simultaneous assessment of zoonoses in the three sectors—health, livestock, and wildlife—generates more information on their epidemiology.
- Trans-sectoral economic assessment of costs of zoonoses provides the basis for valuing the financial contributions of each sector (public and private) involved in prevention and control of zoonoses.
- Assessment of response capacity in key sectors involved in prevention and control of epidemic zoonoses guides the planning of joint surveillance and contingency plans.
- Costs of human and animal health delivery services can be shared between sectors using the same infrastructure (e.g., vehicles and cool chain), particularly in remote rural areas.

Gaps in the program: Policy formulation is needed for national zoonoses control programs. In Chad, the government has initiated a policy formulation workshop involving a range of sectors, led by the Ministry of Finances.

How CG can help: Providing more evidence on the role of livestock in nutrition, health, and sustainability in arid and semi-arid regions.

Support to Household Food Security and Nutrition, FAO, and the Ministry of Agriculture (Afghanistan)

Goal: The project aims to contribute to improve household food security, nutrition, and livelihoods situation in Afghanistan by addressing root causes of malnutrition such as fragile institutional capacities in coordination and implementation, limited knowledge on nutrition and improper feeding practices, limited access to food especially during the winter seasons. The participation of women in agricultural development is addressed as a crosscutting issue contributing to the goals.

Interventions: The project supports the integration of food security and nutrition in national policies and strategies by contributing to the intra- and interministerial and interagency dialogue and by developing the required capacities (i.e., Ministry of Agriculture, Ministry of Public Health, Ministry of Education, national NGOs, as well as development guidelines, etc.). To strengthen the integration of nutrition in the agriculture, education, and health sector as well as the direct implementation of community-based food security, nutrition and livelihoods are the priorities of direct implementation (i.e., support to literacy classes and community groups; training of teachers, and health and agriculture extension workers; establishing and training of women groups).

Target populations and reach: Besides support at the national level, the project directly implements activities in three provinces, working with target groups mainly through local government structures or in collaboration with national and local NGOs and community networks, such as women's committees and women's groups.

Early evidence of what works: Highlights are the successful contribution to the integration of food security and nutrition into the Afghan National Development Strategy, the National Nutrition Policy and Strategy, and the Infant and Young Child Policy, curriculum development or the contribution to MAIL monitoring system. National guidelines have been developed and largely disseminated (i.e., Afghan Family Nutrition Guideline, Complementary Feeding Guideline, Food Processing Guideline, etc.). The project supported the establishment of the MAIL's Home Economic Department as well as their subnational network reaching out to 18 provinces. In 2009, for example, the established network was able to reach out to 72,000 individuals providing nutrition education. Linkages to donors were established (i.e., Spanish and Government). In 2010, the department was able to receive additional donor as well as internal funding to extend those food security and nutrition activities. The project also supports 5 to 8 pilot projects annually, working with most vulnerable households in linking food production, food processing, and better family nutrition.

Gaps in the program: The focus of the project was given to the development of capacities, piloting, and implementing food and nutrition activities under MAIL. In order to embed the lessons learnt, a more systematic scale-up and a continued monitoring and evaluation system would be required. Furthermore, additional limited technical capacities are hindering large-scale and sustained impacts if the actual project support phases out.

How CG can help: Sharing lessons with other projects would help to design effective interventions to improve community nutrition through the agricultural sector. A systematic review of the different interventions applied to tackle household food insecurity and malnutrition, followed by a promotion and advocacy for successful food-based approaches are required to increase recognition and to institutionalize the measures. This is important to ensure that achievements are sustained.

Appendix 3, Table 1. Summary of case studies of programs integrating agriculture, health, and nutrition

Implementer/geographic coverage/CG collaborator	Type of program and intervention package	Goal	Where CRP4 can help
<p>Helen Keller International</p> <p>South Asia and West Africa</p> <p>(950,000 families) in Bangladesh, Cambodia, Nepal, and the Philippines</p> <p>IFPRI</p>	<p>Enhanced Homestead Food Production (E-HFP):</p> <ul style="list-style-type: none"> • Village model farms with food crops, poultry, and livestock. • Agriculture training and inputs • Nutrition education and behavior change (focus on child feeding practices and other essential nutrition actions). • Involvement of local health staff and primary health care input. • <i>Target women, address gender equity.</i> 	<ul style="list-style-type: none"> • Improve women’s and children’s nutrition through: food production, consumption of high quality foods, income (through sale of products), better knowledge, attitudes, practices, and empowering women. 	<ul style="list-style-type: none"> • Evaluating impact, impact pathways, and cost-effectiveness • Assessing whether model can be scaled up or replicated in other settings (e.g., targeting ultra poor; adapting to Sub-Saharan Africa) • Assessing how to address local dietary deficiencies • Strengthening gender analysis • Bringing state-of-the-art knowledge of crop breeding, livestock, water and pest management, and M&E
<p>Concern Worldwide</p> <p>Zambia</p> <p>3,000 households (at onset)</p> <p>IFPRI</p>	<p>Realigning Agriculture to Integrate Nutrition (RAIN):</p> <ul style="list-style-type: none"> • Agriculture project (home and community food production; small animal husbandry) • Nutrition and health intervention package • <i>Integration of women’s empowerment into food-based approach</i> 	<ul style="list-style-type: none"> • Improve maternal and child nutrition • Generate evidence and inform policy on how agriculture projects can contribute to reduce child stunting 	<p>Note: project is still in design</p> <ul style="list-style-type: none"> • Providing technical expertise in design, implementation, monitoring, and evaluation (e.g., involving ILRI, World Fish, IITA, HarvestPlus, the World Vegetable Center) • Strengthening impact evaluation using program theory and impact pathway methodologies • Documenting lessons learned; publishing and disseminating results
<p>Millennium Villages</p> <p>West, East, and Southern Africa</p> <p>Bioversity and IFPRI</p>	<p>Millennium Villages Project:</p> <ul style="list-style-type: none"> • Villages as demonstration sites for integrated delivery of agriculture, nutrition, health infrastructure • Integrated food- and livelihood-based model that delivers comprehensive package of health and development interventions 	<ul style="list-style-type: none"> • Accelerate progress toward MDG targets: MDG 1—To eradicate poverty and under-nutrition; MDG 4 and 5—To improve child and maternal health 	<ul style="list-style-type: none"> • Bringing new tools and methodologies for ANH implementation research • Strengthening evaluation • Documenting lessons learned and impact pathways • Formulating scaling-up strategies • Comparison of cost-effectiveness and impact in relation to other programs • <u>As partner in local and national capacity building</u>
<p>McGill University, Kenyatta University, National Museums of Kenya, Universite de Abomey Calavi</p> <p>Kenya, Benin, and South</p>	<p>Agriculture Diversity for Nutrition:</p> <ul style="list-style-type: none"> • Seed distribution for increased biodiversity in local food systems • Training local producers in mixed cropping systems • <i>Target women and children under 5</i> 	<ul style="list-style-type: none"> • Identify contribution of local biodiversity to diets • Mobilize local biodiversity resources • Draw on health, agriculture, and 	<ul style="list-style-type: none"> • Establishing an evidence base on the contribution of agrobiodiversity to improving child undernutrition and human health • Applying model to other ecosystems and environments

Implementer/geographic coverage/CG collaborator	Type of program and intervention package	Goal	Where CRP4 can help
Africa/Bioversity		environment sectors to achieve trans-disciplinary strategies for better health	
Catholic Relief Services Asia, Africa and Latin America IFPRI and Bioversity	Agriculture for Nutrition interventions including: <ul style="list-style-type: none"> • Kitchen and community gardens, Junior Farmer Field schools for youth affected by HIV/AIDS, and baby-friendly farms • Local production and marketing of nutrient-rich crops • Education on labor-saving techniques (for people living with HIV), nutrition, and food safety • Integrated water, sanitation, and agricultural programs 	<ul style="list-style-type: none"> • Ensure that agriculture programs improve access to good nutrition and clean water 	<ul style="list-style-type: none"> • Carrying out in-depth analysis of technical approaches; evaluating what works, where, and why • Evaluating how innovations from CGIAR and universities can be incorporated and scaled up • Supporting data analysis, documentation of experience, and publication of lessons learned
ICRAF and partners Cameroon 7095 farmers 50 entrepreneurs 485 communities ICRAF	Food for Progress: <ul style="list-style-type: none"> • Domestication of indigenous fruits and nuts • Capacity building and training on community tree nursery management, via rural resource centers 	<ul style="list-style-type: none"> • Empower smallholder farmers through environmentally and socially sustainable farming systems, to improve health and reduce poverty and hunger 	<ul style="list-style-type: none"> • Assessing impacts of better livelihoods and diversified diets on nutrition and health • Developing project as model for using agriculture to promote improved health and nutrition • Generating evidence to support the domestication of traditional species • Using time series data to document impact on nutrition and health
Emory University Kenya, Uganda, and Rwanda (pastoral communities) ILRI	East Africa Dairy Development: <ul style="list-style-type: none"> • Dairy hubs organized around dairy farmer business groups, to provide steady market input and business development services 	<ul style="list-style-type: none"> • Increase dairy income and improve child nutrition in agro-pastoralist communities 	<ul style="list-style-type: none"> • Assessing nutritional impact • Identifying holistic approaches that increase nutritional benefits and control risks of zoonotic diseases

Implementer/geographic coverage/CG collaborator	Type of program and intervention package	Goal	Where CRP4 can help
<p>Program for Appropriate Technology in Health (PATH); Kenyan Agricultural Research Institute (KARI)</p> <p>Western Kenya</p> <p>900 pregnant women and their households</p> <p>CIP</p>	<p>Orange-Fleshed Sweet Potato program in HIV-affected areas:</p> <ul style="list-style-type: none"> • Community education on nutrition and prenatal care • Peer support through pregnant women’s clubs • Mother-child health care services through use of health workers and existing facilities • Promotion of biofortified orange-fleshed sweet potato (OFSP) • <i>Targets pregnant women and children up to 2 years</i> 	<ul style="list-style-type: none"> • Improve nutrition of pregnant women and children under 2 by integrating OFSP and health service delivery in HIV-affected areas 	<ul style="list-style-type: none"> • Assessing the effectiveness of linking biofortification with health services such as de-worming • Testing integration of traditional vegetables, fruit trees, and small animals
<p>Bangladeshi and Danish institutes; FAO</p> <p>Bangladesh</p> <p>WorldFish</p>	<p>Carp-mola polyculture research:</p> <ul style="list-style-type: none"> • Food consumption surveys and analysis of nutrient content of fish species • Production trials of carp-mola pond polyculture • Training and dissemination of results 	<ul style="list-style-type: none"> • Increase production, accessibility, and intake of small, nutrient-dense indigenous fish species for better nutrition and health 	<ul style="list-style-type: none"> • Assisting with behavior change communication and health education • Strengthening marketing and processing of fish species • Establishing links to other development sectors • Influencing national policy • Building regional program
<p>Swiss Tropical and Public Health Institute/ Kenya, Ethiopia, Chad, Mali, Côte d’Ivoire, Mauritania, Kyrgyzstan, and Mongolia/ ILRI</p>	<p>Ecohealth Model:</p> <ul style="list-style-type: none"> • Mixed health and agricultural teams conducting nutritional, epidemiological, environmental and economic assessments in pastoral communities using an “eco health ” approach 	<ul style="list-style-type: none"> • Identify and apply synergies between human and veterinary medicine to improve the health of humans and animals • Control zoonoses 	<ul style="list-style-type: none"> • Assist with policy formulation for national zoonoses control programs • Generate evidence on the role of livestock in nutrition, health, and sustainability in arid and semi-arid regions
<p>FAO, Ministry of Agriculture</p> <p>Afghanistan</p> <p>IFPRI</p> <p>Bioversity</p>	<p>Support to Household Food Security and Nutrition in Afghanistan:</p> <ul style="list-style-type: none"> • Support national policies and strategies that promote integrated food security and nutrition • Capacity building within and across ministries and agencies • Direct implementation activities, including teacher and extension worker education, and training of women’s groups 	<ul style="list-style-type: none"> • Improve household food security, nutrition, and livelihoods by addressing the root causes of malnutrition 	<ul style="list-style-type: none"> • Analysis of how to scale up and continue M&E efforts • Expanding technical capacities • -Systematic review of different interventions and lessons learned • Promotion and advocacy for successful food-based approaches

Appendix 4. Examples of Evidence-based, Cross-Sectoral Interventions

Three examples illustrate how past innovations can be built upon for much broader impact across agricultural-health-nutrition boundaries: (1) brucellosis control in Mongolia (Roth et al. 2003), (2) smallholder dairy in Kenya (Kaitibie et al. 2008), and (3) pesticide regulatory policy in the Philippines (Templeton and Jamora 2008).

In the case of brucellosis control in Mongolia, research was carried out to estimate the economic benefits and cost-effectiveness of improving human health in Mongolia through the control of brucellosis (a disease that can pass between livestock and humans) by mass vaccination of livestock. Researchers calculated the monetary benefits to the agricultural sector, the public health sector, and private households. This case shows how incomplete data from separate sectors could be used in models to highlight some of the most difficult questions for policymakers and their implications. What is the most effective way of controlling a human health problem originating in the agricultural sector? The identification and control of zoonotic diseases increasingly depends on surveillance and action in the agricultural sector. Second, what are the fiscal incentives that need to be put in place for effective control of diseases? Compensation of farmers for culled stock and free vaccination may be necessary for compliance. Finally, within government there must be protocols for the Ministries of Agriculture and Health to allocate the necessary funds according to some principle of cost-effectiveness and ultimate beneficiaries from the action. Collaboration is more difficult when it involves real claims on Ministerial budgets.

In the case of smallholder dairy in Kenya, health regulations requiring pasteurization of milk entering commercial circuits were reversed in the light of research into public health risks and a socioeconomic poverty impact assessment by ILRI and partners. This research is relevant to many locations in East Africa and South Asia.

In the case of the change in pesticide regulatory policy in the Philippines, IRRI and its partners documented growing health concerns in the 1980s, particularly the harmful effects of pesticide use, through detailed analysis of private health costs and environmental effects of rice farming in the Philippines. This research led the Philippine government to instigate a suite of pesticide regulatory policies and implementing guidelines and launch integrated pest management (IPM) as a national program. There are a number of important lessons from this work: (1) the impact of policy research is difficult to estimate; (2) there is seldom only one study that deals with an important issue (and the case of pesticide in the Philippines goes back 20 years and IRRI studied it several times); and (3) there always multiple drivers of decisions. These are all good points for policy analysts to keep in mind.

All three examples illustrate the importance of bringing together knowledge and evidence, decisionmaking processes, partnerships, communication and advocacy, and other elements in support of integrated decisionmaking across the agriculture, health, and nutrition sectors.

Appendix 5. Implementation and Partnership in Policy Processes: The CAADP Example

There are four types of delivery mechanism to disseminate the products of research to partner organizations, stakeholders, and policymakers. *Carrier policy processes* are ongoing policy processes that provide an opportunity for the CRP to add value to planning and implementation activities at the country and regional levels, in terms of technical information, tools, and capacity building. As an illustration, the Pillar 3 dealing with hunger and nutrition and, in particular the technical planning and implementation work that is being carried out by Regional Economic Communities (RECs) and their member states, would constitute the appropriate carrier policy processes for the CRP under the CAADP agenda. The different opportunities for value addition at the country, regional, and continental levels are specified in the middle column of the chart. The first value addition opportunity in this area at country level would consist in assisting countries to better understanding and properly articulating the issues related to agriculture for improved health and nutrition in the formulation of long term policy and strategy options as well as action plans under this pillar. The second opportunity for value addition would emanate from the need for technical guidance for the design of health and nutrition components in the current country CAADP investment plans. In both of the above cases, the input from the CRP could be prototypes to scale up, best practices for adoption, benchmarks to guide action by stakeholders, tools and other knowledge products to facilitate implementation, and even action research to clarify the future course of action. The value addition opportunities at the regional and continental levels are described in the bottom two boxes of the middle column of the chart.

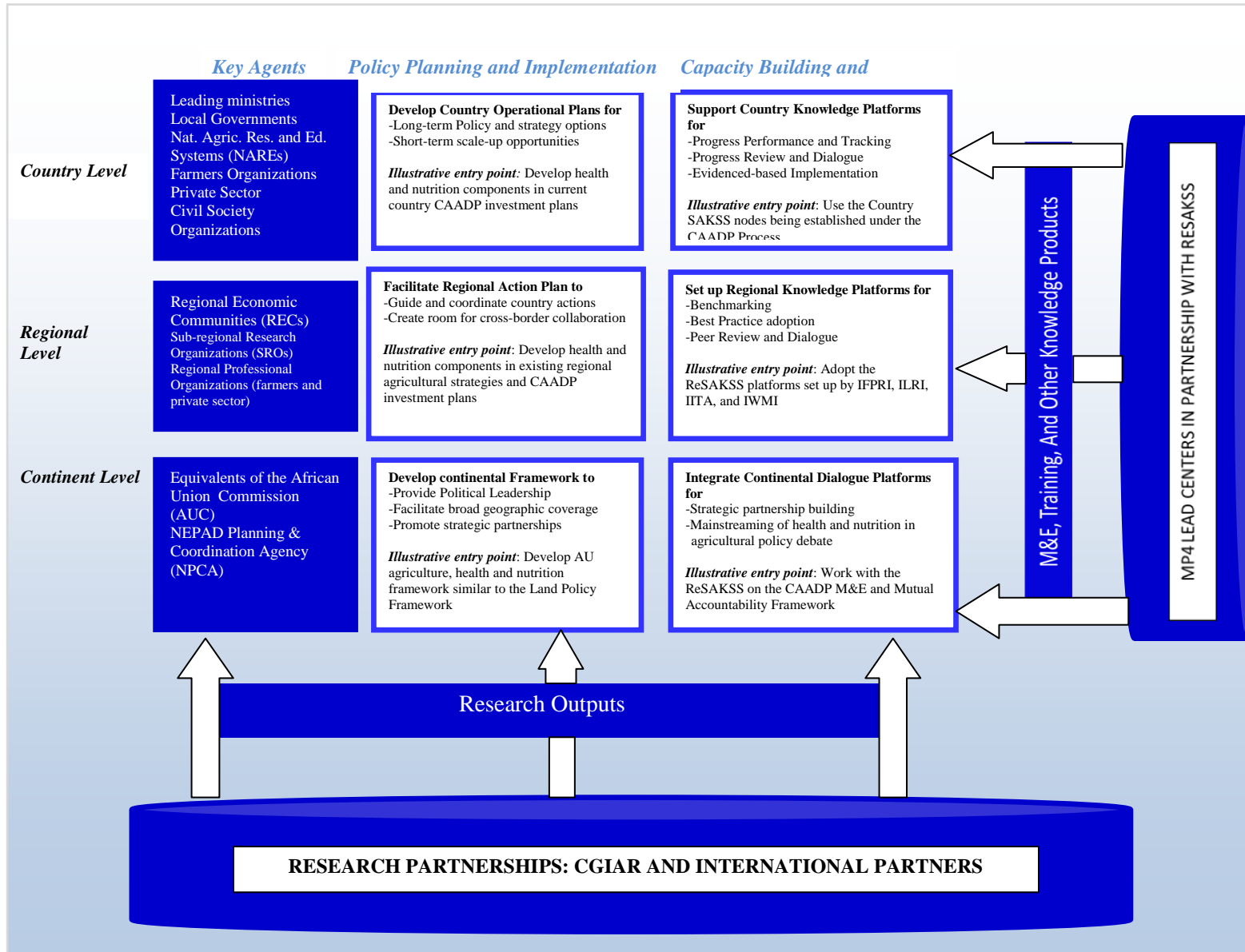
Anchor organizations and *operational actors* are at forefront of policy planning, implementation, and coordination at the continental, regional, and country levels. They need to be engaged in order to influence the policy and program planning and implementation process and to learn from that process in return to inform the research agenda setting under the CRP. Engagement with the anchor organizations allows the CRP leadership to identify the relevant carrier policy processes and work with the appropriate stakeholders to create the space and opportunity for value addition. In the CAADP examples, they include the African Union Commission (AUC), the NEPAD Planning and Coordination Authority (NPCA), the Regional Economic Communities (RECs), leading national ministries, local governments, the national research and education systems (NARES), and the various professional and civil society organizations (see first column).

The CRP leadership will initiate engagement with the anchor organizations very early in the implementation phase. The preparation of the partnership strategy, roadmap, and action plan is a good opportunity to initiate this engagement.

Knowledge Platforms are not only important as means to facilitate the access to and use of the different research outputs under the CRP by stakeholders, ranging from various knowledge products, tools, and methodologies. They are also a critical support for the monitoring, evaluation, and impact assessment work as well as the related review and learning activities that are critical ingredients of the process of informing policies and fine-tuning the research approach and agenda of the CRP. Illustrative examples from the CAADP process include the Regional Strategy Analysis and Knowledge Support Systems (ReSAKSS), established by four CG centers, IFPRI, IITA, ILRI, and IWMI in collaboration with three RECs: the Common Market for Eastern and Southern Africa (COMESA), the Economic Community of West African States, and the Southern African Development Community (SADC). ReSAKSS operates three regional nodes which are hosted by ILRI, IITA, and IWMI and coordinated by IFPRI (www.resakss.org). The nodes support the M&E, review, benchmarking, and learning processes under CAADP. They do that by creating knowledge products to guide implementation, tracking implementation performance and progress towards policy goals, documenting and disseminating lessons, and building capacities at the local level. The corresponding ReSAKSS activities at the continental and regional levels are described in the right-hand side column of the chart.

Given that ReSAKSS is already operating within the CG system, its facilitators include the two leading centers of the CRP, and well implanted in the CAADP process, it would make sense to consider using it as a knowledge platform to support the CRP's work.

Appendix 5, Figure 1. CRP4 partnership and value addition illustrated using the CAADP Framework



Appendix 6, Table 1. Potential Interactions between CRP4 and other CRPs

	Common interests and goals	Other CRP inputs relevant to CRP4	CRP 4 inputs to other CRPs	Mechanisms for collaboration
CCRP 1.1	Improve nutritional security and agroecosystem resilience in dry farming systems	Assess the availability of agrobiodiversity products; validate their importance for nutrition and health Research nutrition impacts of diversification of livelihood; research synergies among crops, including those of high nutritional value	Research on food safety and neglected zoonoses as constraints to both human health and animal production/productivity	Direct links through addressing the same target groups; work closely on enhancing food quality and diet diversity
CCRP 1.2	Improve nutrition of the poor in humid farming systems; address issues of pesticide use	Address nutritional risks through market and food-based approaches; reduce health risks from pesticide use and intensification Feedback humid-system research needs to CRP4	Research on the ability of systems to deliver food quality and safety without trading off other attributes; food safety risks and emerging disease as constraints to rapidly emerging value chains; pesticides as occupational hazards and food safety risks	Joint contributions to better performing systems in terms of food production, emphasizing quality, safety, and environmental sustainability.
CCRP 1.3	Improve nutrition through promotion of fish production and intake and healthy aquatic ecosystems. Focus on gender, women's participation, empowerment and nutrition and health of mothers and young children	Provide field locations for research into nutrition and occupational health; research on wider services and support needed to build healthier communities in remote and poor aquatic agricultural systems	Exchange of cutting-edge advances in homestead food production systems including fish ponds; promotion of consumption of fish; value chain for fish; and integrated ANH programming	Collaboration on value chains for nutrition and on ANH programs
CCRP 2	Ensure food and nutrition security; focus on policies to achieve these impacts	Assess impacts of a wide range of policies on poverty, nutrition and health and ways to strengthen policymaking to achieve greater impacts Focus on gender analysis and impacts, and methods to assess changes in gender-disaggregated outcomes Identify institutional arrangements that contribute to health of children (social protection and market mechanisms); analyse gendered consumption patterns, domestic roles, and nutrient intake	<u>Components 1&2:</u> Identify opportunities along the value chain to enhance nutritional value of biofortified crops and other nutritious foods <u>Component 3:</u> Generate evidence on how policy and market structure can affect agriculture-associated diseases (AAD) Develop metrics for the multiple burdens of food-borne disease and zoonotics;	Coordinate food safety research and delivery of biofortified products and other nutritious foods to poor populations through value chain research Work jointly, and generate research results, methods and tools to analyze policy impacts on nutrition and health outcomes Collaborate on research on

	Common interests and goals	Other CRP inputs relevant to CRP4	CRP 4 inputs to other CRPs	Mechanisms for collaboration
		Research access to resources, inputs and knowledge around agriculture-health-nutrition linkages; explore livelihood diversification and improvement of health and nutrition Improve efficiency of value chains to enhance nutritional security for neglected populations	provide evidence for targeted and informed policy advocacy, institutional capacity building, and awareness-raising around AAD <u>Component 4:</u> Transfer learning from ANH programming and policy to other types of programs such as social protection, risk management and gender programs and policies	social protection policies, risk management, gender policies, and knowledge management
CCRP 3.1	Ensure that wheat meets users' quality and nutrition needs	Technology generation of nutritionally improved wheat; exploring new traits of nutritional significance High throughput, low-cost phenotypic screening for nutritionally important processing-quality traits and associated marker genes Breeding for protein quality and quantity and micronutrients; ensuring that wheat nutritional quality improvements fit with needs of processing industry	Technical and institutional aspects, including policy, dissemination, and adoption; targeting, advocacy, and promotion of biofortified wheat. Approaches to empower women to protect family health and nutrition; interventions to increase consumption of nutrient-rich wheat by women, children, and other vulnerable groups Identify points where nutrients are lost and gained in the wheat value chain	Based on priority setting and co-funding by CRP4, WHEAT will partner with CRP4 on biofortification and technology adoption in specific countries.
CCRP 3.2	Nutritious maize	Develop biofortified maize (macro- and micronutrients), nutritionally enhanced germplasm, breeding approaches, and functional markers Nutrition research to assess factors influencing bioavailability Assess impact maize interventions on child nutrition; insights from gender and value chain analysis that may influence impact pathway of nutritionally enhanced maize	Research on human nutrition, food technology, nutrient analysis, and micronutrients Targeting, advocacy, and promotion of biofortified maize Empower women to enhance family nutrition and health; interventions to increase consumption of nutrient-rich maize, especially by women & children Identify points where nutrients are lost and gained in the value chain, and potential interventions	Based on priority setting and co-funding by CRP4, CRP3.2 will focus on developing nutritionally improved maize; CRP 4 will focus on technical and institutional aspects of nutrition including policy, dissemination, and adoption of biofortified crops (HarvestPlus) Joint priority setting for new traits Co-funding of technology development and adoption in target countries for nutritionally improved maize
CCRP 3.3	Improve nutrition and health through	Nutritional enhancement of rice; research into genes and allelic diversity conferring enhanced		Co-investment by CRP 4 into GRiSP for biofortification rice

	Common interests and goals	Other CRP inputs relevant to CRP4	CRP 4 inputs to other CRPs	Mechanisms for collaboration
	rice research	nutrition Estimate impact of improved rice on health and nutrition through DALY assessments		breeding (HarvestPlus)
CCRP 3.4	Grain legumes for health and nutrition Mycotoxins Plant toxins	Program Thrust 2 (Legumes for nutrition and health): mechanistic studies on effects of legume consumption on health; preparation methods to increase bioavailability and attractiveness of legumes; nutritional and biochemical profiles Improving agronomic practice to eliminate food hazards such as aflatoxins Development of nutritionally enhanced varieties; improved seed systems for nutritionally enhanced crops; promotional messages that stress nutrition	<u>Component 1:</u> Incorporating nutrition and food safety considerations in the value chains for legumes; and improving processing to protect nutritional value <u>Component 3:</u> Evaluation of low-toxin grass-pea and faba beans, and improved agronomic practices and food-processing methods Integrated pest management to allow reduction of pesticide use Developing and evaluating cost-effective, pro-poor and appropriate risk management for mycotoxins that can be scaled out <u>Component 4:</u> Integrate innovative agricultural technology and expertise into integrated community-based ANH programs.	Coordinate work on value chains for grain legumes to incorporate nutrition and food safety concerns and activities Work on breeding programs conducted under HarvestPlus and AgroSalud Coordinate incorporation of safe and nutritious bean products in ANH programs
CCRP 3.5	Enhance the role of roots, tubers, and bananas in reducing risk of malnutrition Food safety issues	Breeding for improved nutrition; nutritional studies to understand bioavailability and retention of minerals and vitamins during storage, cooking, and processing Food safety issues and product quality	Evaluation of low-toxin cassava, improved agronomic practices, and food-processing methods	Collaboration on diet diversification, biofortification, and deployment of high nutrition varieties
CCRP 3.6	Enhance nutritional benefits of dryland cereals Mycotoxin control Pesticides	Program Thrust 3 (healthy cereals for improved nutrition and wellbeing): accelerate and modernize development of resilient dry land cereals of improved quality, through biotechnology, marker technology, and participatory research. Provide evidence, aggressive advocacy on health and nutrition benefits of dryland cereals Research into health benefits of dryland cereals (and livestock products from animals fed on dryland cereals); develop traditional and alternative diverse food products high in nutrition	<u>Component 3:</u> Research on pesticides as occupational hazards and food safety risks Developing and evaluating cost-effective, pro-poor and appropriate risk management for mycotoxins that can be scaled out for wide-reaching impacts.	Collaborate on innovative strategies for using dryland cereals to improve human nutrition

	Common interests and goals	Other CRP inputs relevant to CRP4	CRP 4 inputs to other CRPs	Mechanisms for collaboration
		Tools and capacity to monitor mycotoxins contamination; research into health effects of pesticides		
CCRP 3.7	Produce more meat, milk, and fish to increase income, food security, health and nutrition of poor populations	Provide comprehensive framework in focal countries and sites to channel research on health and nutrition for communities dependent on AAS	Global, regional, national, and household level analyses of food safety, health and nutrition issues that need to be addressed in CRP 3.7 value chains work; guidance on best practices	Joint analysis of health and nutrition issues in countries targeted by CRP 3.7; Joint participatory diagnoses to develop integrated projects that link CRP3.7 and CRP4 Collaboration on value chains targeted by CRP3.7 to enhance nutrition and food safety along the value chain and increase the poor's access to safe and nutritious foods Joint work on incorporating production and consumption of animal source foods in ANH programs to improve nutrition and health
CCRP 5	Improve livelihoods through research on water scarcity, land degradations, and ecosystem sustainability	Research into new socially (and economically) attractive, larger-scale approaches to water management, designed to optimize water productivity while minimizing health risk and environmental damage	Inform CRP5 by adding health considerations as a faction in agricultural water management interventions	Coordinate water management options to reduce AAD Address health risks in research projects hosted by CRP 5 on water management interventions
CCRP 6	Enhancing contributions of forests, agroforests, and trees to communities and smallholders and to the environment	Policy and market research for NTFPs and fruit trees for nutritional and medicinal value; conservation of wild relatives of important food and medicinal resources Research on forest and health issues at landscape scale, linked to the emergence of new diseases Research on medicinal plants in a variety of contexts	Assessment of nutritional value and food safety risks of NTFPs and fruit trees in the context of value chain research Research on health service effects of forest agroecosystems; research on disease emergence linked to use of forest agroecosystems; research on medicinal plants as relevant	Work together in developing capacity for nutrition and health research around forests and fruit trees Work on participatory domestication of indigenous, underutilized fruit trees species in different agro-ecological zones and on the development and improvement of value chains for their traditionally used, nutrient- rich products.

	Common interests and goals	Other CRP inputs relevant to CRP4	CRP 4 inputs to other CRPs	Mechanisms for collaboration
CCRP 7	Pro-poor adaptation to and mitigation of climate change	Climate change and environment are critical considerations for vulnerable and marginalized populations; these are also most vulnerable to threats to food and nutrition security and to AAD. CRP7 will produce downscaled climate and development scenarios for targeted regions. Analysis of adaptation options that may feed back to nutrition and human health, through shifts in the food system arising from diversification. CRP7 will bring CRP 4 outputs into the climate community	CRP 4 will produce scenarios of intensification and disease futures that will inform CRP7's work Effect of climate change on micronutrient quality, types of plants grown, and genotype of staple crops grown (and effects on micronutrients)	Collaborate on evaluation of health implications of adaptation options Collaborate on assessing the impacts of climate change on consumer choices regarding nutritious foods, including changes in availability and access, in environments with different levels of susceptibility to climate change shocks.

Appendix 7, Table 1. CRP4 capacity-strengthening strategies, outputs, outcomes and impacts

Capacity-strengthening strategies	Outputs (direct result of CRP4 efforts)	Outcomes (change in behavior)	Impact (long-term effects)
1. Capacity assessment	<ul style="list-style-type: none"> • Identification of capacity needs, existing capacity and capacity gaps to achieve CRP4 goals • Capacity-strengthening strategy developed for individual components and CRP4 	<ul style="list-style-type: none"> • Well-defined CRP4 capacity-strengthening needs • Well-developed monitoring indicators for tracking the activities and outputs of capacity-strengthening efforts 	<ul style="list-style-type: none"> • Enhanced capacity for better integration of agriculture nutrition and health objectives in development interventions
2. Individual capacity strengthening	<ul style="list-style-type: none"> • Increased number of skilled researchers, scientists, analysts, and policymakers who can generate and use knowledge for CRP4 objectives • Capable research collaborators with up-to-date knowledge on tools and methods applied in CRP4 research 	<ul style="list-style-type: none"> • Higher quality research on CRP4 issues • More relevant problems identified and addressed by national scientists • Better and equitable research partnership with national research and extension systems (NARES) 	<ul style="list-style-type: none"> • Improved technologies, policies, and program interventions contribute to sustainable agricultural system • Increased research outputs/publications by national research partners • Stronger national research systems/ institutions
3. Institutional capacity strengthening	<ul style="list-style-type: none"> • Well-targeted collaborative partnership with national organizations • Focused capacity strengthening of policymakers, program managers, and research managers • Improved institutional capacity to design and implement research and program interventions 	<ul style="list-style-type: none"> • Strengthened research organizations strategic in problem-solving • Better engaged national policymaking systems for CRP4 goals • Increased publishing / outputs by national systems • Effective use of research 	<ul style="list-style-type: none"> • More relevant priorities set for institutions; improved ability to attract funding • Better managed national systems of agriculture research and institutions

4. Supporting teaching and training organizations	<ul style="list-style-type: none"> • Improved organization ability to design, implement, monitor, evaluate, and assess the impact of integrated program interventions • CRP4 research results and methods developed as learning resources; country-level case studies developed as source book for use in training and learning programs • Enhanced interaction within target countries among the research, education, and policymaking institutions; exchange of collaborating researchers and students 	<p>results for designing better-integrated program interventions</p> <ul style="list-style-type: none"> • Educational and training organizations incorporate learning content and case studies from CRP4 research in curricula • Joint output through exchange visits that enhance the quality of research in targeted countries 	<ul style="list-style-type: none"> • Students and researchers familiar with results and research methods from CRP4 • Joint research products owned and used internally in the country for designing program interventions and policymaking
5. Support to learning networks	<ul style="list-style-type: none"> • Well-functioning formal/informal learning networks that use CRP4 methods and results 	<ul style="list-style-type: none"> • Improved knowledge-sharing among the network members on issues related to CRP4 • Increased ownership and sustainable use of CRP4 results and methods for research and educational programs • Regional and sub-regional policy organizations adopt results from CRP4 research as part of policy and strategy development • Use of CRP4 technologies, research, and methods of analysis at various stages of policy process in targeted countries 	<ul style="list-style-type: none"> • Informed members of the learning networks use the knowledge gained for future research programs • CRP4 knowledge access and use by a wide range of institutions in North and South • Improved policy environment that enables integration of agriculture, nutrition, and health policies and programs • Improved policies and strategies at the national level that recognize and use results of CRP4
6. Improving policy environment through capacity strengthening	<ul style="list-style-type: none"> • Strengthened capacity of policymakers and strategy developers at regional and sub-regional policy organizations for making informed policies using CRP4 results • Improved understanding of the policy process and actors at the national level for increasing the use of CRP4 research results 	<ul style="list-style-type: none"> • Strengthened capacity of policymakers and strategy developers at regional and sub-regional policy organizations for making informed policies using CRP4 results • Improved understanding of the policy process and actors at the national level for increasing the use of CRP4 research results 	<ul style="list-style-type: none"> • Strengthened capacity of policymakers and strategy developers at regional and sub-regional policy organizations for making informed policies using CRP4 results • Improved understanding of the policy process and actors at the national level for increasing the use of CRP4 research results

Appendix 8. CRP4 Capacity Strengthening Activities by Component

Component 1 – Nutrition-Sensitive Value Chains

Capacity development will be critical for the complex multi-disciplinary and multi-sectoral research under this component. Full participation of regional partners will ensure individual and institutional capacity strengthening. This will also ensure that methodological frameworks for data gathering and analysis are harmonized, that the tools and methods developed are used widely, and that the concepts of nutrition-sensitive value chains are adopted and disseminated. Researchers will be trained in several specific areas: dietary assessment, including consumption and use of traditional crops; impact assessment regarding the contribution of traditional crops and the potential contribution of specific interventions; and intervention design to increase demand for nutrient-rich foods.

Institutional capacity support of value chain stakeholders at all levels (and particularly women) will be critical to sustainability, including farmers' organizations, NGOs, public sector marketing agencies, representatives of the processing industries, women entrepreneurs, and consumer associations. A major emphasis will be on educating these value chain stakeholders to use a nutrition lens and to identify opportunities to enhance the nutritional value of foods at different steps of the value chain. Capacity development will also include training to enhance their skills as advocates in promoting nutrition-sensitive value chains (similar to the Bioversity–M.S. Swaminathan Research Foundation training courses for women entrepreneurs). This component will also engage with relevant universities and training organizations, supporting them to incorporate new knowledge generated by the research into their training and education curricula.

Component 2 – Biofortification

Lessons learned from existing biofortification programs point to three specific agricultural research and delivery areas that particularly require strengthening.

1. Capacity building to enable National Agricultural Research and Extension Systems to develop, evaluate, and disseminate biofortified crops. Crop evaluation, in particular, requires infrastructure for high throughput and precision phenotyping for quality traits, as well as technical backstopping for optimizing phenotyping assays. Short-term training will be provided on an ad hoc basis for adaptive research or GXE analysis, as an area that pertains directly to product development within this time-bound program. Training may include supporting the secondment of CGIAR scientists to target countries to oversee biofortified crop development activities, providing valuable one-on-one training to NARES partners.
2. Strengthening seed systems for seed multiplication and dissemination, to ensure that commercial release of crops is supported with abundant quality seed for farmers. Actors along the seed system value chain will be identified, and individuals and institutions responsible for seed policy will be targeted for capacity strengthening.
3. Because biofortification is such a new science, there is limited capacity for nutritional analysis of staple crops by NARES in target regions. All target countries of this component will need a regular program of laboratory assessments.

Component 3- Control of Agriculture Associated Diseases

Capacity-strengthening activities of this component will focus on three main related areas: (i) capacity to generate trans-disciplinary knowledge and innovative strategies; (ii) capacity to disseminate, adopt, and sustain knowledge; and (iii) capacity to build partnerships and innovation networks. The overall strategy will be to leverage on existing national and regional capacities rather than building new ones, by encouraging south-south collaborations. Specific strategies for capacity strengthening will include: capacity needs assessment with development partners; building on existing innovation platforms;

capacity-building targets for development partners; and graduate and post-graduate training. This component will work with other expert boundary partners, including the advanced research institutes in both developed and developing countries as well as national and international NGOs. Participation of women will be actively encouraged, with specialized training provided at individual and institutional levels. In addition, young researchers and technicians will be encouraged to enroll in degree programs, with the component providing a platform for collaborative research.

Component 4 – Integrated Agriculture, Nutrition, and Health (ANH) Programs

Component 4 will focus on building individual, group, institutional, and policy level capacities through research collaboration.

Specific capacity development activity at the individual level includes strengthening the skills of the policy researchers and analysts for designing and implementing studies to evaluate the impact of program interventions in agriculture, nutrition, and health. At the group level, it will build and support learning networks among research and policy organizations. Learning networks will take advantage of complementarities among organizations, encourage shared learning and capacity development, and focus attention on integrated agriculture, nutrition and health program interventions.

At the institutional level, capacity will be strengthened to engage in the research process and to extend or use research results, working with organizations such as government ministries, civil society organizations (CSOs), international and local non-governmental organizations (NGOs) and private organizations. Program managers and policy decision makers will be targeted to mainstream the integrated approach into program design and implementation. This component will also engage in organizational capacity strengthening to design, manage, use, and evaluate research outputs, to develop community-based programs integrating ANH interventions. In addition, field research sites will serve as platforms for academic institutions in the north and south to interact and collaborate on program-relevant applied research and to acquire invaluable field and research experience. This component will also engage with relevant universities and training organizations, supporting them to incorporate new knowledge generated by CRP4 into training and education curricula and other learning resources.

At the policy level, CRP4 will also link with regional organizations for capacity strengthening, providing inputs in support of existing policy platforms that integrate agriculture for improved nutrition and health. Initially, two key partners will provide entry points for cross-sectoral engagement, in the target regions of Sub-Saharan Africa and South Asia.

- In Africa, AU/NEPAD (through its CAADP process) is a central animator in agricultural interventions, with capacity to link these to broader cross-sectoral engagement through regional economic communities and national government plans. The key target audience for this exercise would be policy decisionmakers at the regional and sub-regional levels. At the AU/NEPAD level, thematic sessions on integrating agriculture, health, and nutrition will be conducted for program leaders and policy decisionmakers. Similar thematic presentations will be made to strengthening the knowledge base of the policymakers in sub-regional organizations, such as COMESA in eastern and southern Africa and ECOWAS in Western and Central Africa.
- In the much larger South Asia region, planning ministries and national food security task forces in individual target countries will be strengthened for mainstreaming integration of ANH objectives in national policies and strategies. Regional and national forums and networks will be strengthened for policy dialogues and communications. For example, the Public Health Foundation of India provides a forum for looking at innovative public health solutions, including agricultural ones, to improve nutritional and health performance.

At the national level, leadership and managerial skills are needed to manage cross-sectoral collaboration. In order to bring together the sectoral policymakers from agriculture, nutrition, and health,

there is a need to understand and strengthen the policy process. Results and methods generated from this component will be used to develop cross-sectoral capacity throughout the policy process, targeting the national food security and nutrition taskforces to engage in a series of policy dialogues, to identify capacity gaps and to strengthen their capacity for incorporating the results of research into national policies and strategies.