

MP4: Agriculture for Improved Nutrition and Health

1. Justification: Challenges and Opportunities

In recent years, the world's poor and hungry have been hard hit. The recent food and financial crises heavily impacted food security, pushing the number of hungry people to more than 1 billion. Progress in combating maternal and child malnutrition has stalled in many high-burden areas, leading to long-term and irreversible negative effects on the cognitive and physical abilities of many people in developing countries, and on those countries' economic productivity. Maternal and child undernutrition contributes to more than one-third of child deaths and 10 percent of the global burden of diseases. 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 and 10 percent of deaths in low income countries. The economic toll of these health losses is also huge: as an example, severe acute respiratory syndrome (SARS) cost an estimated US\$50 billion; a major influenza pandemic could cost more than US\$1 trillion. The cost of malnutrition to economic development is estimated at \$ 20-30 billion annually. Without the right 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 interplay between nutrition and health: It is the primary source of calories and essential nutrients, it is a source of income for 80 percent of the world's poor, and it is essential for human life, health, and culture. On the other hand, livestock and wild animals are also the source of the great majority of human infectious and emerging disease. As a result, agricultural development is fundamental for sustaining the nutritional and health status of billions of people. However, many challenges (such as population growth, urbanization, and climate change) threaten the availability of water, land, and other natural resources needed to sustain the world's population, and these must also be addressed

Business as usual is no longer sufficient. As a result of agricultural intensification, agriculture-associated diseases could spread further and new ones could develop rapidly. The failure of agriculture to provide access to nutritious foods and high-quality diets could aggravate the widespread problem of micronutrient deficiencies. Diets centered on cheap, calorie-dense, nutrient-poor foods rather than vegetables, fruits, and animal-source foods could deepen the emerging epidemic of obesity and chronic diseases in countries undergoing economic and nutrition transitions.

A focus on agricultural development and growth presents enormous opportunities: If the agricultural intensification needed to feed a growing world population can be managed in a sustainable way, the health and nutrition of vulnerable populations can be vastly improved. Better food safety, water quality, and control of occupational, zoonotic, and emerging diseases can reduce disease risks and improve health and nutrition. Greater access to more nutritious and diversified diets can accelerate progress in reducing malnutrition and diet-related chronic diseases and infections. Improved nutrition and health, in turn can reduce poverty for the 1.4 billion people living on less than \$1.25 a day. A greater focus on the role of women in agriculture, as potential mediators of household and individual food and nutrition security as well as on the intra-household food allocation could accelerate progress in improving the nutrition and health of women and young children. The key is to act now, just as the health, nutrition, and agriculture communities are beginning to recognize that they cannot do it alone and that only by working together will they have a chance to meet their common goals of reducing poverty, malnutrition, and ill health.

The importance of agriculture for nutrition and health is recognized now as never before. This will allow MP4 to **enhance old and create new long-term partnerships among agriculture, health, and nutrition researchers, policymakers, and development practitioners** to: (1) strengthen their capacity in developing, adapting, evaluating, and using new methodological tools and approaches to link agriculture, nutrition and health in research, policy, and practice; and (2) design and implement integrated, gender-responsive, multisectoral programs and policies that cut across the traditional sectoral divides, evaluate them, and generate lessons learned from these experiences.

The research program will tackle this complex agenda by focusing on two broad research components: maximizing the potential of agriculture to improve nutrition through better dietary quality; and promoting safe agricultural and food systems practices that reduce infectious and chronic disease risk. The two research areas will be brought together under a common framework to build on the synergies between agriculture, health, and nutrition. The research program focuses on two target populations: 1) populations that are directly involved in or exposed to agriculture intensification; and 2) marginalized, vulnerable, and/or ultra poor populations (communities, households and individuals with the highest rates of chronic hunger, undernutrition, and infectious diseases like HIV/AIDS). The latter group also includes populations that have traditionally been excluded from development, such as pastoralists, ethnic minorities and people affected by conflict. For these groups, joint agriculture-health-nutrition solutions will be linked to broader social protection programs.

By forging new partnerships in programs in which agriculture has a profound impact on human health and nutrition, MP4 is expected to significantly improve the livelihoods of the poor, especially women, as measured by increased incomes and food security, and by enhanced diet quality, health, and nutrition. This partnership agenda will have a strong focus on building capacity of key actors along the impact pathways. On the macro scale, MP4 has the potential to increase the health and nutrition benefits of agricultural research, programs, investments, and policies. These benefits can feed back to agriculture, creating stronger, more effective, and sustainable agri-food systems that promote better health and better-nourished producers and consumers.

2. Overall Objectives

The overall goal of this research program is to contribute to the CGIAR impacts of improving food security, enhancing environmental sustainability, and reducing poverty through agricultural interventions that improve human health and nutrition. Poor health and nutrition are inextricably linked to poverty. Specific objectives include:

1. Maximize the impact of agriculture on food security, diet quality, and nutrition through: a) nutrition-sensitive agriculture to improve the availability, access to, processing, and consumption of nutrient-rich and diverse foods for the poor, especially for women and young children, b) biofortification to increase access to and intake of nutrient-rich staple foods.
2. Develop new gender-responsive approaches to control agriculture-associated diseases in marginal and vulnerable populations that suffer from neglected diseases including food borne infections and intoxications, and water-associated, zoonotic and occupational disease.
3. Assess and mitigate the agriculture-associated health risks involved in intensifying agri-food systems through improved food safety, water quality, agricultural practices, and the control of infectious (zoonotic and emerging) diseases to enhance environmental sustainability, reduce poverty, and increase food security.
4. Improve agricultural development planning and policymaking to achieve better health and nutrition, promote sustainable intensification of agri-food systems, and support marginal and vulnerable peoples in developing countries.

To achieve these objectives, research in the program will promote, coordinate, and undertake cutting-edge research on the interactions between agriculture, nutrition, and health, to better catalyze nutritional, health, and agricultural outcomes. Emphasis will be placed on forging partnerships and strengthening the connectivity between agriculture and health organizations to exploit synergies in research, policy, and practice. The value added of this approach will be to effectively meet the increasing demands of health, nutrition and agriculture professionals and policy makers to contribute evidence, tools and approaches to improve health and nutrition through agriculture.

3. Innovation

This research program will exploit new opportunities to strengthen and forge unique multi-sectoral partnerships for delivering gender-sensitive agricultural solutions to the most pressing nutritional and health problems of the poor and vulnerable. It will also confront the health threats and nutritional challenges in rapidly intensifying agri-food systems, by bringing new technologies and science approaches to shaping more sustainable and equitable agri-food systems in the future at the national, regional, and global levels.

Growing awareness of the importance of food and nutritional security and of the critical role of agricultural research sets the stage for program's goal of deepening partnerships in the agriculture, nutrition, and health research and development communities. The program will also integrate gender equity considerations in all its activities, recognizing the critical role of women in household and community delivery of improved health and nutrition outcomes. The initial proposition of MP4 is to focus on new partnerships along three critical impact pathways.

The first is to develop innovative coalitions of agriculture, nutrition, and health in large-scale social protection and development programs to address the global challenge of improving nutrition and reducing the multiple burdens of disease for poor and vulnerable populations. New trans-disciplinary approaches will tackle age-old malnutrition and neglected-disease problems in marginal and vulnerable communities to more effectively improve livelihoods and reduce poverty.

The second pathway is to accelerate the supply and demand for more nutritious and healthy foods, through a two-pronged approach of (1) linking improved production of highly nutritious foods, including biofortified staples, to their better availability and accessibility to poor and vulnerable populations, and (2) raising global awareness and knowledge of the importance of nutritious foods and high-quality diets for the prevention of malnutrition and diet-related chronic diseases. These solutions are mediated through changes in agricultural production and food systems largely implemented by other MPs and partners.

The third pathway will expand and strengthen agriculture–health partnerships to reduce disease threats. Recent human health scares (such as bird flu, mad cow disease, HIV/AIDs, and spreading water-related and food-borne diseases) have had disastrous impacts on people, economies, and livestock. They have also brought new commitment to the problem of diseases associated with agriculture and unprecedented willingness to collaborate across sectoral and geographical divides. This research program will be positioned to bring agricultural and livestock research into the center of the global One (human, animal and environmental) Health initiative. Proposed agriculture-based interventions in this context are complementary and much more cost-effective than traditional health approaches.

The complex challenge of sustainably shaping agri-food systems to meet the rapidly growing demands in developing countries has large health and nutrition implications. A variety of technological and methodological innovations are now possible. The integration of technological innovations (metagenomics, proteomics, rapid diagnostics, and information technologies such as mapping and mobile phones) with methodological innovation (participatory risk assessment, gender analysis, ecohealth, integrated disease management, value-chain analysis and governance, multiple disease burden assessment and scenario modelling) will be a novel feature of research within this MP. Specifically, this research program will tap into the enormous resources of international public- and private-sector biomedical research to provide vaccines, diagnostics, and other technologies to improve health through control of zoonotic and emerging diseases. Smarter surveillance systems applying a range of genomics, spatial targeting, and participatory epidemiology will be linked to information and knowledge management systems at national, regional, and global scales.

Impacts will be delivered through others. Thus, the details of these impact pathways and new approaches need to be developed with partners. An essential part of those discussions is agreeing to joint priorities and roles and promoting co-investments that link research inputs to development programs and capacity development. Better approaches for targeting interventions must take into account the critical role of gender in household and community delivery of improved health and nutrition outcomes.

4. Research Program (Activities, Outputs, Outcomes, Impacts, and Impact pathways)

4.1 Realizing the potential of agriculture to improve nutrition

Agriculture is essential for nutrition. As a major source of income and food security, agriculture can provide the energy and essential nutrients needed for nutritional wellbeing. Figure 1 shows that improving access to food is one of three main pillars for improving nutrition, along with providing adequate resources for care and increasing access to health services. Each pillar is essential but

insufficient in itself. This is why improvements in agriculture do not guarantee reductions in malnutrition; unless significant improvements are seen in all three pillars simultaneously, nutrition will continue improve too little and too slowly. This Mega Program component will develop new approaches to use agriculture as a key instrument for promoting better nutrition, and a platform to deliver preventive health and behaviour change interventions.

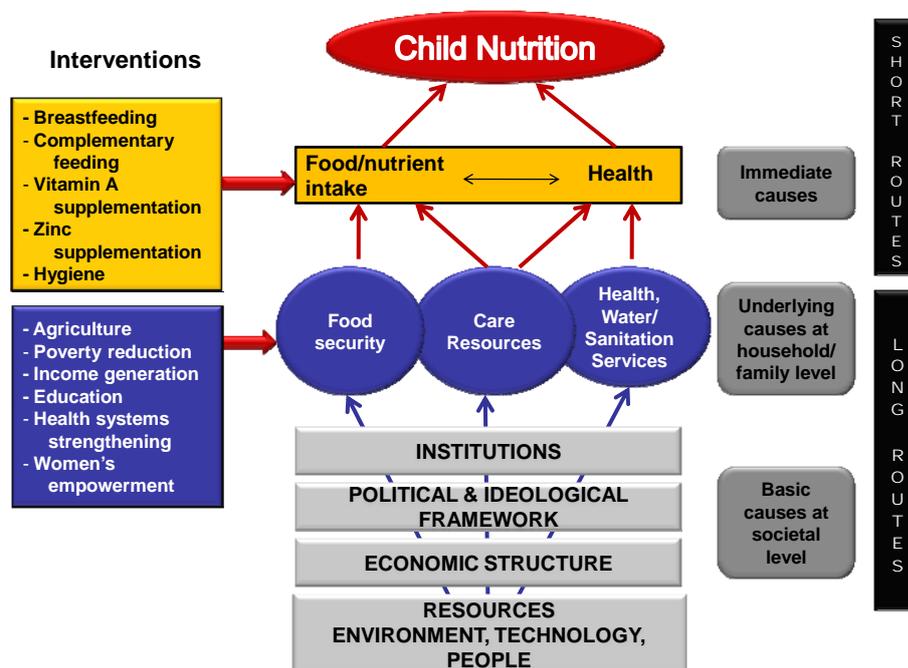
The component includes two interrelated subcomponents:

- 1) **Agriculture for improved food security, diet quality, and nutrition.** This research focuses on developing, testing, and evaluating gender-equitable approaches to maximize the impact of agriculture (and agri-food systems) on improving the availability, access to, processing, and consumption of nutrient-rich and diverse foods to enhance overall diet quality and nutrition.
- 2) **Biofortification of staple foods.** This research focuses on biofortification (breeding higher amounts of essential micronutrients in staple foods) to increase access to, and intake of affordable micronutrient-rich staple foods for better nutrition.

The two subcomponents share the common goal of enhancing the impact of agriculture on nutrition by making agriculture more nutrition-focused. They also both focus on reducing the gender gap in women’s access to, and control over assets. They differ in research scope, activities, processes, and actions for achieving this goal, but are fundamentally complementary.

Agriculture is defined broadly to include pastoralism, fishing, and harvesting of wild foods; malnutrition refers to poor diet quality and nutritional deficiencies with or without energy deficits.

Figure 1. Determinants of nutrition and interventions to address them



Source: Adapted from UNICEF model.

4.1.1. Agriculture for improved food security, diet quality, and nutrition

Background. Currently, an estimated 1.02 billion people suffer from hunger and food insecurity, which is defined as not having enough food (calories) to live a healthy life. These estimates, however, do not take into account the other critical components of food security: having physical and economic access to *nutritious* foods, *at all times*. This subcomponent focuses on making nutritious foods more

available and accessible to the poor throughout the year. Nutritious foods include animal-source foods (fish, meat, eggs, and dairy products), fruits and vegetables, biofortified staple foods, and wild foods with high nutrient content. The key target group of the research in this subcomponent is marginalized and vulnerable populations, including those affected by HIV/AIDS, and women and young children in particular. It also addresses some of the challenges faced by countries and populations undergoing economic and nutritional transitions.

Objectives. The ultimate goal of this subcomponent is to synergize agriculture and nutrition linkages and make agriculture the powerful vehicle it should be for improving diet quality and nutrition. Well-nourished and healthier producers and consumers will have greater productivity and income, breaking the insidious cycle of poverty, malnutrition, and disease. The specific objectives are to:

- 1) Develop, test, and evaluate novel approaches to maximize the impact of agriculture (and agrosystems) on improving the availability, access to, processing, and consumption of nutritious and diverse foods, with a special emphasis on women and young children; and
- 2) Develop, test, and evaluate new tools to increase global awareness and knowledge of the importance of nutritious foods and high-quality diets for the prevention of malnutrition and diet-related obesity and chronic diseases.

Activities. Below are some examples of broad categories of research that will be undertaken.

Strengthen food systems that increase the availability and accessibility of nutritious foods such as animal-source foods, fruits and vegetables, biofortified foods, and wild foods. Using the example of fish, research will identify means of aligning fisheries and aquaculture development and policies with the nutritional needs of poor consumers. MP4 will add a nutritional dimension to systems and commodity development actions of other MPs. Nutritional input will help in the design of economic and institutional mechanisms to balance the potential for capture fisheries and aquaculture to generate export revenues in the global seafood trade, with their role in providing nutritious food for the poor at the local level. Work will also be undertaken to develop approaches to manage the productive ecosystems of coastal and inland waters to protect the diversity of fish and other aquatic animals that contribute to the diets of the poor. Another research area could consist of designing aquaculture-development technologies that are suitable for small farmers, to bring both nutritional and income benefits to the poor. Similar nutritional and health inputs into broad-based research will be undertaken for other food commodity systems, including for the promotion, dissemination and marketing of new biofortified staple crops as they become available.

Use agrobiodiversity to improve nutritional diversity. The first set of activities in this area will assess patterns, levels of use, and the role of local biodiversity in people's diets. This information will be used to develop and evaluate approaches aimed at enhancing current use of local foods (including local crops, indigenous vegetables, animals, and wild fruits) to contribute to greater dietary diversity and increase the availability of nutritious crops for production and consumption year round by vulnerable populations, including those affected by HIV/AIDS. Research will focus on women as priority stakeholders, aiming to enhance their capacities to mobilize greater benefits from local crops for both household consumption and market benefits. It will also focus on poor rural and urban areas, with benefits expected for chronically poor populations as well as those affected by nutrition transitions. Another activity will consist of evaluating the genetic variation in nutritional content of important local foods, quantifying the retention of key nutrients and other health-promoting bioactive compounds during storage and processing, and analyzing their bioaccessibility and bioavailability. Using banana as a case study, cultivar diversification strategies will be piloted in traditional farming systems. The existing genetic diversity will also be deployed in crop-improvement programs.

Develop tools to increase the demand and supply for nutrient-rich foods along the value chain, including biofortified staples as well as local foods from agrobiodiversity and from open-access and common property resources (such as fisheries, non-timber forest products, and wild foods). The goal of this activity is to educate consumers, producers, and other value-chain actors in the production, processing, preparation, and consumption of nutritious foods. This will require understanding the

factors that affect the demand for such foods in the value chain, and promoting innovation by working with small-scale producers, processors, and other market actors to create new products. Studies to assess consumer willingness to pay will also be conducted. Opportunities to reach new target groups such as future caregivers through school feeding programs or HIV/AIDS affected populations will be explored.

Develop new technologies and strengthen traditional ones for small scale food processing to improve the value-added of farm produce and enhance women's income-generation opportunities. Post-harvest practices and processing (such as drying of fish and vegetables) can help preserve foods, reduce the anti-nutritional factors, and expand their season of availability. Research on the retention of nutrients during processing is important to ensure best practice to maintain nutritional quality. Research on pre- and post-harvest management options to monitor and reduce mycotoxin levels in processed foods is also critical to their safety and marketability. New research could also test the feasibility of small-scale, staple-food fortification at community mills using vitamin/mineral pre-mixes. Another promising area is the local production of ready-to-use therapeutic foods (RUTF), which are used for home-based rehabilitation of severely malnourished children. Local production can reduce product costs, benefit local agriculture, generate employment and income, create ownership among communities, and most importantly, save lives.

Design, implement, monitor, evaluate, and scale up nutrition-focused agriculture programs and link them to broad social protection policies. Agriculture programs such as homestead food production (HFP) or home, school or community gardens, are designed to integrate women's empowerment and nutrition interventions into agriculture programs focused on the production of nutritious foods such as fruit and vegetables, biofortified staples, small animal husbandry, and/or fish ponds. The programs can also be adapted to include and promote nutritious varieties of local foods or biofortified crops. Research will be conducted jointly with implementing partners to strengthen the design and implementation of such programs, to evaluate them, and to generate lessons learned for scaling up. Enhanced programs will have stronger and better targeted nutrition interventions and strategic links with the health sector to provide preventive health care services for women and young children. The redesigned programs will serve as platforms to deliver nutrition and health inputs, and will use women as "agents of change" for linking agricultural gains to improved health and nutrition. Given the flexibility of the model, several variations can also be tested and adapted, including school-based community gardening programs, and programs with a greater emphasis on aquaculture. Where relevant, linkages will be established with existing social protection programs and policies.

Assess the constraints in and develop approaches for institutionalizing nutrition awareness building and knowledge acquisition regarding healthy diets, nutritious foods, biofortified staples, agrobiodiversity, and the special needs of vulnerable household members into agriculture policy, programs, and training. In order to expand awareness building beyond the target areas of the MP, this research activity will focus on institutionalization and mainstreaming strategies. The project will promote country-based intersectoral collaboration, drawing from existing experiences from around the world and from regional and international collaborative frameworks. Mechanisms such as multistakeholder information platforms will be launched, along with a wide range of communication tools that help translate research outputs into agriculture and health policies. Extension services programs and university curricula will be developed, disseminated, and promoted in collaboration with new initiatives on Agriculture and Health training such as the Leverhulme Center for Integrative Research on Agriculture and Health. A broad range of formal and informal learning methods will be used to strengthen the capacity of NAREs in mainstreaming nutrition activities.

Research outputs. The research activities will generate broad knowledge on the following:

1. Constraints to fruitful collaboration between agriculture and nutrition;
2. Effective mechanisms to foster collaboration between agriculture and nutrition, and to mainstream nutrition within the agriculture sector;
3. Innovative advocacy tools to raise awareness about nutrient-rich foods and diet diversity;

4. Value-chain approaches for stimulating demand for nutritious foods;
5. Role of agrobiodiversity in increasing diet diversity and nutritional status within different contexts, and approaches to reinforce its deployment in sustainable food system;
6. New models of agriculture-sensitive programs, and knowledge of their cost effectiveness and impact, and of what is needed to scale them up; and
7. Methodologies to evaluate the implementation, impact, and cost effectiveness of integrated multisectoral programs.
8. Methodologies to effectively monitor and reduce mycotoxin contamination in harvested commodities and processed foods

Expected outcomes. The research outputs will generate the following outcomes:

1. Better connected communities of knowledge and practice—from the agriculture, health, nutrition, and social protection sectors;
2. Innovation platforms and learning alliances bringing together farmers, extension workers, implementers, and other stakeholders;
3. Nutrition and health considerations mainstreamed in agriculture technology development in target countries and regions;
4. Policy recommendations and regulatory frameworks developed in support of the mainstreaming of agrobiodiversity use across sectors ;
5. Widespread knowledge and awareness of the importance of nutrient-rich foods and diet diversity, including within-crop (cultivar) diversity, used in policy and practice; and
6. Agriculture-sensitive programs successfully implemented and scaled up, and contributing to overall social protection agenda.

4.1.2 Biofortification of staple foods

Background. The second broad research subcomponent under this MP's nutrition theme focuses on biofortification, a process that uses plant breeding to increase the density of minerals, vitamins, and other nutrients and compounds in food staples eaten widely by the poor. Biofortification offers a *rural-based* intervention that, by design, initially reaches the more remote populations that comprise a majority of the undernourished in many countries, and then penetrates to urban populations as production surpluses are marketed. Initial investments in agricultural research at a central location can generate high recurrent benefits at low cost as adapted biofortified varieties become available in country after country across time at low recurrent costs.

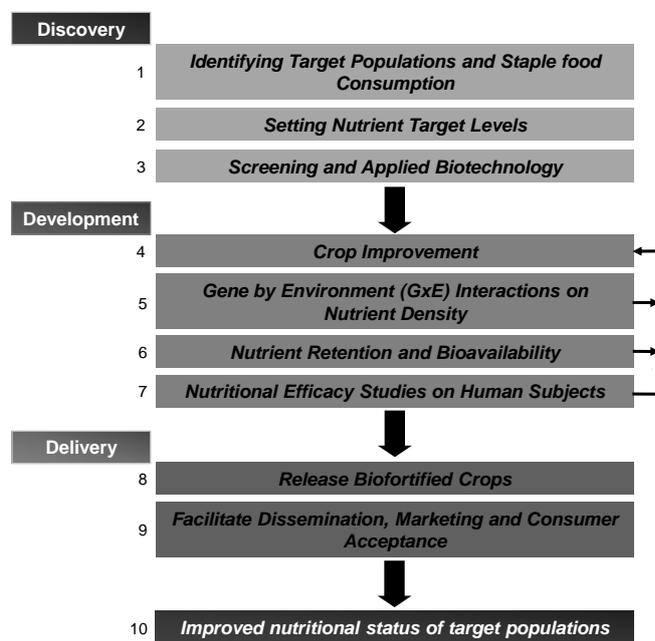
In broad terms, three activities must be accomplished for biofortification to be successful. First, the breeding must be successful—high nutrient density must be combined with high yields and high profitability. Second, efficacy must be demonstrated—the micronutrient status of human subjects must be shown to improve when consuming the biofortified varieties as normally eaten. Thus, sufficient nutrients must be retained in processing and cooking and these nutrients must be sufficiently bioavailable. Third, the biofortified crops must be adopted by farmers and consumed by those suffering from micronutrient malnutrition.

Objectives. Biofortification activities within the CGIAR are largely, but not exclusively, organized under the HarvestPlus Challenge Program. The objective of HarvestPlus, which began operations in 2003, is to increase access to, and intake of, affordable micronutrient-rich staple foods in order to reduce global undernutrition and have a measurable positive impact on human nutrition.

Activities. Much of the evidence available to address the three broad areas of activities outlined above has been generated by HarvestPlus. Through its 15-year program, HarvestPlus seeks to develop and distribute varieties of food staples (rice, wheat, maize, cassava, pearl millet, beans, and sweetpotato) that are high in iron, zinc, and provitamin A using an interdisciplinary, global alliance of scientific institutions and implementing agencies in developing and developed countries. For each crop, HarvestPlus organizes its activities around the ten steps outlined in the Figure 2.

HarvestPlus currently supports breeding for the following crop–nutrient combinations at the following Centers: rice–zinc (IRRI); wheat–zinc (CIMMYT); pearl millet–iron and pearl millet–zinc (ICRISAT); maize–provitamin A (CIMMYT and IITA); cassava–provitamin A (CIAT and IITA); and beans–iron (CIAT). For these six crops, funding is also provided to NARS in target countries and to

Figure 2. The 10 steps of staple crop biofortification



non-CGIAR collaborating institutions for retention, bioavailability, and efficacy studies. HarvestPlus will also organize activities for delivery of these six crops in Africa and South Asia, and for delivery of high provitamin A sweetpotato in Africa. Lower levels of funding for initial breeding studies have been provided for the following crops: potato–iron (CIP); lentils–iron (ICARDA); banana and plantain–provitamin A (Bioversity and IITA); sorghum–iron and sorghum–zinc (ICRISAT). HarvestPlus also provides funding to CIP for development of the NIRS methodology for rapid and low-cost screening of nutrient levels in crosses/candidate lines during breeding. HarvestPlus supports biofortification “country programs” in Brazil and China. In addition to co-funded research to develop multiple biofortified crops in each country, an important objective is sustained institutional coordination of biofortification activities in these countries. In India, HarvestPlus coordinates its biofortification research activities in India with those of the Department of Biotechnology, and seeks to expand this coordination to include biofortification research activities of the Indian Council of Agricultural Research.

Biofortification Activities Currently Outside of HarvestPlus or Proposed To Be Undertaken Outside of HarvestPlus.

1. Agro Salud (CIAT, CIMMYT, CIP, and non-CGIAR institutions) – biofortification activities for rice, maize, sweetpotato and beans in Latin America and the Caribbean
2. Golden Rice (IRRI)
3. Breeding, improved agronomic practices, and delivery of high provitamin A sweetpotato (CIP)
4. Barley, faba beans, chickpea (ICARDA)
5. Groundnuts and chickpea (ICRISAT)
6. Quality protein maize (CIMMYT)

One of the primary objectives of HarvestPlus is for biofortification to become institutionalized at agricultural research centers after HarvestPlus is discontinued (see section 7 below), so that these types of activities are encouraged, and technical assistance may be provided.

Expected outputs and outcomes. Research output from biofortification research consists of findings (published in scientific articles) associated with each of the 10 steps in Figure 2. The main output of this work is an increase in interdisciplinary communication between plant scientists and human nutrition scientists.

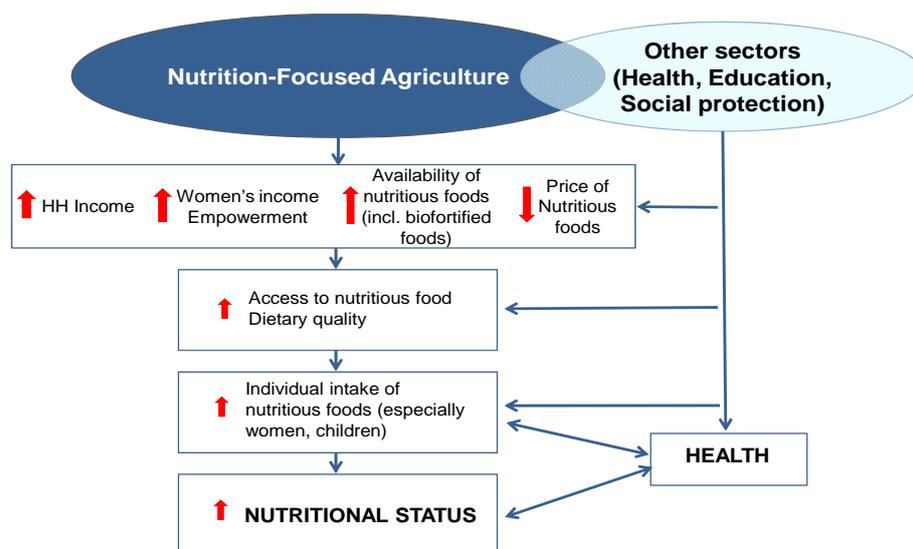
4.1.3. Impact and impact pathways of research activities for “Realizing the Potential of Agriculture to Improve Nutrition”

The expected long-term impacts of the nutrition component of MP4 are:

1. A more productive agriculture sector, as a result of improved population health and nutrition;
2. Farming systems enriched with a broad range of high-value, nutritious foods, including new biofortified staple crops, for income generation and year-round supply and consumption;
3. Increased household and individual consumption of nutritious foods and increased diet quality
4. Reduced prevalence of child stunting, and micronutrient deficiencies in women and children (vitamin A, iron, zinc) in high-burden countries;
5. A slowed rate of increase of obesity and chronic diseases risks in countries undergoing a nutrition transition.

The pathways of impact are illustrated in Figure 3. Broadly, nutrition-focused agriculture with strong linkages to the health sector (and to social protection and education) will increase the income of men and women, empower women, increase the overall availability of nutritious foods, including biofortified staples, and reduce their price. This in turn will increase household access to nutritious foods and will improve the diet quality of its members. A critical step in the impact pathway for biofortified crops and other nutrient-rich foods is that farmers adopt promoted varieties and that consumers in vulnerable groups eat them in sufficient quantities. Thus, impact will depend on the rate and extent of adoption of nutrient-rich foods by both farmers and consumers. Once this is achieved, better diets and improved health will enhance nutrition, and gains in nutrition will in turn promote health, especially for women and young children.

Figure 3. Pathways of impact of nutrition-focused agriculture on nutrition



4.2 Managing the Multiple Burdens of Agriculture-associated Disease

In poor countries, agriculture-associated disease (AAD), not including malnutrition, is responsible for around 12 million lost disability adjusted life years (DALYs) every year. This amounts to one-twelfth of the total disease burden and one-fourth of the total infectious disease burden. The economic, social,

and environmental costs of AADs are of a similar order of magnitude. The big issues related to agriculture-associated disease are shown in Box 1.

Box 1: Issues related to agriculture-associated disease (AAD)

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| <p>Food-borne disease</p> <p><i>Infections</i> Diarrhea is one of the top three killer infectious diseases in most poor countries and 70 percent is attributed to food and water borne infections. Non-diarrheal food-borne disease imposes a similar level of burden. Inability to meet food safety standards also excludes small producers from higher value markets.</p> <p><i>Mycotoxins</i> Mycotoxins are human carcinogens and combine with chronic hepatitis B virus to increase liver cancer risk up to sixty-fold. Approximately 25% of crops are affected. Loss in trade and market access is estimated at somewhere between US\$0.5-1.2 billion per year.</p> <p><i>Food intoxicants</i> A number of plants are toxic and especially during famines, ingestion leads to important diseases (lathyrism, favism and konzo), particularly in South Asia and sub-Saharan Africa. Often impacts are severe but need further quantification.</p> <p>Zoonotic disease At least 61 percent of all human pathogens are zoonotic. Endemic zoonoses in poor countries are neglected with gross under-reporting and ineffective control. For example, echiniococcosis causes as much as 1 million DALYs, in addition there are human-associated annual economic losses (including medical costs, wage losses and post-operative deaths) estimated at US \$1.9 billion and livestock losses at US \$2.1 billion. Sleeping sickness, rabies, leishmaniasis, cysticercosis, brucellosis, and leptospirosis are diseases of similar impact.</p> | <p>Water-related disease Farmers and consumers are affected by water contaminated with pathogens or chemicals entering the food chain, as well as by infectious water-related diseases such as malaria and schistosomiasis and emerging diseases such as cryptosporidiosis, giardiasis, buruli ulcer, often maintained by poorly designed or managed irrigation or water storage systems, or environmental risk such as toxic algal blooms, associated with agrochemical water pollution. Wastewater irrigation supports the livelihoods of 20-50 million farmers and feeds up to one billion consumers; who are also a risk group where crops are eaten raw. In addition, water pollutants can impact on the health of livestock and consumers of animal products.</p> <p>Emerging Infectious Disease The whole world bears the burden of diseases that originate in animals such as HIV/AIDs or swine or avian influenza but the crucible for emergence is often poor countries, especially intensifying, unregulated livestock systems, urban and peri-urban agriculture, and where wildlife are unsustainably exploited.</p> <p>Pesticides and occupational disease People working in agri-food systems are exposed to a range of biological, chemical and physical hazards (applicators safety) which can also enter the food system. Pesticides and antibiotic residues are especial areas of concern for consumers (consumer safety).</p> |
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The concept of One Health, endorsed at global level through a partnership between FAO, OIE and WHO, recognizes that animal, human, and environmental health are inter-dependent and that agriculture-based interventions play an important role in managing agriculture-associated diseases. MP4 will generate evidence, and will develop and test methods and tools with partners, resulting in more and better control of agriculture-associated diseases in two key populations: **vulnerable and marginalized** people depending on livestock and poor people in **rapidly intensifying agri-food systems**.

Objective. To **measure** and **mitigate** the **multiple** burdens of agriculture-associated disease

Activities/propositions. MP4 offers the opportunity of new ways of working with new partners to provide strategic inputs into bigger One Health initiatives. The program will build partnerships, find out what partners need, and share research ideas. A process of measuring and mapping the burdens will lead into jointly identifying opportunities. Hence, while activities are broadly scoped, they are not pre-specified, so they will need to be developed further with partners. The following section describes some promising directions.

1. Map and measure AAD burdens and intervention opportunities into the future. A critical weakness in current agriculture and health planning is that the true burdens of disease are underestimated. Human health burdens (DALYs) for relevant AADs need to be combined with other burdens, including equity (effects on women and vulnerable groups); economic cost of illness; lost human and animal productivity; trade; market access; ecosystem services; and others to produce an assessment of multiple disease burdens.

Based on initial analysis, opportunity sets of priority AADs best managed through agricultural interventions will be identified, where MP4 can make valuable contributions and where interventions are acceptable, equitable (including gender equity), affordable, and sustainable.

2. Develop and scientifically evaluate better ways of managing priority AADs. Key propositions, to be refined with partners, would include more integrated ways of studying and managing AADs based on converging Ecohealth and One Health approaches, which take a systems approach and integrate participation, trans-disciplinarity, and gender and social equity as essential contributors to health outcomes. This could also include local approaches such as indigenous knowledge and medicines. Within these broad frameworks, analytic approaches include:

- **Scenario** and other futures analysis to understand disease trajectories and plan accordingly
- **Risk analysis** for better managing food- and water-borne disease and occupational hazards, including promoting appropriate levels of protection based on the multiple burdens of disease and improving risk prioritization and management by national partners.
- **Value-chain analysis** in hotspots where food and feed value chains are complex and heterogeneous in order to upgrade the ability of value chains to deliver safe products.

Critical to assessing better ways of preventing and managing AADs are stakeholder and institutional analyses to engage key stakeholders and help build the capacities of key actors. .

3. Predict, plan for, and prevent diseases emerging from agriculture and agro-ecosystems.

Emerging diseases are recognized as an increasing risk with potentially devastating economic consequences, and improving prediction will require a better understanding, quantification, and modelling of the drivers of disease emergence as well as identifying options for reducing key risks in hot spots of disease emergence. Based on these analyses and other approaches, MP4 research will provide evidence and advocate for the development of more effective surveillance and response systems by, for example, incorporating participatory derived data and better linking wildlife, animal, and human surveillance systems.

Research outputs. The specific research outputs will depend on the consultative and collaborative processes. The following examples are based on our current understanding of the priority problems and on research outputs that have demonstrated effectiveness and impact.

1. Produce data and information to contribute to global databases and maps of AAD multiple burdens and intervention opportunities. New and on-going studies will be supported to improve their estimation of burden and benefits from different interventions. Methodologies will be documented and agreed upon with WHO, FAO, and OIE.
2. Identify 5-10 systems and geographical areas as most promising for research into intervention opportunities. Action research projects in these areas will be completed and assessed for effectiveness, efficacy, and impact. Examples of these might be:
 - Developing new diagnostics, vaccines, and treatment or management options for key AADs
 - Improving the safety of food systems through incentive-based interventions such as training and certification of informal sector workers, the majority of whom are women,
 - Testing simple, effective, and attractive technologies for mycotoxin management, and
 - Reducing the risk of food intoxications through breeding of less toxic varieties.
3. Develop communications outputs based on an uptake strategy to facilitate research into use. These would include peer-reviewed publications, policy and technical briefs, extension material, decision support tools for policymakers and implementing bodies, workshops, meetings, exchange visits, experiences, media events, and documentaries.
4. Make recommendations for mitigating the drivers of emerging infectious disease and improving detection and response.

Expected research and development outcomes. Expected outcomes based on likely outputs and activities are given below, though it should be noted that, as with other aspects of the project, these outcomes will be modified and finalized after further stakeholder consultation:

1. A global assessment of AAD Multiple Burdens and intervention opportunities, leading to:
 - an improved understanding of AAD and ‘best fit’ interventions,
 - increased knowledge of the best-bet and best-fit interventions (using an evidence-based hierarchy) used to inform intervention decisions, and
 - a more transparent, efficient, effective, and equitable allocation of resources to AAD.
2. Integrated disease-control and risk management strategies for AAD developed jointly with decision makers and communities in 5-10 target systems leading to changes in the knowledge, attitude, and behavior of decision makers and implementers— shifting from eliminating informal food systems to engaging with them and upgrading them,
 - changes in policies based on hazard and risk analysis, leading to improved water quality and safer food while safeguarding market access for the poor, and
 - changes in policy and practice among the partners responsible for disease control and the involvement of new partners in this area, shifting toward **more** and **better** control of AAD.
3. Outcomes from 5-10 target systems, will be scaled out through an active engagement with research and development partners in other areas with similar problems and of global and regional media and decision makers, leading to:
 - adaptation of solutions and innovations that are tested and proven in the high-priority systems to enable their widespread use,
 - changes in the knowledge, attitude, and behavior of decision makers and those responsible for AAD management to encourage uptake of proven solutions, and
 - changes in policy and practice, shifting to more and better control of AAD.
4. The generation of evidence and the development of methods and tools for better preventing, detecting, and managing diseases emerging from agro-ecosystems, will support international, regional and national partner programs leading to:
 - improved surveillance, planning, and response in hot spots for emerging infectious disease emergence, and
 - the implementation of programs to mitigate the drivers of disease emergence.

Expected impacts. Better policies, programs, and support services will lead to an improvement in the lives of the poor. MP4 will not directly implement these policies, programs, and support services, but will contribute to their improvement by meeting (and if necessary creating) demand for evidence, innovation, and capacity building among and with partners. An underlying rationale for expecting MP4 outcomes to contribute to major impacts is the empirical finding that the majority of disease burden is caused by a minority of diseases, the majority of disease burden falls on a minority, and the majority of risk is created by a minority of value-chain actors. This implies that through **risk-targeting** and strategic inputs/outputs, MP4 can help **partners** to better control AAD for the few people who bear and create most risk, and thus MP4 can leverage large impacts from strategic outputs. Methodologies will be developed and tested in Year 1 to improve the assessment of burden of agriculture-associated disease (AAD). These will be applied and refined in Years 2 and 3 with partners to develop data on the global burdens of disease and the impacts of their control to provide recommendations for cost-effective, agriculture-based interventions for policymakers and investors. While AAD burdens are being estimated, MP4 research will engage with partners to conduct action-research projects on priority agricultural interventions for health outcomes. Based on these pilots, the program expects to support action-research projects implemented by partners in five priority systems targeting 5 million people. MP4-associated research would include up to 10 systems by the end of Year 6, and knowledge and evidence passed on to partners through the networks of OIE, FAO, WHO, and others would multiply the number of beneficiaries over time. Depending on co-investments and partner engagement, up to 200 million poor people would benefit from less risk and better management of AAD. This could translate into approximately 12 million DALYs saved each year by reducing infectious and occupational diseases best targeted through integrated agriculture in least-income countries. This amounts to one-twelfth of the total disease burden and one-fourth of the total

infectious disease burden. The associated economic, social, and environmental benefits would be of the same order of magnitude. (Tools will have been developed in the Multiple Burden Assessment).

Impacts will be achieved through multiple agricultural interventions, to be defined iteratively and collaboratively. Based on past experiences and current knowledge, some potential examples could include:

1. Reducing the epidemiological burden of AADs through quality-assurance schemes for disease-free pork that adopted by the government and the private sector. Interventions could include improved human hygiene, vaccination of pigs for cysticercosis, better smallholder pig management systems, and risk-based food safety systems. Multiple benefits would arise from reducing the number of people at risk from cysticercosis associated with pork production from 50 million to 25 million, and increasing the productivity, competitiveness and income of smallholders in pig production.
2. Reducing the economic burden of disease in poor communities due to lower cost of illness and improved human and agricultural productivity through the development of cost-effective technologies for mycotoxin detection linked to integrated field-control programs, policies, and guidelines for mycotoxin prevention and control. Given appropriate investments, this could reduce DALYs associated with mycotoxins by 50 percent and increase sales of agricultural products by 50 percent, resulting in US\$500 million more in annual sales.
3. Reducing the risk of emergence of new diseases in agro-ecosystems through developing approaches for integrating human, animal and wild-life surveillance and incorporating geo-spatial and participatory information, reducing by 50 percent the time taken to find and respond to agriculture-associated emerging infectious disease, and reducing the economic impact of emerging infectious diseases.

Impact pathways and stakeholder engagement. Diverse initiatives at the global, regional, and national levels are tackling human health problems related to agriculture. Recent disasters such as the bird flu pandemic have made it clear that a one health approach is needed to better manage the diseases that come from agro-ecosystems. MP4's niche is to create demand for and meet the need for evidence, and for those science-based solutions for AAD that can best be delivered through agriculture research. Though a relatively small player, MP4 can in this way have highly strategic inputs into much bigger programs and initiatives.

MP4 will engage with those partners who are responsible for and can influence the delivery of health initiatives and agricultural initiatives influencing health. Research partners will include ARIs, NARS, local universities, and private sector R&D institutions. Development partners will include national governments, civil society, and global organizations. Stakeholder engagement and capacity building will be 'designed to scale up and out.' Participatory Impact Pathways (PIP) and uptake strategy methodologies already used within the CGIAR will be further developed. A Research into Use strategy will be developed that will include:

- identification of key stakeholder groups: scientific experts, development professionals, policymakers, development intermediaries, media, public, and end users,
- identification of desired attitude and behavior change in partners, and channels for influence. Development of targeted products and communication opportunities that go beyond evidence to the information and experiences that can change attitude, beliefs, values, and behaviours, and
- progress monitoring, including process monitoring and stakeholder reflection.

Generic impact pathways are shown in Figure 4. Nested within this overall pathway are the specific pathways that will deliver better management of AAD. The details will be developed consultatively with partners, but experience suggests major impacts are achievable. For example, Figure 5 shows a possible impact pathway linking MP4 outputs to a reduced burden of diarrhea. All the outputs shown and changes in partner practice have been achieved by the CG in specific projects, resulting in quantifiable change in policy and practice and quantifiable improvements in food quality and reduction in risk. Hence, it is plausible to assume that with greater resources and wider partnerships, they can be delivered on a wider scale.

Figure 4: Generic pathway for how MP4 research outputs lead to impacts in key populations

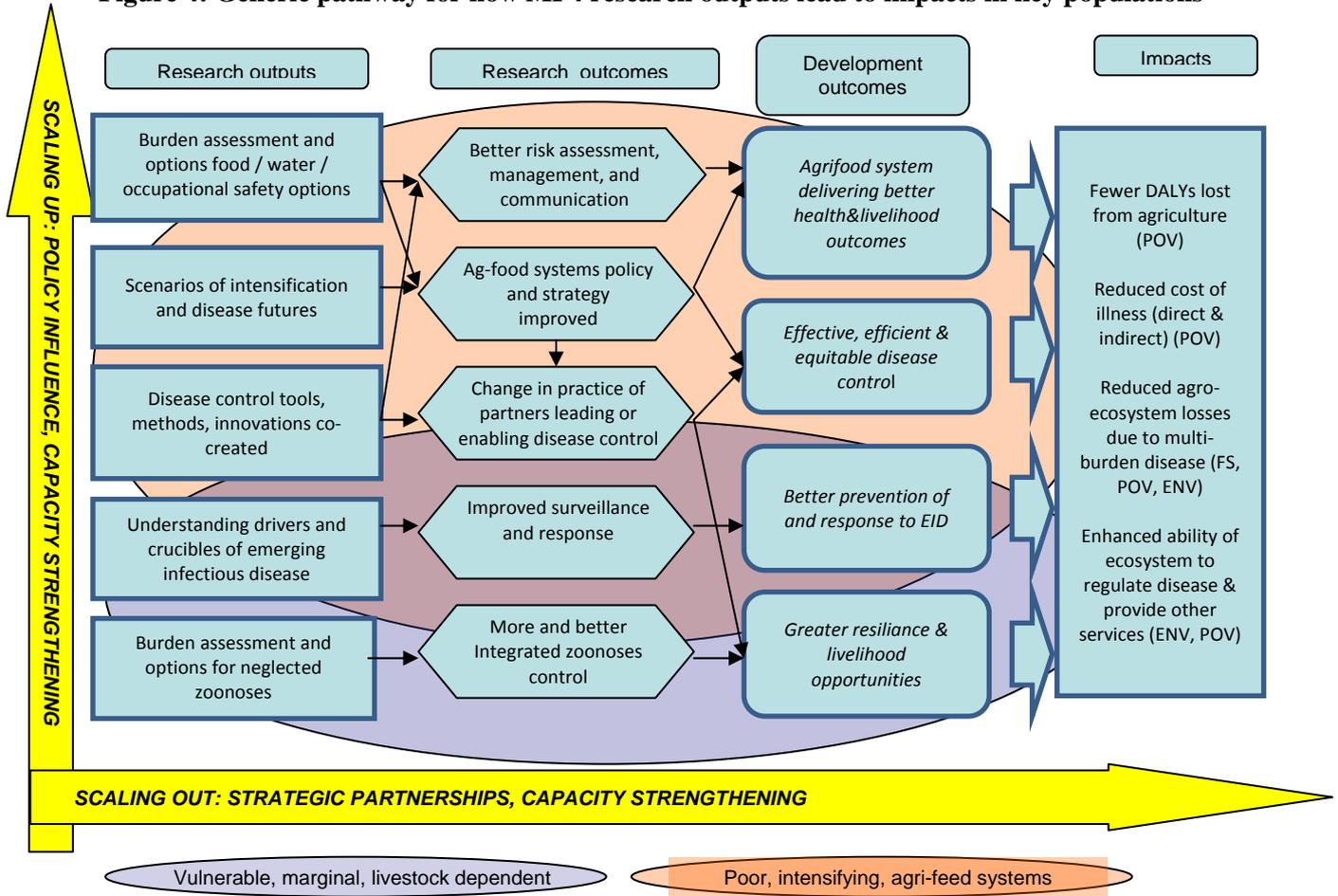
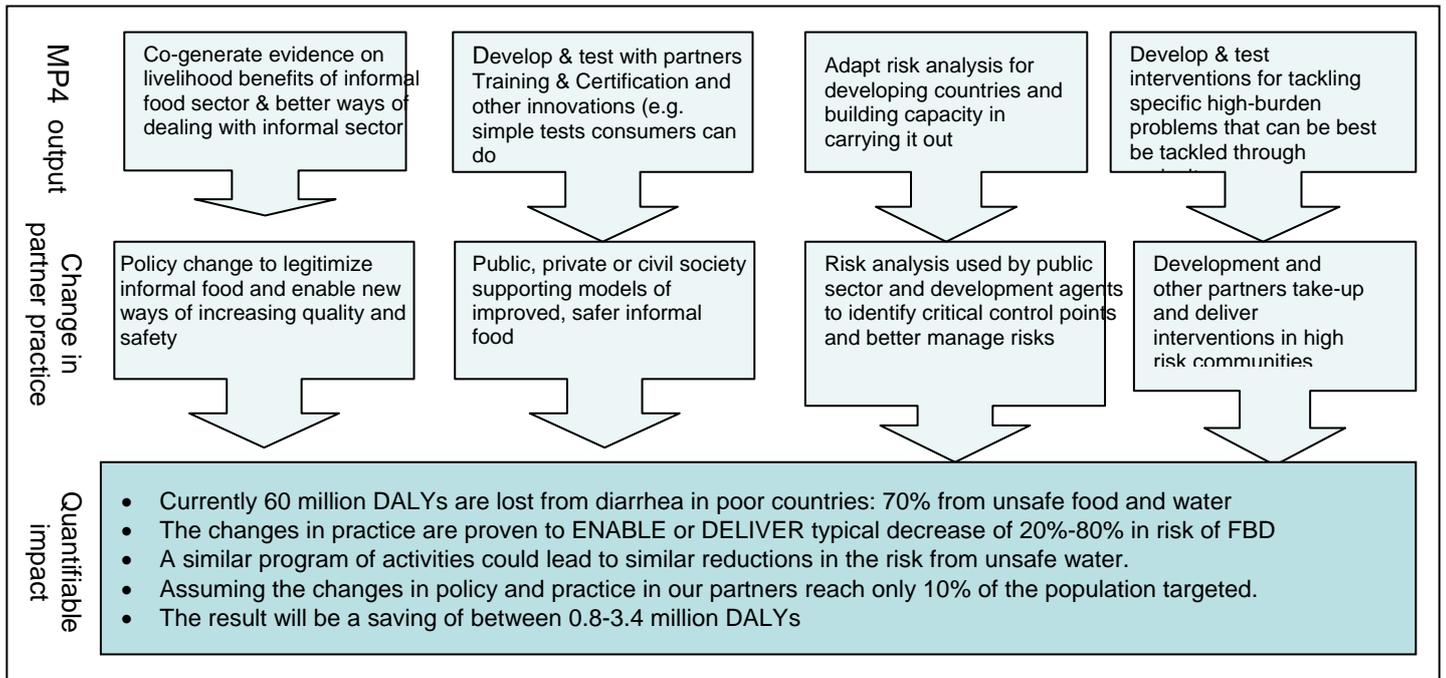


Figure 5. Example of a detailed impact pathway showing reduction in the burden of diarrhoea



5. Partnerships

Partnerships are critical for consortium centers to use their agricultural research expertise to improve nutritional and health outcomes for hundreds of millions of poor people. There are already important links between the centers and nutrition and health partners, as well as more systematic linkages under the CGIAR Agriculture, Health, and Nutrition Platform.

| Partners | Research Partners | Development Partners | Policy and Knowledge Partners |
|--------------------------------|---|---|---|
| Global and Regional | | | |
| Nutrition and Biofortification | CGIAR centers AVRDC – The World Vegetable Center, Advanced research institutes and universities (e.g. Zurich, London) | WFP, International NGOs (e.g. Concern, Hellen Keller Int., CRS), private-sector companies, AVRDC | FAO, WHO, UNICEF, regional organizations (e.g. FARA, ECOWAS, WAHO), Global Horticulture |
| Health | CGIAR centers, Icipe, advanced research institutes (e.g. CIRAD, universities with veterinary, public health, and biomedical research (STPH, IGS, London-RVC, LSHTM, Oxford, Guelph and others), International Ecohealth Society and Alliance for Ecosystem Health | International NGOs (e.g. IUCN, WWF, Oxfam), private-sector companies, public-private partnerships (FIND, GALVmed) | FAO, WHO, OIE, UNICEF, regional organizations (e.g. AU-IBAR, ECOWAS, WAHO) PROMED, UNAIDS, ILRI |
| National and Local | | | |
| Nutrition and Biofortification | National agricultural research and nutrition research institutes and universities | National NGOs, CSOs and private sector | National governments |
| Health | National agricultural research, public health and bio-medical research institutes and universities | National NGOs, CSOs and private sector | National governments |

MP4 will build on programs for the improvement of plant and animal foods, either through improved availability of highly nutritious foods or in biofortification. Harvest Plus has been integrated into MP4 and provides a US\$25 million per annum platform for delivering enhanced nutritional traits through a wide variety of crop-improvement programs, both directly funded and through shared knowledge. The program will bring better nutritional assessment, targeting, and testing to the design of research and development programs for nutritional security. Research to enhance the impact of food-based nutritional solutions will bring together agricultural partners and nutrition colleagues from research, development, and policy perspectives in global, regional, and local arenas. MP4 will build on existing networks and make concerted efforts for more engagement with the private sector and development partners. Vulnerable and marginal communities suffering from poor nutrition and health and gender inequity will be a key target group. In this, international public and nongovernmental organizations are key partners. The program will provide better agriculture, nutrition, and disease control (of zoonotic, food-, and water-borne diseases) and mitigation of the impact HIV/AIDS through agriculture-based solutions within the broader social protection and development programs of these partners.

There are ongoing partnerships around the health risks associated with food and water quality; safety, occupational, and agricultural risks; and zoonoses and emerging diseases in intensifying systems. Research partnerships span bio-medical and public health research, from genomic to participatory epidemiology. These research partnerships will strengthen links with WHO, FAO, OIE, and UNICEF in the global One Health framework. MP4 research will provide evidence to support development of appropriate policies and regulations that offer opportunities for poor countries to improve and evolve

the health performance of their agri-food systems. At a more operational research for development level, the program will more actively engage with the private sector and national public partners to improve food and water safety and veterinary and human disease prediction and response. Given the complexity of the natural and social systems being addressed, ecohealth approaches will be used through established research, investors (IDRC), and national partner networks.

Partnerships will be forged to influence agricultural development strategies and the shaping of agri-food systems to enhance nutrition and health outcomes. MP4 will engage development agencies, investors, social science research groups and policy makers. The program will also develop broader research and development networks with international and advanced research institutes and think tanks examining different agri-food scenarios, and will link more effectively with environmental research organizations, NGOs, and civil-society organizations (such as IUCN, WWF, Oxfam, and others). Capacity development will be integral to all partnerships and an important role and responsibility for all participating Consortium Centers.

Roles of different consortium centers

| Consortium Center | Roles within MP4 | Complementary Roles |
|-------------------|--|--|
| IFPRI | Largest expertise in CGIAR in nutrition (diets and biofortification), risk analysis/food safety, economics, gender analysis | Economic impact, gender analysis |
| ILRI | Largest expertise in CGIAR in health, disease epidemiology, surveillance and risk analysis, food safety, animal-source foods, ecohealth, genomics, occupational health | Livestock production and marketing, economic impact, gender analysis |
| CIP | Nutrition (diets and biofortification), food safety, occupational health | Crop breeding and management, marketing, economic analysis |
| CIAT | Nutrition (bioactive compounds, diets, biofortification, nutrition impact studies), food safety, occupational health | Crop breeding, management and marketing, economic impact and gender analysis |
| CIMMYT | Nutrition (diets and biofortification), food safety, occupational health | Crop breeding, management and marketing |
| Bioversity | Nutrition (diets and biofortification), biodiversity | Production systems, value chain analysis, marketing |
| IITA | Nutrition (diets and biofortification), food safety, occupational health | Crop breeding, management and marketing |
| ICRAF | Nutrition (diets), indigenous knowledge (medicinal plants) | |
| ICARDA | Nutrition (diets and biofortification), food safety | Crop breeding, management and marketing |
| IWMI | Water quality, disease epidemiology, risk analysis | Water management |
| WorldFish | Nutrition (diets), water quality | Fish production and marketing |
| ICRISAT | Nutrition (diets and biofortification), food safety, occupational health | Crop breeding, management and marketing |
| Africa Rice | | Crop breeding |
| IRRI | | Crop breeding |

6. Capacity Building and Knowledge Sharing

Capacity strengthening and knowledge sharing will be essential to the delivery of research outputs and to the overall impact of MP4, and will be coupled with activities to support the improved response and resilience capacity of actors at all levels. The **capacity-strengthening activities** will focus on three main and 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. While proper capacities at every level will play a crucial role along impact pathways, capacity development will have to be strategic in view of the complexities of MP4. Collective efforts with international, regional, and national partners will focus on strategic inputs that allow for scaling up and out with key policy, NARs, NGO, and private-sector partners. The program will focus on individual and institutional capacities, with a special focus on poorly-linked peoples and sectors (such as women and people in tribal areas) and will promote the use of new knowledge-sharing, management, and information technology tools and methods. The research program will link with educational institutions in the focal research countries to bridge the health, nutrition, and agriculture curricula. Capacity development is constantly evolving and the tools, strategies, and methods will be adapted for different locations, technological levels, problems, and partnership arrangements.

For the required development outcomes, MP4 will focus on the overall agriculture–health innovation system and how to improve the response and adaptive capacities of the different actors to play their needed roles. Socioeconomic research will play an important role in understanding the interests and incentives of different actors and organizations.

7. Gender Integration

There are strong links between gender, nutrition, and health. Given their role in agriculture and in the household economy, women are most often the mediators of household nutrition (as is the case for 80 percent of economically active women in Sub-Saharan Africa, for example). Furthermore, evidence shows that women and girls have lower nutritional status and greater risks of acquiring agriculture-associated diseases. These risks are exacerbated by factors linked to poverty and to exclusion from agricultural extension programs that normally target men. Improving women’s access to and control of resources (including assets and income), improves nutritional outcomes for themselves and their families. Various infectious disease control programs specifically target children, which presents opportunities to reach certain age and gender groups that are usually not visible in agriculture. Likewise, we can benefit from the collaboration with health sector partners, where information is usually disaggregated by gender and age, which has already helped focus agriculture-health interventions (for example on women cultivating inland valleys in West Africa, and children-headed households in Southern Africa). For these reasons, gender integration in the research program is crucial. MP4 will focus on leveraging opportunities through differentiation of the roles and responsibilities of women and addressing the inequities in nutritional status, access to resources, and exposure to health risks.

MP4 will integrate gender in three ways: (i) **in key research approaches and activities**, including gendered risk analysis to assess the differential risk from agriculture-associated diseases, and increasing participation of and benefits by women to resources, capacity, and information; (ii) **via gendered indicators** that measure the impacts of the program’s interventions on old and young men and women. Such indicators will include reductions in disparities in nutritional status of women and girls and of children in male- versus female-headed households, reduced disease risk to women, and others; and (iii) **through strategic research** that helps to understand the gender-health-nutrition-agriculture linkages. This may include identifying the major livelihood strategies for women and understanding how these can support gender-mediated food production and income pathways through which agriculture can lead to better nutrition. This information will be used to inform the research, target interventions, capacity and information resources, and programming and policy.

8. Integration with Other MPs

As noted above, the improvement of plant and animal foods for food-based nutritional solutions will link closely with food staple programs in MP3 and also with fruit trees in MP6. With regard to biofortification, the Harvest Plus Challenge Program will be fully integrated into MP4 and will continue to play its convening and facilitating role.

Research in different sites will be coordinated with MP1 for drylands, humid areas, and coastal and aquatic systems. MP1 will be largely responsible for establishing the research for development partnerships in different places, while MP4 will add the nutritional and health dimensions.

Strong links will be developed with MP2 to coordinate food-safety research and delivery of biofortified products to urban populations with value-chain research that can deliver food-based nutrition solutions. Work related to food safety and broader health issues regarding specific commodities (such as mycotoxins), and to zoonoses and emerging diseases will be coordinated with MP3 food staple programs. For example, endemic animal disease research that will be carried out as part of livestock sector research for development will be done in MP3, while biotechnology and epidemiology research associated with zoonoses and emerging diseases will be done in MP4. Water-quality and water-safety research as well as water management options to reduce AADs will be closely coordinated with MP5. MP4 will focus on health risks from wastewater, while MP5 will examine wastewater as a source of nutrients and water. MP4 will also inform MP5 by adding health considerations for agricultural water-management interventions.

Significant dialogue will need to be established across MPs with regard to agricultural development strategies and shaping agri-food systems for sustainability and better nutrition and health outcomes. This work will link closely with policy and future foresight research in MP2 and 5, and will also link to MPs 1, 3, 6 and 7.

9. Governance and Management

There are a few key features of governance and management for MP4 that need to be highlighted.

1. The need to ensure strong leadership in both nutrition and health outcomes, and solid engagement with partners who are crucial to delivering research and development outcomes and impacts.
2. Mechanisms to ensure coordination and alignment between the different Consortium Centers, different MPs and key partners. Note that almost all Consortium Centers are partners in MP4.
3. Maintain existing management arrangements that are functioning well (e.g. Harvest Plus) while seeking more programmatic integration over time.

Before finalizing governance and management arrangements, decisions by the Consortium Board and discussions with partners will be required. The Consortium Board needs to decide on whether a single lead Center, joint venture of two Centers, or some consortium-type arrangement would be most appropriate. In addition the nature of how partners engage in participating and steering MP4 needs further discussion. Given that several centers are interested in actively participating in MP4, the leader(s) will convene regular twice-yearly meetings of research leaders to plan and coordinate research activities, outputs and outcomes, program and partnership development, and resource mobilization. Hopefully, fostering effective collaboration between researchers should not require additional formal governance strategies. Participating centers will be responsible for MP planning, communications, coordination, and monitoring and evaluation through sub-contracts. Given the imperative of linking agriculture to nutrition and health, a strong coalition of partners is necessary to ensure links between agriculture, nutrition and health research and also to coordinate research with development actions. A strong program advisory or steering committee will be formed to advise the leader(s) and the research teams and managers. This will involve an annual meeting (in conjunction with research–development partner meetings) to review and give advice on programs.

Given that HarvestPlus: (i) has been operating as a joint venture agreement under CIAT and IFPRI for seven years, (ii) has a well-functioning governance and management system already in place, and (iii) has existing contractual commitments to donors through 2013, it is proposed that HarvestPlus maintain its current institutional arrangements through 2013, at which time its status will be re-evaluated. Harvest Plus will integrate its activities into MP4 and The HarvestPlus director will attend the MP4 meetings to ensure that activities are coordinated.

10. Risk analysis and monitoring and evaluation

The table below represents an initial assessment of key risks, which will be updated annually in consultation with partners. Internal MP monitoring and evaluation processes will be established to assess and revise impact pathways and outcome mapping to support the capacity of key actors. Progress indicators for these will be developed with partners and will be incorporated into annual learning evaluations, and formal impact assessment methods will be established in accordance with ISPC guidelines. Finally, advice from the partnership advisory committee will be enhanced by periodic external reviews as agreed with the Consortium Office.

| Major Risk | Mitigation measures / assumptions |
|--|--|
| Difficulties in engaging essential partnerships between agriculture, nutrition, and health | Recognition of the importance of agriculture for nutrition and health outcomes. Building on experience of CGIAR in agriculture–nutrition and health partnerships including the Agriculture, and Health Research Platform. Partnership Advisory Committee |
| Lack of capacity in key national and local actors to implement and adapt to unforeseen challenges | Capacity-development activities will be built into research efforts, and capacity-building needs in impact pathways (including support to capacity development organizations in target countries) will be clearly specified. |
| Complexity of research agenda – combining natural and social research, spanning agriculture, nutrition, and health | The experience of CGIAR and partners in both natural and social research with several CGIAR researchers having biomedical and veterinary backgrounds, which facilitates dealings with the health sector. Also some experiences in new health related research such as ecohealth. Partnership arrangements will be used in coordinating research actions. |
| Lack of financial and human resources to achieve program outputs and outcomes | Strong partnership coalition. Credible research plans and longer-term commitment of Fund Council. |
| Failure to engage and coordinate with development enablers and implementers | Strong emphasis on the part of co-lead centers and the partnership advisory committee to link research with development priorities and actions for improved nutrition and health outcomes that Consortium research can inform and support. |

11. Time Frame

Detailed planning will require discussions with partners and a clear idea of resource availability. Some indicative targets over the next 10 years include:

Nutrition

a. Diets

- Analysis of crop diversity, food systems and value chains for nutritional opportunities (2013)
- Pilot testing of agriculture interventions linked to better nutrition (2013)
- Scaling up of interventions (progressively from 2013-2020)

b. Biofortification

- Breeding biofortified and improved agronomic trait varieties for release (a detailed schedule is available from 2011-2013) covering a number of countries in South Asia, Sub-Saharan Africa and Latin America
- Facilitate dissemination, marketing, and consumer acceptance of improved varieties (to 2018)

Health

- Assessment of multiple burdens of agriculture-associated disease in four target systems (2011-2013)
- Pilot testing of agriculture–health interventions for neglected diseases (2013)
- Scaling-up of interventions (progressively from 2013-2020)

12. Budget

As described above, the impact potential for improving human nutrition and health through agricultural interventions is enormous. MP4 proposes a major scale-up of CGIAR efforts to this end. As a relatively new area of CGIAR emphasis, it should be expected to grow relatively quickly if the key partnerships and research programs can be developed.

Eleven centers provided budget information (Bioversity, CIAT, CIP, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, ILRI, IWMI and World Fish). From these submissions, a budget of US\$38.7 million, representing 2010 approved budgets for MP4 activities and 5% increase for 2011. This represents 6-7

percent of current CGIAR expenditures. Of this, approximately 60 percent is for nutrition and 40 percent is for health. IFPRI accounts for approximately half of the nutrition expenditure and ILRI accounts for two-thirds of the health. Within this budget is funding for Harvest Plus coordination activities. In addition to what is included in the MP4 budget, Harvest Plus disperses approximately US\$20 million per year for crop improvement—about half to CGIAR centers and half to other partners.

The consolidated MP4 budget proposal for 2011-2013 is based upon a 5-percent increase from the 2010 base, though it is expected that this MP should grow faster than average and we would envisage that a 20 percent rate of increase would be required to meet the program ambitions presented.

| MP4 Costs | 2011 | 2012 | 2013 |
|---|---------------------------|---------------|---------------|
| Description | Amount in ,000 USD | | |
| Personnel Cost | 13,505 | 14,495 | 15,168 |
| Travel | 1,716 | 1,755 | 1,829 |
| Operating expenses | 8,492 | 8,781 | 9,243 |
| Traning / Workshop | 755 | 827 | 848 |
| Partners / Collaborator Contracts | 6,212 | 6,628 | 6,905 |
| Capital and other equipment for project | 585 | 598 | 616 |
| Research support Services | 722 | 758 | 796 |
| Regional Office Operating costs | 707 | 743 | 780 |
| Contingency | 347 | 367 | 387 |
| Institutional Overhead (avg 18%) | 5,669 | 6,065 | 6,404 |
| TOTAL | 38,711 | 41,016 | 42,977 |
| MP4 Funding | | | |
| Description | 2011 | 2012 | 2013 |
| Description | Amount in ,000 USD | | |
| CGIAR fund | 10,193 | 12,873 | 16,107 |
| Bilateral Donors | 24,548 | 25,003 | 24,800 |
| Bilateral Donors "matching funds co-financed by unrestricted funding" | 2,552 | 1,721 | 760 |
| Other incomes | 1,209 | 1,224 | 1,147 |
| Overheads from bilateral grants and CGIAR fund (window 1&2) | 62 | 73 | 85 |
| Institutional support required from window 3 | 149 | 120 | 78 |
| TOTAL | 38,711 | 41,016 | 42,977 |