CIMMYT 2007-2009

Medium-Term Plan

Moving the Vision of *Seeds of Innovation* into Action

C I M M Y T

2007-2009

Medium-Term Plan

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of *Seeds of Innovation* into Action

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Executive Summary

Following recommendations of the 5th External Program and Management Review (EPMR) panel in early 2005, CIMMYT fleshed out the vision of its strategy document, *Seeds of Innovation*, in a practical, impact-oriented, operational document: "CIMMYT Business Plan 2006-2010." A transitional document for CIMMYT, it describes the Center's transformation from a structure involving the 6 programs mentioned in the 2006-08 MTP to the present 11 Projects. Within the Projects, CIMMYT and partners will develop 37 outputs—international public goods that relate in diverse ways to the development and delivery of flagship products (see below) defined as part of the Business Plan. Both Center staff and the Board of Trustees helped craft the Business Plan, which reflects input from development investors, research partners, and other stakeholders, and was well received at the CGIAR Annual General Meeting in 2005.

CIMMYT flagship products

- New or improved traits through allele mining and gene discovery to best use global crop biodiversity.
- Improved tools and methodologies for genetic improvement.
- Stress tolerant maize for enhanced food security and crop diversification.
- Bio-fortified maize for improved nutrition and health.
- Opportunities for income generation from special trait maize.
- Wheat with enhanced water productivity and appropriate quality profiles.
- Rust resistant wheat.
- Resource conservation technologies for maize and wheat cropping systems.
- Capacity building in national agricultural research system breeding programs.

CIMMYT Projects

Projects 1 and 2 involve the application of advanced tools in the use of crop genetic resources, focusing on value-added traits—stress tolerance, disease and pest resistance, micronutrient enhancement, to name several—for rapid introgression into breeding materials. The intermediate breeding materials containing these traits are for direct use by the maize and wheat improvement Projects, P3 through P9, as well as to other partners and beneficiaries. Project 10 involves research on conservation agriculture systems, helping farmers in developing countries to test and adopt more productive, profitable, and resource-conserving practices. Through Project 11, CIMMYT will continue its tradition of excellence in socioeconomic and impacts research, providing support for pro-poor research in the biological sciences, as well as creating and sharing of knowledge in complex innovation systems.

The MTP was developed with careful consideration of CGIAR System priorities and Millennium Development Goals. Permanent feedback and participation from stakeholders will help refine targeting and priority-setting, and will add to CIMMYT and partners' knowledge bases on maize and wheat, related cropping systems, and commodity and value chains. The resource allocations that underpin the work are described in the budget tables and the section on finances.

Vigorous new partnerships—including the ICARDA-CIMMYT Wheat Improvement Program, the IRRI-CIMMYT Alliance, and full participation in Challenge Programs—are both helping CIMMYT better to fulfill its mission and providing an example of integration and cooperation among CGIAR Centers to benefit stakeholders, farmers, and consumers in developing countries.

CIMMYT 2007-2009 Medium-Term Plan

Moving the Vision of *Seeds of Innovation* into Action

International Public Goods and CIMMYT's Flagship Products Portfolio

CIMMYT has focused its agenda around nine flagship products, an approach that emerged since the last MTP and as a result of developing a Business Plan for the period 2006-2010 during the latter part of 2005. In most cases, the flagship products constitute genetically enhanced, seed-embedded technologies for which pathways to impact on poverty and livelihoods have been mapped out. The flagship products form an exciting portfolio backed by world-class expertise and developed in consultation with clients. They will be delivered through 11 Projects that, with a wide range of partners, will produce 37 outputs—international public goods which relate in various ways to the development and delivery of flagship products detailed below:

New or improved traits through allele mining and gene discovery to best use global crop biodiversity. Crop-related biodiversity is the founding asset of the CGIAR and the basic raw material for the international breeding programs of CIMMYT. An emerging area of comparative advantage for the Center is to develop and apply technology-assisted methodologies to efficiently identify the genetic variation underlying target, value-added traits. The latter include enhanced resilience to abiotic stresses, yield stability under biotic stress, nutritional quality for humans or animals, and simple profitability. As part of this, CIMMYT and partners will develop value-added international public goods such as structured and well-characterized germplasm subsets, methodologies for allele and gene mining in global germplasm collections, internet-based information management, analysis and decision-support systems, the generation and analysis of trait-specific genetic stocks (near-isogenic, introgression, and substitution lines), enhanced gene pools, double haploid lines, synthetic polyploidy genotypes, genetic mapping populations, and mutant stocks. These products will be fully integrated in CIMMYT and partners' commodity improvement efforts.

Improved tools and methodologies for genetic improvement. CIMMYT has a pivotal role to play in the global research community, bridging upstream innovation generators and downstream product development and delivery providers. CIMMYT will continue to develop and validate new tools and methodologies for more efficient manipulation of new alleles and genes for traits prioritized by end-users in CIMMYT regional programs, and in NARSs and small and medium enterprise (SME) breeding programs. The Center will give considerable emphasis to the systemic integration into these programs of diverse fast-track breeding techniques, including molecular genetic fingerprinting, marker-assisted selection, double haploids, genetic transformation, advanced biometrics, informatics, and simulation-based decision support tools. In addition, the Center will provide technical backstopping for targeted enhancement of flagship breeding products by CIMMYT, NARSs, and SME programs.

Stress tolerant maize for enhanced food security and crop diversification. Maize is grown as a staple crop, often under highly-variable, stress-prone conditions by some of the world's most disadvantaged farmers—people frequently constrained to obtaining food and livelihoods from agriculture alone, and with poor access to markets, infrastructure, or social support systems. To achieve reliable food security, many such households allocate a disproportionate area of their land to maize, leaving little for fallows, cash crops, or other beneficial diversification. Human malnutrition and soil degradation are frequent and few escape this poverty trap. CIMMYT is already seeing successes in implementing innovative approaches that generate stress tolerant, nutritious maize strains with significantly increased productivity under such harsh conditions. Among other things, they permit farmers to produce more and healthier food on a smaller land area, leaving more labor and land for growing soil-replenishing legumes or cash crops. This pioneering work requires further enhancement and deployment to a wide range of stress environments worldwide.

Biofortified maize for improved nutrition and health. Poor people often survive on high intakes of inexpensive cereals and nutritionally imbalanced diets. It is estimated that over 3 billion people suffer from protein, iron, or vitamin A malnutrition. Pregnant and breast-feeding women and young children are most affected. Dietary diversification is most desirable, but relatively more expensive vegetables, legumes, and meat are often beyond the economic reach of the poor. Maize provides opportunities for increasing the intake of essential amino-acids, pro-vitamins A, and potentially iron and zinc. Quality protein maize (QPM) has 60 to 100% more lysine and tryptophan than normal maize—represented a biological value in protein equivalent to that of milk. CIMMYT breeders and social scientists are working with a consortium of partners in Africa, Latin America and Asia to develop and deliver stress-tolerant, agronomically-competitive QPM for food or feed, as well as identifying sustainable delivery chains that ensure impacts on human malnutrition and income generation.

Opportunities for income generation from special trait maize. An increasingly globalized world has left smallholder farmers in developing countries with few comparative advantages for income generation. Drawing on the wealth of maize genetic resources it holds in trust, CIMMYT will seek to offer new income-generating options for farmers through specialty traits, value addition, or multi-purpose uses of maize. Market potential and benefits of feed and specialty maize will be assessed, and analyses of alternate suppliers and incentive-based value chains used to highlight opportunities and recommend priorities for research investments in Asia, sub-Saharan Africa, and Latin America. Possibilities include production of high-protein maize by smallholder farmers in sub-Saharan Africa or Asia for sale to poultry producers, maize types usable for food and feed in maize-livestock systems, or specialty maize produced in Central America for sale in US markets. Options pursued will offer new income opportunities and a competitive edge to poor and often land-constrained maize farmers, where other opportunities are few.

Wheat with enhanced water productivity and appropriate quality profiles. Nearly half the wheat in developing countries is grown under resource-poor, rainfed conditions. Some of the poorest and most disadvantaged wheat farmers live in areas with less than 350 mm annual

rainfall and often depend solely on income from wheat production. Wheat in these areas is a staple food, providing around half the daily caloric requirement, and wheat straw is an important source of fodder for livestock. In irrigated areas there is increasing pressure on water resources, driving the need for effective use of applied water and for water-use-efficient germplasm. CIMMYT will intensify work to develop more input-use-efficient wheat, including lines that give more "crop per drop." The genetic basis of drought tolerance in wheat is complex, but CIMMYT is well-positioned to address the issue. Conservation agriculture practices will complement and enhance the value of drought-tolerant wheat.

Rust resistant wheat. Rust diseases arguably pose the most serious pathogen threat to wheat production worldwide. Wheat grain losses of only a few percent globally from a serious rust outbreak would spike prices and disproportionately hit the world's poorest consumers. A 2004 study found that CIMMYT and partner's efforts in leaf rust resistance breeding for spring bread wheat alone over 40 years had generated net benefits valued at over 5 billion 1990 US dollars.[1] CIMMYT will draw on sizeable collections of wheat genetic resources, proven expertise in genetic improvement, an extensive network of partners, modern bioscience innovations, and social science capabilities to create a new generation of stable, resilient, and profitable wheat cultivars carrying durable resistance to a range of rust diseases.

Resource conservation technologies for maize and wheat cropping systems. Through partnerships with NARSs, agri-business, and other CGIAR centers, CIMMYT undertakes research on conservation agriculture and resource-conserving technologies for maize and wheat cropping systems. In the coming years, agronomy research at CIMMYT will focus strongly on conservation agriculture principles and approaches. These technologies improve rural incomes and livelihoods through sustainable management of agro-ecosystem productivity and diversity, while minimizing unfavorable environmental impacts. From a research product perspective, CIMMYT will examine the potential of plant pests and diseases in such systems and look at germplasm enhancements that might reduce vulnerability. Beyond a focus on higher grain production and adapted germplasm, this research will seek more efficient and sustainable use of water and other inputs, lower production costs, better management of biotic stresses, and enhanced cropping system diversity and resilience.

Capacity building of NARSs and SME breeding programs. Impacts at the NARSs and farmer level can only be achieved if adequately trained people manage the process. CIMMYT is committed to providing both improved germplasm and building the capacity of national breeding programs which best serve poor farmers in our target regions. Indeed, with the growing strength of some NARSs and the emergence of a commercial seed sector in several target countries, there are great opportunities for more intimate, interactive, synergistic partnerships. As part of its evolving capacity-building strategy, CIMMYT will give greater emphasis to building the capacity of emerging entrepreneurs to assist in the development of a strong commercial seed sector. It must also be remembered that the capacity of many NARSs

[1] Marasas, C.N., M. Smale, and R.P. Singh. 2004. *The Economic Impact in Developing Countries of Leaf Rust Resistance Breeding in CIMMYT-Related Spring Bread Wheat. Economics Program Paper 04-01.* Mexico, D.F.: CIMMYT.

has in real terms declined over the last decade. This weakness also needs to be addressed directly through training and indirectly through streamlined knowledge-sharing systems. CIMMYT is making a strong commitment to fostering effective activities and linkages with other key players in the overall value chain, including synergizing the development of effective seed systems in our target regions.

Highlights of 2005

The following stories illustrate the diversity of CIMMYT research and partnerships, and help provide an idea of the complex pathways by which the Center's products and interventions contribute to farmers' livelihoods and food security.

The Asian Maize Biotechnology Network (AMBIONET), 1998-2005
The Division of Genetics of the Indian Agricultural Research Institute (IARI) developed a new, downy mildew resistant maize hybrid now in trials prior to its release. Underpinning this achievement was IARI's participation in the Asian Maize Biotechnology Network (AMBIONET), comprising maize scientists from NARSs in China, India, Indonesia, Philippines, Thailand and Vietnam. The network helped enhance the capacity for marker-assisted breeding for products such as the Indian hybrid, and assisted national molecular breeding laboratories and staff of China, India, Indonesia, and Vietnam in addressing key maize production constraints. Participants took part in collaborative international trials to identify chromosome regions associated with disease resistance of interest across the region. During the life of AMBIONET, national research systems leveraged approximately US $1.1 million in additional investments for maize breeding. The network was organized by CIMMYT, with funding from the Asian Development Bank

Quality protein maize (QPM) in Asia
Drawing on CIMMYT germplasm and training, Bangladesh, India, Indonesia, and Vietnam recently released QPM hybrids and open-pollinated varieties (OPVs). Research and commercial investments in QPM are growing in these and neighbouring countries, including China, Nepal and the Philippines. Approximately 200,000 hectares of QPM were grown in India during 2005; lesser areas were planted elsewhere. Throughout the region, the superior nutritional value of QPM appeals to farm households as feed for commercial poultry production, providing increased productivity and profitability. QPM is also advantageous for swine and fish production common in small rural households in China and Bangladesh. Malnourished human consumers of maize can benefit from replacement of normal maize with QPM in their diets. Moreover, QPM represents a source of additional income for seed, grain, and livestock producers, and for all the actors along the maize value chain.

Advanced lines of drought tolerant wheat in national breeding programs
During 2005 ten national breeding programs selected 1,194 lines of drought tolerant wheat from CIMMYT's international screening nurseries. Wheat production in countries that reported selection of CIMMYT germplasm (Afghanistan, Bolivia, Brazil, Ethiopia, India, Iran, Morocco,

Nepal, Pakistan and Zimbabwe) accounts for 50% of the low potential, drought-stressed, rainfed wheat production in the developing world. Together, these countries have more than 39% of the world's poor, as defined by living on less than US $1 per day. Published evidence of variety releases based on lines bred by CIMMYT (or lines developed using CIMMYT materials as parents for 2005) is usually available two years after the varietal release date. During 2003 more than 100 varieties released in developing countries cited CIMMYT as the origin of the material or the use of CIMMYT parental lines in the development of these varieties. It is expected that 2005 varietal release data, when available, will show a similar order of magnitude. Of these, around 40% were released in countries where drought can limit wheat production.

Bed planting in the Yellow River Basin, China
Resulting from a coordinated public-private sector program, the raised-bed planting system has been adopted on nearly 50,000 ha in Shandong Province, providing major savings in irrigation water use. Farmers also obtain higher wheat yields and better grain quality, as a result of reductions in crop lodging and the incidence of powdery mildew and sharp eyespot. The bed planting system cuts production costs by allowing farmers to seed maize directly onto existing beds, relay planting into wheat or immediately following wheat harvest. Several small factories are building appropriate bed planters in response to demand by individual farmers and service providers. In 2005, the Chinese government honored Wang Fahong, Shandong wheat scientist who has promoted bed planting, with a special award and a substantial grant to continue his work. Wang Fahong learned of bed planting through CIMMYT and, along with many Chinese colleagues, has benefited from the Center's technical and other support.

Center Financial Indicators

The primary financial and management aims of CIMMYT during the period of this MTP can be summarized as follows:

- Fully implement the outcomes of the detailed business plan (2006-2010) that was developed by management during 2005 and formally adopted by the Board of Trustees in January 2006.
- Implement a comprehensive resource mobilization strategy.
- Complete the rebuilding of the Center's financial reserves during 2006.
- Address the issues raised by the 5th EPMR.
- Undertake a strategic review of infrastructural needs and develop a long term sustainable capital investment plan.

CIMMYT funding overview
Budget tables are located on pages 95-110. Total grant revenues as detailed in this MTP amount to US $35.50M for 2006 and US $37.75M for 2007. Both unrestricted and restricted grants are predicted to decline in 2006 due to a combination of known or expected reductions in donor contributions and continued volatility in currency markets.

Unrestricted donor funding for 2006 is budgeted at US $12.6M—a decrease of approximately 5% compared to 2005 (Table 6). A major funding concern for the Center remains the ongoing uncertainty with respect to the unrestricted contributions from major donors. CIMMYT has received indications that material reductions may be experienced, however the actual situation will not be resolved until later in 2006.

Restricted donor funding is budgeted at US $22.3M for 2006 - a decline of approximately 3.5% compared to 2005. This is the result of the loss of certain targeted donor funding and the completion of a number of large projects. The effects of the initiation of a more active resource mobilization strategy are expected to result in an improving level of restricted project funding in 2007 and future years. As with the previous MTP, the increased level of uncertainty regarding restricted funding is reflected in the unidentified funding category in our donor projections. Unidentified funding as per our submission amounts to US $1.31M for 2006 and US $6.86M for 2007 (Table 6).

Business Plan implementation
Following the completion of a detailed business plan during 2005, the financial tables for this MTP have been constructed in accordance with the eleven (11) MTP Projects that have been developed by CIMMYT management and approved by the Board. It is expected that these Projects will continue to be refined during the life of the MTP.

Working capital reserve
During 2005, CIMMYT increased undesignated, unrestricted reserves to a level in excess of US $7.2M (Table 11). Reserves now approximate 74 days of operating expenditures and during 2006 CIMMYT will achieve the CGIAR mandated level for working capital reserves (75-90 days).

Partnerships: Core Component for the Development and Delivery of Flagship Products

Partnering with national programs and regional organizations
Partnerships with national agricultural research programs have been at the heart of the development and delivery of CIMMYT's improved germplasm and other products. Linkages with national programs in many key countries—India, Mexico, Pakistan, Turkey, and China, to name a few—date back to Green Revolution and continue to contribute materially, financially, and technically to CIMMYT's global work, as well as benefiting from it to further their and the Center's missions. Here are highlights from just three countries with highly viable NARSs whose interactions with the Center have been particularly productive. These examples highlight the role of CIMMYT in identifying and/or developing technologies that cross borders and regions.

- In Mexico, these include strong partnerships with the farmer organization "El Patronato" and the National Institute of Forestry, Agriculture, and Livestock Research (INIFAP) in

wheat improvement, and with the Institute of Agriculture, Livestock, Water, and Forestry Research and Training of the state of Mexico (ICAMEX) for highland maize, to name just a few examples. Wheat varieties grown worldwide have derived from this collaboration.

- Long-term partners in India include the Indian Council of Agricultural Research (ICAR), with which CIMMYT has collaborated in research on maize and which is helping to fund the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains, the delivery of seed of quality protein maize, and the Global Rust Initiative. Through the RWC, which is hosted in India, CIMMYT has partnered with institutions such as Haryana Agricultural University, Punjab Agricultural University, GB Pant University of Agriculture and Technology, the Agricultural University of Uttar Pradesh, and Banaras Hindu University, as well as state extension agencies.
- China's wheat researchers have provided more than 1,000 commercial wheat lines to CIMMYT, and received more than 15,000 of the Center's experimental lines, which contribute high yield potential, disease resistance, and grain quality to Chinese germplasm and disease resistance to CIMMYT's wheats. CIMMYT and the Chinese Academy of Agricultural Sciences (CAAS) jointly operate internationally recognized wheat quality programs. NARSs and Center scientists have developed shuttle breeding programs for improving wheat resistance to *Fusarium* diseases and yellow rust.

As NARSs in specific regions join in partnerships, CIMMYT is working through sub-regional organizations, such as ASARECA and SADC in eastern and southern Africa, and in regional and bilateral networks that bridge public and private efforts and result in international public goods.

Partnerships with the private sector and advanced research institutes

Bioscience research over the last decade has seen a major shift, with an increasing proportion of research in plant science being proprietary and conducted by the private sector or advanced institutes. Public-private and public-public alliances are critical, if relevant research results are to be adapted in ways that enable resource-poor farmers to benefit. The strengths of advanced institutes and the private sector in genomics and biotechnology, and CIMMYT's partnerships and capacity in germplasm development for the resource-poor, provide firm bases and considerable impetus for forming alliances. CIMMYT will enter such alliances when they significantly enhance the Center's ability to develop and make available public goods with particular benefit to the resource-poor. In addition, such arrangements should permit both CIMMYT and partners to retain their own identities and credibility, based on their individual missions and constituencies. Over the next year, CIMMYT will make it a core business to develop a policy statement that further specifies the conditions for engagement in such alliances, with the aim of fostering transparency in the choice of partners.

Market liberalization has led to an increasing number of small- to medium-scale private enterprises (SMEs) interested in marketing public sector maize germplasm in lower margin markets. CIMMYT and NARSs partners are developing joint strategies for strengthening SMEs, to reach farmers who would otherwise not enjoy access to seed of improved cultivars.

Partnerships with CGIAR institutions
CIMMYT is an active and full partner with other centers of the Future Harvest Alliance through the Challenge Programs (participant in HarvestPlus, Water and Food; host center for Generation; laying groundwork for role in Sub-Saharan Africa Challenge Program), inter-center initiatives and system-wide programs (see highlight below on the Rice-Wheat Consortium for the Indo-Gangetic Plains). The Center shares research efforts with CIAT, CIP, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, ILRI, IPGRI, IRRI, and IWMI. Two more recent of these endeavors are of special note, and are described here in greater detail.

IRRI-CIMMYT Alliance. In January 2005, the Boards of Trustees of the two centers held a joint meeting in Shanghai and announced the establishment of the IRRI-CIMMYT Alliance and a Joint Board Committee for the Alliance. The Joint Board Committee met in Amsterdam in July 2005 and further defined the governance and the management mechanisms for the Alliance. Extensive discussions among the centers' staff and consultation with partners and stakeholders resulted in an alliance program that facilitates close interaction in three thematic areas: intensive cropping systems in Asia, research informatics, and knowledge management and sharing for cereals production systems. The two centers will jointly develop and implement an Alliance project for each of these areas. Each project will have a unified budget and a project leader. Developing and strengthening this Alliance is an important element of IRRI's strategy to enhance its value as a partner for science and development in Asia. The centers' complementary scientific skills, capital resources, and networks are being focused jointly to address the three areas described below. Further synergies will be pursued once these projects become fully operational.

Intensive cropping systems in Asia. There are over 30 million hectares of cereal crops in intensively cultivated farm lands across Asia that supply 80–90% of the cereals for Asia's food needs. Asian farmers are rapidly adapting intensive, lowland, rice-based agroecosystems to constraints, such as shrinking irrigation water supplies, but also to market opportunities, through diversification to crops such as maize. Traditional, commodity-based research falls short of addressing emerging sustainability and socioeconomic concerns in this setting. This IRRI-CIMMYT Alliance will apply new approaches and foster partnerships among international centers and NARSs to address these concerns. IRRI's Program 2 will be the core contributor to this work. Given the well-established activities for rice-wheat systems within the Rice-Wheat Consortium for the Indo-Gangetic Plains, efforts will focus initially on rice-maize systems, to

- Assess the biophysical potential and feasibility of rice-maize systems across the Asia region, and impact of introducing maize into intensive rice-based systems on the environment and sustainability of the production systems.
- Develop and deploy resource management technologies for sustainably optimizing system productivity (and profitability) for rice-maize and rice-wheat—including value-adding options.
- Gain understanding of the characteristics of intensive rice-maize systems—including drivers and modifiers of system change, livelihoods, and impact monitoring and forecasting.

- Develop and deploy system-tailored rice, wheat, and maize germplasm with value-adding traits.

Crop Research Informatics Laboratory (CRIL). Responding to the increasing importance of informatics in crop research and breeding and the opportunities for synergy from comparative studies between crops, IRRI and CIMMYT have jointly established a unified Crop Research Informatics Laboratory (CRIL). The laboratory will increase the capacity, efficiency, and efficacy of scientific informatics support for crop research, breeding, and training. The primary pillar of the CRIL vision is the integration and comparative analysis of data across disciplines (within the germplasm enhancement value chain) and across species (within the well-studied cereal crops). IRRI and CIMMYT have established state-of-the-art facilities in the Philippines and Mexico to serve this vision, with regional facilities in India and China. The centers see several areas where this unified facility will help build sufficient critical mass to accomplish previously unattainable goals and help establish a more powerful platform for synergizing progress across cereal species. The development of informatics tools, methodologies, and systems by CRIL will lead to more targeted, efficient, and rapid access to desirable genetic variation in global rice, wheat, and maize biodiversity for IRRI, CIMMYT, NARSs, and small and medium enterprise breeding programs, as well as facilitating use of genetic materials. Currently, CRIL has a total staff of 35, including seven senior IRS, two postdoctoral fellows, and 26 NRS, working in five broad thematic areas:

1. Research support and quality assurance, where differentiation of activities within a unified group offers considerable efficiency gains.
2. Institutional research data management, a critical Institute-wide activity that has long been on the agendas of both institutions. CRIL now offers sufficient critical mass to facilitate rapid progress.
3. Crop information systems for rice, wheat, and maize. With both institutions now committed to the same informatics platform, there are tremendous opportunities for bringing diverse datasets together.
4. Computational biology and bioinformatics. Comparative genomics between rice, maize, and wheat will drive rapid progress in trait dissection and mining of genetic resources.
5. Decision-support tools for crop improvement. The CRIL critical mass provides dramatic opportunities for developing new tools to facilitate the effective and efficient use of biotechnologies in plant breeding programs.

Knowledge management. We are jointly developing an open knowledge-sharing platform focused on international public goods, notably knowledge with value across many countries, to be made accessible online using CGIAR ICT/KM-developed portal technology (such as CGXchange). This platform will align knowledge on rice, wheat, and maize production systems covering topics such as cultivars, production, diseases, and pests, with relevant production systems information (including conservation agriculture) in the form of manuals, tools (rice/wheat/maize "doctor" applications and simulators), multimedia presentations, research findings, best practices and ideas, case studies, interactive tests, and fact sheets.

ICARDA-CIMMYT Wheat Improvement Program (ICWIP) for Central/West Asia and North Africa. The Center's partnership with ICARDA is crucial to the work of CIMMYT and NARSs of Central/West Asia and North Africa, where ICARDA plays a major role (see descriptions of Projects 7 and 8 below for details). Staff of both Centers continue to work together closely on the ground, and great complementarities exist in the respective institutional skill packages. A functional agreement formally implemented by the Centers as of January 2006 allows for clear and effective management of ICWIP through a jointly appointed director and offers tremendous scope for product and service delivery. The agreement focuses on wheat improvement as its primary driver, but also addresses management issues such as joint regional offices. It should also be noted that the two Centers have significant interactions in areas such as agronomy and social science, even though these are not part of the written agreement on wheat improvement.

Impact pathways and interactions with partners in innovation systems

CIMMYT draws on maize and wheat genetic diversity, world-class expertise, and extensive knowledge of global maize and wheat systems to generate and target improved germplasm and knowledge for farmers in developing countries. For each Project described below, the Center has traced a plausible pathway to better livelihoods and reduced poverty for farmers, along with reduced poverty and enhanced food security for rural townspeople and city dwellers. This is achieved by CIMMYT, NARSs, seed companies, farmers, and local organizations working in complex networks that may be characterized as agricultural innovation systems, rather than linear development chains. The genetic diversity in gene banks and breeding lines worldwide, together with the knowledge of this resource, represent the basic material for maize and wheat breeding. Adapting and applying improved tools in the use of this material, CIMMYT and partners produce experimental maize and wheat lines and varieties for specific purposes—for traits such as yield, adaptation, tolerance to drought or low nitrogen soil conditions, resistance to soil-borne and foliar diseases and pests, and end-user grain and fodder quality requirements.

As farmers incorporate improved maize and wheat cultivars, conservation agriculture practices, and better knowledge into their management systems, cereal productivity increases and stabilizes and household livelihoods and income increase (initial farm-level impacts). Increased productivity and reduced risk frequently foster diversification toward high-value crops or livestock, further augmenting household income and providing funds to pursue farm or off-farm businesses. Secondary impacts include enhanced local economies and rural employment, together with the food surpluses to feed cities.

Shaping CIMMYT's Project Portfolio

The Millennium Development Goals and the system priorities set by the CGIAR Science Council shaped the flagship products of CIMMYT's 2006-2010 Business Plan and the Project portfolio given in this 2007-2009 Medium-Term Plan.

The Millennium Development Goals and CIMMYT

Many of CIMMYT and partners' joint efforts contribute directly or indirectly to the accomplishment of the Millennium Development Goals. The following are just a few examples:

- By enhancing maize and wheat grain yields to improve rural and urban food security, while raising farmers' incomes CIMMYT and partners' efforts contribute to *eradicating extreme poverty and hunger*.
- Work in sub-Saharan Africa in support of community seed production by farmer associations and self-help groups, along with initiatives like whole-family training in Bangladesh, are *empowering women*; the Hill Maize Research Project in Nepal especially targets women and disadvantaged groups, promoting equity and *gender equality*. CIMMYT training serves the same purpose.
- The Center and partners breeds for enhanced micronutrient content and protein quality in the grain of both maize and wheat, providing healthier food that *reduces child mortality* and general malnutrition.
- Through the study and promotion of conservation agriculture (for example, the Rice-Wheat Consortium for the Indo-Gangetic Plains; work in eastern and southern Africa) and as custodian of one of the largest collections of maize and wheat genetic resources, CIMMYT and partners foster *environmental sustainability*.
- The Center cultivates *global partnerships for development* of proven effectiveness in all of the areas mentioned above—maize and wheat breeding, conservation agriculture, genetic resource conservation, biofortified grain, and capacity building—as well as many others.

CGIAR System priority setting and CIMMYT flagship products and Projects

More than two-thirds of the Center's investment addresses CGIAR system priority # 2: Producing food at lower costs through genetic improvement (Figure 1). This reflects the needs of maize and wheat farmers for cultivars that withstand biotic or biotic stresses, and for more nutritious and healthy food for consumers. Figure 2 illustrates the relationship between Projects, outputs, and flagship products.

Table 1. Mapping CIMMYT Project outputs (weight in %) to CGIAR system priorities (SP).

CIMMYT 2007-2009 MTP Projects	SP1	SP2	SP3	SP4	SP5	DA	SAT
P1 Conservation, characterization and targeted access to maize- and wheat-related biodiversity.	40	60					
P2 Technology-assisted tools and methodologies for genetic improvement.		100					
P3 Stress tolerant maize.		100					
P4 Nutritional and specialty traits for maize.	20	70	10				
P5 African livelihoods.		40		20		20	20
P6 Maize for Asia and Latin America.		90		10			
P7 Water productive wheat.	10	90					
P8 Enhanced wheat for more durable resistance to diseases and improved production potential.	10	80				10	
P9 Wheat grain enriched for health and profitability.	20	70				10	
P10 Conservation agriculture for maize and wheat cropping systems.*		10		70		20	
P11 Knowledge, targeting, and strategic assessment of maize and wheat farming systems.					70	10	20

SP1 Sustaining biodiversity for current and future generations.
SP2 Producing food at lower costs through genetic improvement.
SP3 Creating wealth among the rural poor through high-value commodities and products.
SP4 Combining poverty alleviation and sustainable management of water, land and forestry resources.
SP5 Improving policies and facilitating institutional innovation.
DA Development activities.
SAT Stand-alone training.
* Includes CIMMYT contributions to the Rice-Wheat Consortium research agenda.

Center resources are also allocated to the four other CGIAR system priority areas (Figure 1), and about 10% for other important areas that contribute to obtaining impacts: seed systems (especially in Africa, as shown in P5), stand-alone capacity building (through P11), and other development activities (through networking in P8, P9, P10 and P11). Finally, a small, unspecified portion of CIMMYT research portfolio is dedicated to exploratory research, whereby scientists test innovations in their particular areas and at their own discretion.

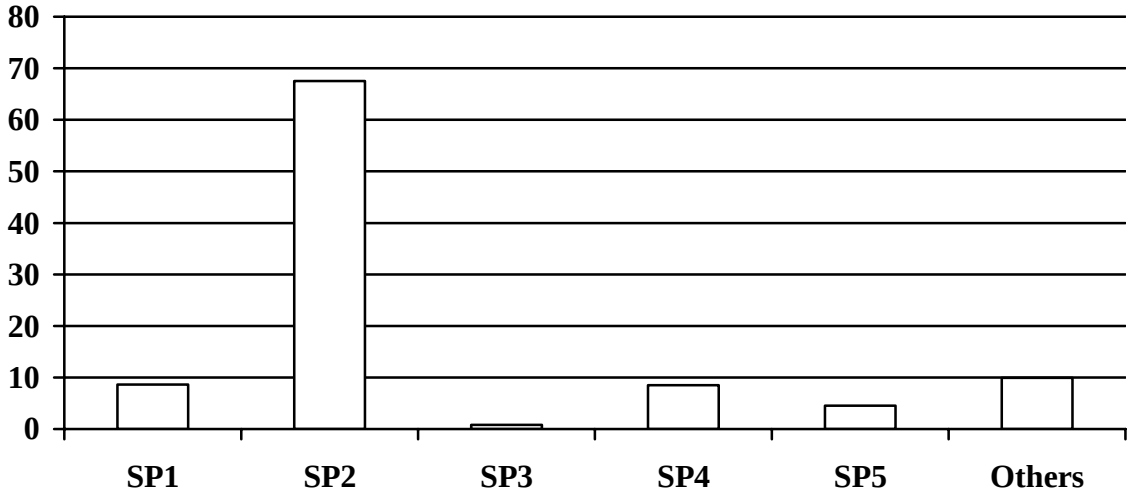

Figure 1. Approximate investments of CIMMYT (% of annual budget) by CGIAR system priority (SP) undertakings.

SP1 Sustaining biodiversity for current and future generations.
SP2 Producing food at lower costs through genetic improvement.
SP3 Creating wealth among the rural poor through high-value commodities and products.
SP4 Combining poverty alleviation and sustainable management of water, land and forestry resources.
SP5 Improving policies and facilitating institutional innovation.

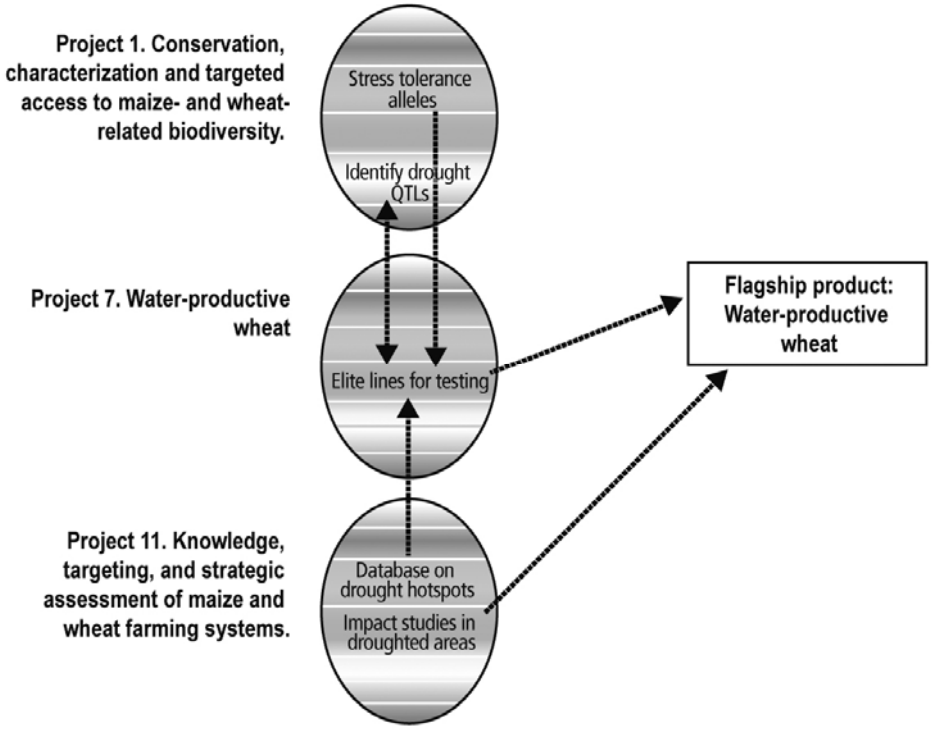

Figure 2. A simple schema of how outputs from MTP Projects (the ovals) contribute to work in other Projects and, ultimately, the development and delivery of a flagship product. All flagship products draw on Project outputs.

Highlights of the 2007-2009 Project Portfolio

The flagship products described above are embedded as outputs in a focused Project portfolio. The 2007-2009 Medium-Term Plan Projects are described below in highlights and fleshed out in the logframes. Key areas of focus and strategy are also briefly described.

Project 1. Conservation, characterization and targeted access to maize- and wheat-related biodiversity.

Crop-related biodiversity is the founding asset of the CGIAR and the basic raw material for the international breeding programs of CIMMYT. The emerging niche of the CGIAR in the new millennium builds on this foundation, but now with greater emphasis on technology-assisted methodologies and intermediate products associated with the efficient identification of target value-added traits and their rapid introgression into elite breeding material. Structured and well-characterized germplasm subsets, trait-specific genetic stocks (near-isogenic, introgression and substitution lines), double haploid lines, synthetic polyploidy genotypes, genetic mapping populations and mutant stocks, enhanced gene pools, advanced lines, and diverse cultivars are becoming an increasingly critical asset for the global plant research and breeding community. Targeted development, intensive characterization and extensive evaluation (under diverse field conditions) of this germplasm is increasingly seen as the rate-limiting factor for translation of outputs from the genomics and information technology revolutions into tangible products for developing country farmers. Application and translation of upstream research outputs for the development of intermediate products with multi-disciplinary added value will be increasingly dependent upon effective data management systems. Thus, a major new strategic focus in P1 is the creation of a fully integrated web-based support system for partners involved with conservation, utilization, evaluation and enhancement of genetic resources, whereby all types of data can be integrated, compared and collectively analyzed and queried by anyone anywhere.

<u>International public goods:</u>

- Methodologies for trait and gene-based identification of useful crop-related biodiversity.
- Capacity building and technological backstopping to assist NARS, SMEs, and CIMMYT breeders to make best use of maize and wheat-related biodiversity.
- Development of fully integrated, public-access, germplasm characterization information resources.
- Generation and/or characterization of near-isogenic, introgression and substitution lines, enhanced gene pools, synthetic polyploidy genotypes, genetic mapping populations and mutant stocks for trait-targeted genetic investigations.
- Targeted collection, conservation, characterization and distribution of crop-related bio-diversity.

<u>Impact pathways and partnerships:</u>

Intermediate products from P1 focus on tools, methodologies, and germplasm associated with more targeted, efficient, and rapid access to and use of the most desirable genetic variation for maize and wheat breeding programs. The primary users of these intermediate products—who will also take part in their development—span breeders and other researchers from CIMMYT,

NARSs, SMEs, and advanced institutes. These intermediate products should have a direct impact on the efficiency and ultimate impact of CIMMYT and partners' maize and wheat breeding programs. Clearly the extent to which activities in this Project can effectively target access to the most desirable genetic variation remains a hypothesis. However, the combined application of genomics and informatics will arguably improve the routine rates of success as compared to historical systematic screening approaches. The extent to which this genetic variation is taken up by CIMMYT, NARSs, and SME breeding programs will also greatly influence the overall contribution of these intermediate products to the final impact of finished varieties and improved cropping systems. Project researchers and other CIMMYT staff will synergize the process through advocacy, facilitation, catalyzing, and technical backstopping. International treaties or national legislation that restrain the Center's ability to fill gaps in germplasm collections represent a long-term constraint for this pathway; this can be addressed through balanced partnerships with countries in key centers of diversity. Similarly, the lack of capacity or willingness of some NARSs or SME breeding programs to adopt products from germplasm enhancement programs (as compared to finished products from conventional breeding programs) also constrains the scope and depth of impact of this approach. Thus, CIMMYT is launching a major effort in communities of practices for technology-assisted breeding, to bridge the gaps in capacity and openness. In general the intermediate products from this Project are likely to have an impact on the productivity, stability, and resilience of new, experimental maize and wheat varieties within 8-10 years. Resultant impacts of new varieties on livelihoods are envisaged within 12-15 years. In most cases, direct impacts will be first on the CIMMYT breeding programs through other CIMMYT Projects (#3 to #10), then through NARSs intimately involved with CIMMYT through globally decentralized shuttle breeding initiatives, and then to other NARSs and SME breeding programs in target countries, with hopefully just 1 to 2 years between each phase.

In the new vision of P1, NARSs partners—particularly in primary centers of maize or wheat diversity—and CGIAR and other advanced gene banks play a critical role in synergizing P1 activities in germplasm conservation and characterization. Similarly, CIMMYT's participation in the Generation and HarvestPlus Challenge Programs will provide unique access to global germplasm for drought tolerance and biofortification. Finally, our partnerships with advanced institutes such as CRC-MPB (Australia), Cornell University, USA, and NIAB, UK, provide essential access to new technologies for target trait-based access to germplasm, particularly allele and gene mining technologies. General conservation and utilization activities among CIMMYT and other international centers take place under the System-wide Genetic Resource Program (SGRP). CIMMYT predominantly focuses on applying related technologies for its maize and wheat germplasm collections. CIMMYT, NARS, and SME breeders also play a critical role in orientating these efforts toward the highest priority traits. P1 researchers reach up the value chain by committing to provide technical backstopping for the routine application of new tools and methodologies in CIMMYT, NARSs, and SME breeding programs.

Project 2. Technology-assisted tools and methodologies for genetic improvement.
This Project develops and validates new methodologies for more efficient and targeted manipulation of new alleles and genes for traits prioritized by end-users in CIMMYT's regional

programs, NARSs, and SME breeding programs. The ultimate goal is to enhance resilience to abiotic stresses, yield stability under biotic stress, nutritional quality for human and animal consumption, and the profitability of maize and wheat cultivars, through targeted use of genetic resources. CIMMYT and partners' molecular breeding application facilities urgently need to evolve to a new paradigm that takes maximum advantage of out-sourcing enterprises for genotyping. Similarly, the identification of new marker associations is often better achieved in advanced institutes. Nevertheless, CIMMYT has a primary niche in developing central information resources, coordinated analysis, and facilitation of the overall product development chain. Similarly, it is CIMMYT's role to validate and refine outputs from advanced institutes to ensure robust and efficient application in plant breeding programs. In particular, this will involve applying quantitative knowledge-led phenotyping systems, analyzing environmental and genetic background effects, developing improved methodologies through retrospective analysis of current breeding data, and devising new selection systems based on holistic indices and computation decision support tools.

International public goods:

- Web-enabled integrated data management and analysis systems linking genetic resources, biotechnology, breeding, and varietal releases.
- Biotechnology and/or computationally-assisted germplasm enhancement tools and strategies.
- Capacity building and technological backstopping to assist NARS, SME, and CIMMYT wheat and maize breeders to make best use of new germplasm enhancement tools, methodologies, and genetic resources.
- *Ex ante* or cost-benefit analysis of impact from outputs/intermediate products (germplasm, tools, and methodologies) from CIMMYT's Genetic Resources and Enhancement Unit (GREU) in flagship projects.
- New genetic engineering methodologies and systems for breeding GM crops.
- New maize and wheat molecular breeding tools through translational genomics from rice and other model systems.
- New maize and wheat molecular breeding tools through functional genomics analysis of metabolic pathways important for agronomic traits such as drought tolerance and developmental biology.

Impact pathways and partnerships:

The development, validation, and facilitated application of new tools and methodologies for genetic improvement programs is a fundamental niche for CIMMYT researchers to improve the efficiency and impact of CIMMYT, NARSs, and SME breeding programs. Along with value-added genetic resources (P1), these tools and methodologies (P2) are the cornerstone of CIMMYT's intermediate products, which have indirect impacts on stakeholders by improving the speed, precision, and efficiency of crop breeding programs. These tools may be based on tissue culture, genomics, or transgenic technologies; new methodologies increasingly rely on advanced biometrics, informatics, simulation, and modeling. The extent to which the potential benefits of such new tools and methodologies are realized relies heavily upon the scope of uptake and skills of implementers. To ensure maximum impact of intermediate products, P2

researchers commit not only to develop, validate, and refine tools and methodologies hand-in-hand with relevant breeding programs, but also to facilitate their effective uptake and application in CIMMYT, NARSs, and SME breeding programs through intensive and proactive technical backstopping. This will be achieved through the development of communities of practice for molecular breeding, building out from partners in the globally decentralized shuttle breeding initiative. CIMMYT is in the vanguard of the CGIAR evolution to focus increasingly on developing facilitating technologies and assisting partners to take over the traditional mandate of developing elite breeding lines and near-finished products. In this scenario, CIMMYT will increasingly emphasize its role as facilitator, enabler, and advocate in the overall value chain, as opposed to primary provider of advanced breeding materials. This transition will clearly move faster in some countries than others. As stronger NARS and SME breeding programs take on a larger role in product development, CIMMYT will focus more efforts on weaker countries with the greatest need (in terms of poverty alleviation) for advanced breeding lines and near-finished products. In turn, as fewer NARS in general require CIMMYT to play this role, then CIMMYT can again refocus efforts on more upstream germplasm enhancement activities.

In the new vision of P2, advanced institute partners play the foundation role of predominant technology provider, although in rare cases where no institute is interested in a priority trait, tool, or methodology, CIMMYT will take up that role. CIMMYT's founding role in the Generation Challenge Program and the Molecular Plant Breeding Cooperative Research Center provides unique access to a huge range of technology options. CIMMYT focuses predominantly on validating and refining those technologies for application in stakeholders' unique situations and integrating diverse technologies into efficient, new genetic improvement methodologies. CIMMYT, NARS, and SME breeders then validate and refine the methodologies. Finally, GREU scientists commit to provide technical backstopping for the routine application of these new tools and methodologies in CIMMYT, NARS, and SME breeding programs. Intermediate products from the Project are likely to have an impact on the productivity, stability, and resilience of new maize and wheat varieties within 8-10 years; resultant impacts of new cultivars on livelihoods are envisaged within 12-15 years. In most cases direct impacts will be first on the CIMMYT breeding programs through other CIMMYT Projects (#3 to #10), then through NARSs intimately involved with CIMMYT through the molecular breeding community of practice (e.g. in Kenya, China, India, or Brazil), and then to other NARSs and SME breeding programs in target countries; hopefully with just 1 to 2 years between each phase.

Project 3. Stress tolerant maize.

Tropical maize growing environments are affected by a wide range of stresses worsened by variable weather conditions, infertile and acidic soils, lack of inputs, labor shortages for other control methods, and soil degradation. In particular, the importance of finding genetic approaches which stabilize and increase crop productivity in the face of climate change and increasing water scarcity is widely acknowledged. Also, for some newly emerging or newly important biotic stresses, no sources of resistance can be found in known or improved germplasm. This Project will use breeding methodologies, genes, chromosomal regions, and allelic variation for exploratory incorporation into elite or farmers' own maize germplasm and

assessment of genotype, gene-by-genotype, and genotype-by-environment effects. It will apply the insights gained to generate strategically important stress tolerant source germplasm and strengthen the capacities of partners to effectively use new and proven tools emerging from other undertakings, such as Projects 1 and 2 and the CGIAR Generation Challenge Program. Traits of interest in the time-frame of this business plan include drought, low nitrogen stress, acidic soils, host plant resistance to *Striga*, stem borers, post harvest pests, and mycotoxin generating ear rots, which are among the most intractable stress factors in maize world-wide. As steward of the world's maize genetic resources, CIMMYT has a global responsibility for developing germplasm with new or more durable resistance to environmental stress factors, diseases, and pests. Within this Project, CIMMYT will provide an effective access path for identifying and availing new sources of resistance from the genetic resources and enhanced germplasm managed by CIMMYT. The Center's accumulated maize research and breeding materials targeting stress environments are regarded as successes. This Project builds upon them to contribute to food security and better use of scarce resources (water, nutrients, labor, and land), in particular as climate change increases the area and frequency of unfavorable production conditions.

International public goods:

- Enhanced maize populations and lines that tolerate drought, N stress, and acidic soils and resist diseases and insects in target areas.
- Maize types with high levels of drought and heat tolerance to offset expected impacts of climate change in the developing world.
- New sources for host plant resistance to diseases and pests that threaten maize production and trade in significant regions of the developing world.
- Seed-embedded options for controlling *Striga,* a parasitic weed that threatens maize production throughout sub-Saharan Africa.
- Conventionally and biotechnologically-derived stem borer resistant maize cultivars.
- Maize types expressing significantly reduced levels of mycotoxins for the improved health of high-risk populations.
- Knowledge-sharing on genetic resources and selection protocols to breed maize germplasm for stress-prone environments and with improved resistance to important biotic stresses.

Impact pathways and partnerships:

The Project develops a variety of improved stress tolerant maize populations and lines, and associated knowledge to contribute to maintain, increase and stabilize farmers' yields in stressed production environments. Breeding of maize germplasm that offers options against intractable traits, and specifically imazapyr-resistant (IR) maize in relation to the threat of the *Striga* weed, exemplify the nature of impact pathways in P3. IR maize is the result of an international public-private partnership among KARI (Kenya), the Weizmann Institute of Science (Israel), BASF, and CIMMYT. CIMMYT's role was to source the resistant gene from BASF which underpins the development of IR maize cultivars adapted to Eastern African environments where *Striga* damage is extensive, for example in Western Kenya. In a parallel activity, CIMMYT collaborates with the Weizmann Institute to develop and improve a low-cost technology for seed coating which is suitable for resource-poor farmers. To illustrate the next

steps of the impact pathway for IR Maize, CIMMYT's breeders in partnership with KARI breeders convert available improved maize lines (e.g. CML216, CML312) adapted to eastern Africa to imazapyr-resistance. Generally it would take about 10 years for development, testing and release of a new hybrid. Then, local seed companies in Kenya (such as Western Seed) which operate in areas where *Striga* is a problem will evaluate the improved varieties, multiply seed and release improved hybrids and open-pollinated varieties or use imazapyr-resistant maize lines in their breeding program. After release (already on-going in Kenya and envisioned in other *Striga*-affected countries within 2-4 years), NARSs and local seed companies will multiply seed of IR maize for use in field demonstrations, while seed production is scaled up, which would generally require 2-3 years. As the improved IR lines become available, several thousand demonstrations of the new material are expected to be organized and run by NGOs across the *Striga*-infested areas of Kenya, especially the high population density and impoverished Western districts. Other countries, e.g., Tanzania and Uganda will follow suit as varieties are released nationally. The adoption of IR maize can tremendously boost maize yields in severely infested fields , e.g. a smallholder farmer growing 0.5 ha of maize might produce an additional 1-2 tones of maize which will lead to improved farm household food security, livelihoods and possibly extra income from the sales of surplus maize. The success of IR maize is likely to foster a restoration of maize areas and production in *Striga*-infested districts of sub-Saharan Africa. The extra income generated for local expenditure will boost the local economy and create extra off-farm work.

Project 4. Nutritional and specialty traits for maize.

The world's maize genetic resources contain a wealth of benefits, including new opportunities for improving nutrition, and multiple uses of maize and maize products. This Project explores new opportunities for highest-priority genetic traits in demand by beneficiaries, partners, and clients, incorporates them into germplasm usable by the wider community involved in maize genetic enhancement, and develops first experimental germplasm for use and feed-back by clients and beneficiaries. Research is on-going to find new traits to biofortify maize for key micronutrients (vitamin A, zinc, iron). This is just one example of groundwork for eventual breeding programs. Other traits include those related to horticultural uses of maize (green-cob, baby-corn, sweet corn) as important sources of cash for growers in Southeast Asia and others near urban areas in Asia, Africa, and Latin America. Likewise, maize with non-food crop uses, such as dual purpose maize (food and fodder) or high-protein maize for poultry producers may provide income-generating options. The Project promotes a strong integration with CIMMYT staff in regional Projects, their clients and beneficiaries, and partners in advanced institutes and Challenge Programs, capitalizing on CIMMYT's comparative advantage to identify in gene bank and breeding materials usable traits for human nutrition and health, horticulture, or multiple purposes. The market potential and benefits of specialty maize will be assessed, and analyses of alternate suppliers and incentive-based value chains used to highlight opportunities and recommend priorities for research investments in Asia, Africa, and Latin America. Armed with these socioeconomic analyses, CIMMYT and partners can form consortia that attract funds to implement research that taps the wealth of maize genetic resources to give farmers new income-generating options. Although QPM is no longer new at CIMMYT, Center breeders will continue to incorporate the quality protein trait into improved maize germplasm.

International public goods:

- Ex-ante impact assessment and analysis of the presence of alternate suppliers for assessing and targeting CIMMYT involvement in nutritional and specialty trait-specific research.
- Identified source germplasm and allelic discovery in maize genetic resources for specified high-priority traits.
- Experimental materials (pyramiding proven new, important traits in adapted genetic backgrounds) for evaluation and use with selected clients and beneficiaries.
- Information about inheritance and breeding methods.
- Publications on recommended pathways (commodity chains) to maximize impact of chosen value-adding maize research investments.

Impact pathways and partnerships:

Agrosalud, a special project funded by the Canadian International Development Agency and convened by CIAT, offers an example of how P4 works with partners to ensure a complete and successful impact pathway. The goal of this special project is to improve the nutritional status of the rural and urban poor in target regions of Latin America by developing and deploying agronomically superior, micronutrient-dense quality protein maize (QPM). Primary target countries are El Salvador, Nicaragua, Honduras, Guatemala, Mexico, Colombia, Ecuador, and Haiti. Most of the germplasm comes directly from CIMMYT or is derived from Center products. Each country team implements a similar impact pathway, which starts from the substantial maize breeding effort which is conducted at CIMMYT, including breeding methodology development and all stages of applied breeding, from identification and creation of sources of variation to development of experimental hybrid and open-pollinated cultivars for evaluation by interested partners:

- Maize breeders in each country will participate in international trials and in adaptive breeding of QPM germplasm distributed by CIMMYT which will lead to release of an estimated 6 cultivars within 5 years.
- Strip-plot demonstration trials will be planted by national program partners (e.g. CENTA in El Salvador; INTA in Nicaragua; UNA and DICTA in Honduras; etc.) on farmers' fields at multiple locations; over about 2 years the most-promising 2 to 4 cultivars will be selected with farmer input obtained during field days and via farmer surveys.
- During 2 to 3 years demonstration plots of the promising cultivars and best currently-available commercial cultivars will be planted at 50 to 200 sites by partners in extension services, NGOs, and farmers' associations. Various stakeholders (private seed companies and NGOs) and policy-makers will be invited to field days together with farmers.
- Training courses on seed production and nutritive characteristics of the QPM cultivars will be organized at the regional level, with participants from NARSs, NGOs, and seed companies.
- Alliances will be developed with private seed, milling, agrochemical, and livestock companies, as well as with universities, health clinics, and schools, to demonstrate the value of and promote QPM cultivars.

- Links to formal or (if necessary) informal seed producers and retailers will be cultivated, to ensure a supply of seed for the QPM cultivars.

Beneficiaries will be maize farmers in the target (and spill-over) countries. The main benefit will be improved maize production and stability of maize production by using the maize varieties developed and disseminated by the Project. For poorest farmers, previously using unimproved varieties, this can represent a doubling of maize yield, whereas for farmers already growing improved varieties, this Project may result in 10-20% production increases.

Box: **Maize, wheat, human nutrition and health**

Humans domesticated plants into crops to address their needs for food, feed, dress, shelter, and energy. Among the most important food crops are maize and wheat that together account for 40% of the calories in the diets of developing world citizens. These two crops are pivotal to nutrition, health, income, environmental sustainability, and overall development for low-income nations. Agricultural researchers continue addressing malnutrition by developing systems that provide more nutritious food or higher incomes to purchase it. For example, plant breeding provides a means for improving micronutrient content and protein quality in crops. The genetic enhancement of crop biodiversity to increase iron content in staple crops that reach a quarter of developing world inhabitants could eliminate up to 100 million cases of iron deficiency every year. Plant breeders are genetically enhancing wheat to produce high-yielding lines whose grain contains 30 to 50% more iron and zinc. The best genetic resources for both micronutrients are grass species that do not cross easily with modern wheat cultivars. Still researchers have been able to hybridize one such grass—*Aegilops tauschii*—with a micronutrient-rich primitive wheat (*Triticum dicoccon*), to obtain the micronutrient-enhanced lines. These are being tested widely in India and Pakistan. One day their citizens, particularly the urban and rural poor, will eat biofortified bread. In maize the naturally-occurring mutant gene *opaque-2*, discovered in a Peruvian maize landrace in 1963, increases levels of the essential amino acids lysine and tryptophan, greatly improving the quality of grain protein. Over two decades of meticulous breeding, CIMMYT researchers developed experimental lines and varieties that feature this enhanced quality, without *opaque-2*'s undesirable effects on grain quality and appearance. QPM improves the diets of people who consume a great deal of maize, as well as the productivity of farm animals, when used in feed. Varieties and hybrids of this quality protein maize (QPM) are grown on more than 650,000 hectares in 25 countries throughout the developing world. These are just a few examples of the impacts of maize and wheat breeding on the livelihoods of both farmers and consumers, which are contributing towards the Millennium Development Goals in today's complex global environment.

Project 5. African livelihoods: Global solutions for maize food and income security in eastern and southern Africa.

Maize is an important lifeline in eastern and southern Africa, where over 340 million people annually consume about 20 million tons or 57 kilograms per capita. Maize production has strategic importance for the food security and socioeconomic stability of the region, which is among the poorest worldwide and afflicted by poor input and output markets, recurring droughts, parasitic weeds, and insect pests. Farmers respond to poor market conditions and variable weather conditions by planting more food crops than needed in an average year and selling surpluses in good years. Land and labor use for cropping maize is to the detriment of legumes, cash crops, or other useful diversification, resulting in human malnutrition and soil fertility depletion. Providing opportunities for farmers to generate healthy food on a smaller land area, in particular as the impacts of climate change become more pronounced, has significant importance for food and income security, market development, and cropping diversification. This Project is an integral part of CIMMYT's maize strategy. Through partnerships with other international centers, NARSs, local NGOs, and entrepreneurs in Africa, as well as linkages with other CIMMYT Projects and advanced institutes worldwide, the Project undertakes research to develop and build the capacity to deliver genetically enhanced maize and resource-conserving practices. These contribute to increased food and income security and cropping diversification in maize-based systems in eastern and southern Africa, as well as creating a sustainable and significant impact on the livelihoods of African farmers. Through its mandate and historically strong presence in eastern and southern Africa, CIMMYT has a comparative advantage and track-record in the use of maize genetic resources, state-of-the-art technologies, and intrinsic knowledge of African farmers' circumstances to generate maize-based solutions that impact livelihoods. CIMMYT is known for developing and applying breeding techniques that improve the tolerance and resistance in maize to intractable stresses (drought, low nitrogen, soil acidity, *Striga*, diseases, and insect pests), and for using maize genetic resources to enhance the crop's productivity and value for human nutrition and health. Similarly, work on resource-conserving technologies links with the Center's global commitment to make their use sustainable for smallholder farmers.

<u>International public goods:</u>

- Multiple-stress resistant, biofortified maize for enhanced food security, nutrition, health, and cropping diversification in eastern and southern Africa.
- Resource-conserving technologies that stabilize and increase productivity in maize-based systems, cognizant of the socioeconomic circumstances of resource-poor farmers in eastern and southern Africa.
- Regional-based capacity building in eastern and southern Africa for NARSs, NGOs, and SMEs, to more effectively prioritize, develop, and deliver maize-based technologies and policies relevant to resource poor farmers.
- Knowledge on more effective, incentive-driven seed delivery pathways to increase the impact of maize genetic gains among farmers in stress-prone and outlying areas of eastern and southern Africa.

- Capacity building in selected NARSs and, particularly, regulatory system staff to incorporate transgenic technology into the development and stewardship of adapted maize cultivars.
- Information, publications, and training modules for CIMMYT-wide knowledge management approaches.

Impact pathways and partnerships:

The New Seed Initiative for Maize in Southern Africa (NSIMA) project, coordinated by CIMMYT and co-funded by the Swiss Agency for Development and Cooperation and the Rockefeller Foundation, offers an example of how P5 will work with partners to ensure complete and successful impacts. This project will contribute to improving the food security and livelihoods of resource-poor farm families in southern Africa by providing farmer-selected maize varieties with increased productivity under the stress-prone conditions typically faced by resource-poor farmers, and by strengthening stakeholders in the maize seed sector to work towards a more diverse and stable seed industry responsive to resource-poor farmers' needs. The project relies on diverse partnerships to develop and strengthen key components of the impact pathway, as follows:

- A significant effort will be made to strengthen the research capacity of NARSs scientists and technicians through collaborative research projects and training on topics encompassing all steps in the impact pathway and ranging from short-duration workshops to supervising MSc and PhD programs. Agreement with sub-regional priorities and links among actors of the impact pathway are strengthened through multi-stakeholder steering committees or coordination units and annual planning meetings at country and sub-regional levels.
- New, stress-tolerant experimental hybrids and open-pollinated varieties will be developed and entered into regional evaluation trials by CIMMYT scientists and, via a competitive grant system to support national program breeding projects, by national program partners.
- In collaboration with the Southern African Development Community (SADC) and other international centers, the project will work with national seed services, policy-makers, and donors to support regional harmonization of seed regulations, thereby promoting seed sector development and enhancing access by resource-poor farmers to seed of improved varieties.
- NARSs, NGOs, rural schools, farmers' associations, and other partners implement farmer-participatory trials will generate quantitative and qualitative data used in cultivar release decisions and to inform further research by NARSs and CIMMYT. Institutionalization of this approach will be promoted by devolving coordination and oversight to teams in 10 countries, with technical support from a regional coordinator.
- Formal (private seed companies) and informal (community organizations) seed producers will be involved as partners at various stages, from farmer-participatory variety testing to seed production, release, and commercialization of the best cultivars. Training of small-scale seed entrepreneurs will be a key activity.

CIMMYT will aim to be an active participant in the Challenge Program for Sub-Saharan Africa.

Project 6. Maize for Asia and Latin America.

Maize is grown on more than 60 million hectares in tropical developing countries, with about 27 million hectares in Latin America and the Caribbean and 16 million hectares in South and Southeast Asia (excluding China, which grows about 25 million hectares). Relative to 1995, by 2020 demand for maize in East and Southeast Asia will have increased by nearly 50% and in South Asia by more than 90%. Much of the demand is for animal feed, but demand for maize as food is also rising, particularly among the poor in densely populated areas. The accelerating demand for maize must be met within the context of increasing competition for water, land, power, and labor resources; innovative science will be required. CIMMYT's wealth of genetically diverse maize is one key to ensuring sustained increases in productivity. Genetic diversity is a fundamental requirement to exploit hybrid vigor and to reduce vulnerability to diseases and pests. As the private sector increasingly meets the demand for improved maize cultivars, issues of germplasm ownership are rapidly narrowing the genetic diversity available to researchers, making CIMMYT an ever-more-crucial source of productivity-enhancing and productivity-protecting genetic diversity. This Project will focus on developing and facilitating the deployment of stress tolerant, nutritious maize adapted to Latin America and South and Southeast Asia. Drought, pest, and disease threats dominate the agenda, with particular attention to emerging constraints associated with agricultural intensification and use of resource-conserving technologies. This Project will facilitate or participate in consortia to develop improved maize technologies (especially germplasm) and to enhance access to them in "poverty peaks" or otherwise marginalized areas in Asia or Latin America.

<u>International public goods:</u>

- Maize germplasm with essential or valuable trait combinations for use in breeding programs especially in the lowland tropics worldwide.
- Maize germplasm with essential or valuable trait combinations for use in breeding programs for the highlands worldwide, but especially in Mexico.
- Maize germplasm suited to resource-conserving cropping systems, in general and for intensive rice-maize cropping in Asia as a contribution to the work of the IRRI-CIMMYT Alliance.
- Maize germplasm that provides insurance against narrowing genetic diversity and emerging constraints to maize production.
- An upgraded capacity in researchers, local entrepreneurs, and institutions to effectively develop and deliver genetic gains and know-how to beneficiaries.

<u>Impact pathways and partnerships:</u>

The Hill Maize Research Project (HMRP), an example of CIMMYT work in P6, is a collaborative project between CIMMYT and the Nepal Agriculture Research Council (NARC), funded by the Swiss Agency for Development and Cooperation. The goal is to improve farm families' food security and livelihoods through the increased productivity and sustainability of maize and maize-based cropping systems in the hills of Nepal. Specific objectives are to develop a sustained capacity within the National Maize Research Program (NMRP) of NARC and in its research partners to develop maize production technologies with and for poor maize farmers and to facilitate the dissemination of appropriate maize technologies through extension and

input delivery channels. The HMRP brings together an extensive array of partners to ensure a complete and successful impact pathway, as follows:

- Professional development of NMRP scientists is continuous and multi-disciplinary, and ranges from short workshops to MSc and PhD programs (e.g., 7 post-graduate students in 2006).
- Stress-tolerant, open-pollinated experimental maize cultivars—introduced mainly from CIMMYT breeding programs in Africa and Mexico—will be evaluated by thousands of farmers in simple, participatory varietal selection experiments implemented by NGOs, government extension services, and farmer associations in remote hill areas. It can be expected that farmers will select 2-4 cultivars each year for further evaluation, and 1-2 new varieties will be released every 3-4 years.
- Little breeding work is planned, except mass selection or adaptive breeding of farmer-preferred experimental cultivars to improve traits prioritized by farmers (non-lodging, stay green, high yield, and grain flavor).
- Foundation seed of farmer-preferred cultivars will be produced mainly on NMRP research stations.
- More than 15 partners, mainly NGOs and District Agriculture Development Offices (DADOs), have been trained by CIMMYT in order to organize and train farmer groups in remote hill areas to produce and market seed. More than 300 tons of seed are expected to be produced through such community-based schemes per year. Most seed production groups will receive training in business skills and will be assisted in linking with seed traders and DADOs to develop marketing networks.
- The HMRP supports competitive small grants program that, among other things, helps farmers to identify profitable crop diversification options, such as intercropping of tomato, ginger, soya, or faba beans with maize.
- Training of and by HMRP partners also benefits hundreds of farmers each year on topics including seed production and small business skills. Tens of thousands of farmers will benefit directly from HMRP-coordinated activities, and many will be women (>50%) and/or from disadvantaged groups (e.g., dalits and Janajati).

Project 7. Water-productive wheat.

Approximately 50 million hectares, or close to 50% of all wheat cultivated in developing countries, is sown under rainfed systems that receive less than 600 mm of rainfall annually. Some of the poorest and most disadvantaged wheat farmers live in rainfed areas of less than 350 mm annual rainfall and their livelihoods often depend solely on income from wheat production, with wheat straw or fodder contributing to farm animal sustenance. In rainfed areas, water availability is limited and unpredictable, and indications are that climate change is making this variability more extreme. Agriculture is a major user of water (72% globally), and supplementary rather than full irrigation is becoming common, exposing wheat to water stress. Water productivity is an increasingly important trait for wheat cultivars for irrigated areas. Recognizing water productivity and drought tolerance as priorities for wheat, CIMMYT has worked to disaggregate drought tolerance *per se* in wheat into distinct components and applies those findings to germplasm improvement. Ongoing research is gaining a better understanding

of traits which have a major effect on water productivity in dryland wheat areas: these include root architecture and physiological traits, resistance to soil-borne pests and diseases, tolerance to heat and saline, zinc deficient, and boron toxic soils. The use of manipulated, repeatable selection environments in Mexico and the data collected and analyzed for genotype-by-environment interactions through a unique network of international partners, enable wheat researchers to make real genetic gains in parental and advanced lines. The combination of improved germplasm; the Center and partners' expertise in drought physiology, soil-borne diseases, and agronomy; and the availability of markers for various traits puts CIMMYT in a unique position to develop water-productive wheat with resistance to the important stresses for use by partners throughout the developing world. This Project is conducted in close collaboration with ICARDA, through the ICARDA-CIMMYT Wheat Improvement Program (ICWIP).

International public goods:

- Spring and winter bread wheat and spring durum wheat with increased water productivity, adaptation and performance stability, multiple resistance to soil-borne and foliar diseases, and appropriate end-user quality, distributed through international nursery trials for sharing and evaluation by NARSs partners.
- Segregating populations targeted to NARSs-specific germplasm requirements and to locations where hot spot screening is needed.
- Germplasm developed through targeted shuttle breeding with partners for specific traits (soil-borne pathogens, micro-nutrient screening, Hessian fly, rust).
- Data and information through the International Wheat Improvement Network.
- New sources of genetic material and associated knowledge for water-use-efficient germplasm.
- Effective breeding methodologies for germplasm improvement for variable locations significantly affected by genotype-by-environment interactions.

Impact pathways and partnerships:

The development of wheat germplasm with broad agro-ecological adaptation will be made possible through selection in diverse environments and at multiple locations. Relevant stresses of major concern to smallholder farmers include tolerance to drought and micronutrient imbalances, nitrogen and other macro-nutrient use efficiencies, and resilience to hot and cold temperatures.

The Generation Challenge Program Consortium is one partner which strengthens the impact pathway for water productive wheat (P7) by using advances in molecular biology to harness the rich global stocks of crop genetic resources to support CIMMYT breeders in creating a new generation of water-productive wheat. The CIMMYT program currently develops some 1,000 lines annually of spring bread wheat, facultative and winter bread wheat, spring durum wheat, and spring triticale, for international distribution. This generally requires 3 to 5 years, substantially quicker than most other wheat breeding programs worldwide because shuttle breeding in Mexico allows two generations per year. Around half of these lines are targeted at regions where water stress occurs, particularly the Asian sub-continent, CWANA and the

southern cone of South America. The next step in the chain is the International Wheat Improvement Network which will distribute CIMMYT germplasm to NARSs, advanced institutes, and SMEs who will, in turn, test the materials in abiotically stressed locations. The resulting data will be collected by all partners and shared via the internet and at local, regional, and international meetings. The wheat improvement programs at CIMMYT and ICARDA act in partnership throughout CWANA.[2]

As an illustration of how CIMMYT advanced lines of wheat reach farmers and improve their livelihoods, the Ethiopian national program is a strong partner. Wheat, grown in Ethiopia since 1,300 BC, today is the fourth or fifth most important crop behind teff, maize, sorghum and barley. It is grown in the Abbysinian highlands on rich soils that are prone to waterlogging, hence farmers often postpone planting of crops as the rainy season subsides, thus exposing the crops to terminal drought stress. In addition, population density pressure in the highland areas has forced many farmers to cultivate less favorable areas which are more prone to climate variability, drought and less fertile soils.

Lines selected from the international bread wheat screening nursery by national breeders are tested throughout the country, at least seven locations which are representative of the agroecological zones where wheat is grown in the country. Parallel to this national testing, the same germplasm is tested by at least 80 other national or provincial programs throughout the developing world. Data collected by International Wheat Improvement Network cooperators is returned to Mexico, analyzed and made available to all network cooperators. Hence, performance of germplasm within Ethiopia can be compared to performance in neighboring countries, in similar agroecological regions. This pooling of data, information and knowledge can decrease the time required for local testing, resulting in quicker release of varieties to seed producers and farmers.

From the time a cross is made in Mexico, to the time a new variety is registered for release in Ethiopia can be as short as 8 years. Farmers are often involved with on-farm testing of candidate varieties, and those candidates that excel in performance or farmer preferences are often actively adopted even before formal varietal release occurs. Assurance that a variety will performance as expected, is necessary to build trust between farmer, extension agent and national researcher, hence testing of germplasm through the International Wheat Improvement Network, involving numerous locations and varied environments add weight to the confidence attributed to new, candidate cultivars.

On-farm wheat technology demonstrations remain an important tool for technology dissemination in Ethiopia. The Sasakawa Global 2000 organization has been instrumental in promoting proven technology innovations to farmers, including use of improved varieties, better crop management practices and seasonly dependent fertilizer application. Wheat varieties from CIMMYT in Mexico, tested and approved by the Ethiopian national agricultural

[2] The facultative and winter wheat germplasm is developed within the joint MARA/CIMMYT/ICARDA International Winter Wheat Improvement Program (IWWIP) hosted by the National Program of Turkey.

research program, reach farmers through NGOs, national and local seed producer and retail schemes.

The ultimate beneficiaries will continue to be smallholder farmers, who will receive improved bread wheat, durum wheat, and triticale cultivars suitable to the environments in question. Because farm sizes are small in Ethiopia, it has been estimated that there are over one million farmers that grow wheat in the country every year. Building upon the foundation of modern wheat cultivars, new releases can be expected to deliver 10% yield gain versus older varieties, be more tolerant to variable climate conditions, and produce more straw – and important component for animal fodder, home cooking firm fuel, and an important home roofing material. Broad adaptation in cultivars buffers farmers' risks in low or variable rainfall distribution settings, while allowing SMEs and progressive farmers economically to produce and market seed of relevant cultivars.

With the assurance of some yield in drought years, farmers are expected to release land and resources for cash crops such as vegetables, herbs and teff which will generate further household income. The increased production during drought years will cushion the wheat price increase and substantially benefit poor urban consumers.

Project 8. Enhanced wheat for more durable resistance to diseases and improved production potential: Galvanized against rust and tempered for productivity.

Until the advent of science-based agriculture, world wheat harvests were held hostage by rapidly evolving fungal pathogens, among the most damaging of which were the rusts (stem, leaf and stripe), other foliar diseases and *Fusarium* head blight. Modern breeding, combined with the free international exchange of experimental wheat lines, resulted in developing and wide dispersion of genetically enhanced wheat germplasm able to resist the rusts and other diseases for several decades. Durable resistance provides farmers with confidence that they will reap reasonable harvests, despite evolving pathogen populations. But because more virulent pathotypes or strains of a pathogen will likely overcome the crop's resistance at some point and to ensure that production increases stay abreast of population growth, CIMMYT emphasizes research aimed at raising the genetic yield potential of wheat while maintaining its disease resistance. This results in enhanced, seed-embedded technology that gives superior performance in farmers' fields. The foundation is improved wheat germplasm and related knowledge built together by CIMMYT and partners; this combination has had demonstrable impact in farmers' fields.

<u>International public goods:</u>

- Disease resistant cultivars with high yield potential for farmers in all wheat producing countries.
- Knowledge of rust epidemiology to assist in the fight against a global stem rust pandemic.
- A global wheat research network: public-private-NGO partnerships among international and national agricultural research and development organizations**.**
- Upgraded institutional capacities for wheat research and extension.
- Knowledge of the basis for durable resistance to the main pathogens of wheat.

- Potential "durable", polygenic sources of resistance from the bread and durum wheat genomes as well as related wild species, for main wheat diseases.
- New sources of resistance to wheat pathogens.

Impact pathways and partnerships:
CIMMYT will select germplasm, often together with national program cooperators, in specific disease hot-spots in China, Ecuador, Ethiopia, India, Iran, Kazakhstan, Kenya, Mexico, Nepal, Pakistan, Turkey, and Uruguay in order to protect farmers' yields from rust and other diseases of wheat. CIMMYT breeders generate some 500 lines annually will broadened, often more durable, types of disease resistance, focusing on leaf, stem and yellow rust, Fusarium head blight and crown rots, and Helminthosporium and Septoria spp..

CIMMYT breeders and pathologists will apply representative yet intensive screening pressures through the Mexican Obregon-Toluca shuttle breeding scheme to identify high-yielding, stable, broadly adapted, disease resistant germplasm suitable to the needs of resource-poor farmers. CIMMYT and all 80+ partners in the International Wheat Improvement Network will also monitor the vulnerability of currently-sown wheat cultivars to emerging disease risks such as the new virulent Ug99 stem rust strain from Uganda which could devastate South Asian wheat fields.

Proactive, visionary germplasm development by CIMMYT and ICARDA will allow deployment of naturally-occurring genetic diversity to guard future cultivars against diseases and pests, while reducing pesticide use and thereby cutting production costs and protecting farmers' health and the environment. The International Wheat Improvement Network which is the contact point for the CIMMYT Global Wheat Program and a global network of wheat research partners who evaluate bread wheat, durum wheat, and triticale germplasm. CIMMYT's improved germplasm will continue to be dispatched through nurseries targeted to specific environments. Data collected by partners from the trials will be returned to CIMMYT, catalogued, analyzed and made available to the global wheat improvement community via the internet.

Performance testing for yield, adaptation, resistance to diseases, tolerance to soils with nutrient deficiency / toxicity and end-user grain quality will allows this pool of germplasm to be honed to approximately 500 lines for annual distribution to partners. Germplasm development at CIMMYT is defined by major, representative global wheat agro-ecologies, termed "wheat mega-environments." The International Wheat Improvement Network distributes mega-environment-targeted wheat nurseries to NARSs, advanced institutes, and SMEs in approximately 100 countries which include some of the most disadvantaged farmers. These partners collect and share performance and evaluation data. Lines selected by partners are regenerated and retested, often at multiple locations and together with farmers, to identify candidates for cultivar release. In areas where formal cultivar release mechanisms fail to reach all farmers, CIMMYT and ICARDA breeders will use participatory breeding schemes.

Worldwide, over 100 new wheat varieties are released from or containing CIMMYT germplasm each year. Countries vary in the length of time needed to achieve formal variety release and registration, some achieving release of new varieties in as little as 3 years from the time of receipt of germplasm from CIMMYT, while other countries may use 10-12 years of local testing and validation before lines are formally released to farmers. Systematic wheat seed production is another problem affecting new varieties reaching farmers. Because wheat is a self-pollinated crop, farmers can re-sow seed from one year to the next without substantially altering the identity or performance of a wheat variety. Hence, because of the common practice by farmers to re-sow seed they have produced, LSME are less interested in commercial seed production of new wheat varieties, unless a clear advantage of the new variety to farmers is proven and recognized. CIMMYT views delay of release of improved, new cultivars' seed into the hands and fields of farmers as a major constraint to best-bet technology transfer.

The governments and national wheat improvement programs in countries that may host CIMMYT Global Wheat Program offices: Afghanistan, Bangladesh, China, Ethiopia, Georgia, India, Iran, Kazakhstan, Kenya, Mexico, Nepal, Pakistan, Turkey will also be critical actors in the impact pathways. Among other things, they will provide substantial direct and in-kind contributions. The Project will also benefit from their knowledge of their scientists on wheat improvement and developing agricultural practices for a respective target region, along with access to experiment station facilities, and special involvement of extension services.

The ultimate beneficiaries will be farmers, including smallholders, who will receive improved cultivars. Through the increased durable resistance their yields are protected and household vulnerability (to famine and sliding into poverty) is reduced. Among the most important P8 partners are:

- The International Wheat Improvement Network. The contact point for the CIMMYT Global Wheat Program and a global network of wheat research partners who evaluate bread wheat, durum wheat, and triticale germplasm. CIMMYT's improved germplasm is dispatched through nurseries targeted to specific environments. Data collected by partners from the trials are returned to CIMMYT, catalogued, analyzed and made available to the global wheat improvement community via the internet. The ultimate beneficiaries are farmers, who will receive improved bread wheat, durum wheat, and triticale cultivars.
- NARSs. Agricultural researchers, policy-makers, seed producers, and farmers are active elements in setting CIMMYT's research agenda and breeding goals, and in knowledge-sharing through their feedback.
- ICARDA. ICARDA and CIMMYT are committed to improving the welfare of poor people and to alleviating poverty in CWANA by increasing the production, productivity, and nutritional quality of wheat. ICARDA has a proven track record in wheat improvement and agricultural systems research, and maintains special and productive relationships with NARSs and farmers in CWANA. The ICARDA-CIMMYT Wheat Improvement Program (ICWIP) strengthens these relationships and improves the delivery of relevant wheat technologies to farmers.

- The governments and national wheat improvement programs in countries that may host CIMMYT Global Wheat Program offices: Afghanistan, Bangladesh, China, Ethiopia, Georgia, India, Iran, Kazakhstan, Kenya, Mexico, Nepal, Pakistan, Turkey. Among other things, they provide substantial direct and in-kind contributions, knowledge of their scientists on wheat improvement and developing agricultural practices for a respective target region, access to experiment station facilities, and special involvement of extension services.
- The Global Rust Initiative (GRI). The GRI is a measured response to the emergence and spread of stem rust race Ug99 in East Africa. First formally noted in 1999, this race appeared to be a significant threat to global wheat production. A consortium of partners from eastern and southern Africa, the Near East, Asia, Australia, North America and CIMMYT and ICARDA, are focusing efforts to breed wheat cultivars with broadened sources of durable resistance to wheat rusts, while promoting the diversification of cultivars grown by farmers.
- The Global *Fusarium* Initiative (GFI). The mission of GFI is to provide a platform for international collaboration on *Fusarium* research projects, facilitating information exchanges, germplasm enrichment, the development of breeding methods and materials, and communication and cooperation among individuals, institutions, and governments focusing on this disease.
- The International Winter Wheat Improvement Program. This program is hosted by the National Wheat Improvement Program of Turkey and jointly carried out by MARA, CIMMYT and ICARDA and develops the winter and facultative germplasm distributed though international nurseries.

Project 9. Wheat grain enriched for health and profitability.

Grain quality is a paramount concern for farmers, processors, and consumers. High-value and value-added traits include improved nutritional quality, better milling and processing qualities, safer food products, and improved straw and forage quality for animal feed and fodder. Wheat breeding has always focused on bread-making quality, but increasing attention is now being given to wheat's use in products such as noodles, chapatti, semolina, and pasta. This Project focuses on traits which add value to wheat by improving its quality, increasing its nutritional value, or enhancing the safety of wheat-based foods. Given that farmers and consumers will not select directly for these traits, they are usually coupled as "covert genes" into well adapted wheat cultivars. This Project will identify new traits and incorporate them into elite germplasm accessible to resource-poor farmers. Its impacts will include improved food security and livelihoods. CIMMYT germplasm must meet the quality demands of a range of clients, markets, and beneficiaries. For the poorest of the poor, biofortification of wheat cultivars through increased micro-nutrient content will be pursued. CIMMYT and partners will also work to provide value-added traits that will enable farmers to meet industry standards. Relevant traits include improved micronutrient and protein content and improved quality for specialized food products. Through resistance breeding, CIMMYT and partners will also work proactively to address food health issues associated with contamination from *Fusarium* mycotoxins.

International public goods:

- Value-added traits incorporated into CIMMYT elite wheat germplasm of relevance to end-users.
- Safer food from wheat through reduced mycotoxin content.
- Molecular markers for relevant traits optimized and applied.
- Wheat processing methods (flour extraction, whole meal flour) optimized to minimize micro-nutrient losses for whole-meal products such as chapatti and nan.
- New sources of germplasm with increased Fe and Zn grain concentrations, and increased nutrient bioavailability, protein content, and quality.

Impact pathways and partnerships:

Better food from wheat grain is CIMMYT's ultimate target. Enhanced nutritional characteristics (higher levels of iron, zinc, protein) in grain will benefit consumers' health, these consumers will include the resource-poor. By working closely with NARSs, agricultural researchers, policy-makers, seed producers, and farmers, local preferences for grain type, grain and flour color, and processing quality will be considered in breeding research to foster adoption and use of resulting wheat cultivars. Carrying out participatory value chain mapping and market demand surveys, the Project will identify emerging market trends and will facilitate greater efficiencies and equity within existing and new value chains. As a result, Smallholder wheat producers will be able to grow marketable grain for local sale and to compete with international exports, as well as certain special-quality grain types that fetch a price premium in domestic markets.

In today's global economy, wheat farmers throughout the developing world compete in their local markets with wheat suppliers from the North. In China, international grain marketing companies and consortia can ship wheat from North America or Australia at delivery prices that may be competitive with Chinese wheat produced in the interior of the country. Furthermore, foreign suppliers can target bulk quality requirements, but may not fully appreciate, nor meet, the diverse flour quality standards required by the entire Chinese food industry. CIMMYT has worked with Chinese researchers and food industry to tailor wheat varieties with varying quality characteristics.

Grain with defined quality traits will add value to farmers' access to markets and consumers. CIMMYT's long association with private sector millers and bakers will continue to refine breeders' grain quality standards for leavened and flat breads, noodles, pasta, cakes and cookies, and overall nutritional content.

Because of the global perspective of CIMMYT Global Wheat Program, germplasm from various wheat genepools can be intercrossed. In this process, genetic diversity is mixed, providing breeding programs throughout the developing world a greater array of genetic diversity to be used and tailored in their own national wheat breeding programs. CIMMYT annually distributes approximately 500 advanced wheat lines to China, using a centralized distribution network coordinated by the CIMMYT office in Beijing, with seed multiplied and distributed from the Yunnan Academy of Agricultural Sciences in Kunming. China has a network of highly

trained and motivated wheat researchers, who extensively scrutinize and use the genetic diversity provided in CIMMYT wheat germplasm in their own crossing programs. Wheat germplasm with diverse, yet appropriate characteristics, facilitate its used in applied wheat breeding programs.

The most important P9 partners will include milling and food processing small entrepreneurs and larger industries in China, East Africa, India, Pakistan, Iran, Kazakhstan and Turkey. End-user raw product requirements influence the prices paid to farmers. By addressing market demands, the CIMMYT-bred germplasm and cultivars will ensure that farmers will meet at times stringent quality requirements and will benefit from this increased market access.

CIMMYT will continue to work with the HarvestPlus Consortium. HarvestPlus is an international, interdisciplinary, research program that seeks to reduce micronutrient malnutrition by harnessing the powers of agriculture and nutrition research to breed nutrient-dense staple foods that are accessible to marginal farmers and poor urban consumers.

Project 10. Conservation agriculture for maize and wheat cropping systems: Safeguarding soils while increasing water productivity and resource use efficiency.
Through partnerships with NARSs, agri-business, and other CGIAR centers, this Project undertakes research on conservation agriculture combined with other resource-conserving technologies for wheat and maize cropping systems. The aim is to improve rural incomes and livelihoods through sustainable management of agro-ecosystem productivity and diversity, while minimizing unfavorable environmental impacts. The Project will focus on the development of appropriate conservation agriculture technologies that reduce tillage, provide adequate surface retention of crop residues, and stress the importance of diversified crop rotations to reverse soil degradation. For small- and medium-scale farmers, the Project will seek more efficient and sustainable use of water and other inputs, lower production costs, better management of biotic stresses, and enhanced system diversity and production. CIMMYT has the knowledge and practical expertise in public-private partnerships for developing, extending, and assessing conservation agriculture in different environments. This provides an excellent basis to build NARSs' capacity while developing appropriate conservation agriculture technologies, with active farmer participation, in several key, well-delineated areas and agro-ecosystems. As resource-conserving practices are adopted, research will address some of the following areas: integrated evaluation of long-term conservation agriculture under different agro-ecological conditions (rainfed vs irrigated, viable crop rotations, limiting factors, residue management, threshold levels of residue cover); soil nutrient dynamics (organic matter, optimization of N fertilizer management, fertilization, legumes/green manures, macro and micro-nutrient balances over time); soil-borne pathogens and pests vs beneficial soil fauna and flora; water management; soil structure dynamics; weed management; impacts on greenhouse gas emissions; adaptive research/policy issues; impacts on household livelihoods, local/regional economies, and food security; and varieties adapted to CA systems.

International public goods:

- Technologies, including varieties, for conservation agriculture systems that are appropriate for small- and medium-scale maize and wheat producers, that generate additional food and/or income, and that facilitate system diversification, reverse soil organic matter loss and soil degradation, improve soil health, and thereby contribute to sustainable production systems.
- Understanding and synthesizing the effects of conservation agriculture systems and practices on land, labor, and water productivity; on soil organic matter and soil physical, chemical, and biological fertility; and on pest and disease dynamics.
- Strengthened capacity of partners (NGOs, NARS, farmer groups, public and private sector entities, and policy-makers) in conservation agriculture research-for-development; the formation and management of farmer-focused innovation systems; the scaling out of conservation agriculture principles and technologies; and the development of local, regional, and national policies that promote sustainable agricultural practices.

Impact pathways and partnerships:

In collaboration with ICARDA in CWANA and NARS in Afghanistan, Azerbaijan, Bangladesh, Bolivia, China, Ethiopia, India, Iran, Kazakhstan, Mexico, Morocco, Nepal, Pakistan, Paraguay, Turkey, Tajikistan and Uzbekistan, CIMMYT has conducted primary research relating to on-farm conservation agriculture practices. This has resulted among other things in the development of new technologies for soil conservation and increased water productivity. Research and appropriate implement development have been participatory, with farmers assessing their requirements and defining appropriate intervention points to facilitate wider adoption. Access to appropriate planting equipment has been a primary focus, often relying on the exchange of agricultural engineering technologies across continents. The specific approaches used depended on the degree of crop production intensity. Under rainfed environments, efforts with ICARDA have focused on the adoption of minimum and zero-tillage. In more intensive irrigated agriculture, conservation agriculture is coupled with establishment of semi-permanent raised-bed planting. Significant efforts have been made by CIMMYT researchers to demonstrate the advantages of conservation agriculture and raised-bed planting to farmers, extension agents, researchers and policy-makers. Efforts have been made to involve small- and medium-sized enterprises for machinery manufacture or modification, and to supply inputs. Experience has shown that even smallholder farmers see benefit from this technology, hiring local agricultural mechanization entrepeneurs, by contracted, to perform sowing and harvest operations. Beneficiaries include farmers, who will save on their natural and economic resources while ensuring more sustainable farming practices, and communities that depend on the improved sustainability of agricultural production. The many P10 partners include:

- NARSs and farmers. Agricultural researchers, policy-makers, seed producers, and farmers are active elements in setting CIMMYT's research agenda and breeding goals, and in knowledge-sharing through their feedback.
- The Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC; see E-1 below for more information). A consortium of South Asian NARSs (Bangladesh, India, Nepal and Pakistan), international centers (CIMMYT, CIP, ICRISAT, ILRI, IRRI and IWMI), advanced institutes,

NGOs, private enterprise, and farmer groups, the RWC was formed to address sustainability concerns for intensive rice-wheat farming systems.

- ICARDA. ICARDA and CIMMYT are committed to improving the welfare of poor people and to alleviating poverty in CWANA by increasing the production, productivity, and nutritional quality of wheat. ICARDA has a proven track record in wheat improvement and agricultural systems research, and maintains special and productive relationships with NARSs and farmers in CWANA. The ICARDA-CIMMYT Wheat Improvement Program (ICWIP) strengthens these relationships and improves the delivery of relevant wheat technologies to farmers.
- As part of its participation in the CGIAR Challenge Program for Water and Food, the Center is contributing to the project "Yellow River Rainfed Conservation Agriculture."

Project 11. Knowledge, targeting, and strategic assessment of maize and wheat farming systems.

The reality is that more than half of small farmers and poor consumers depend on risky and complex maize- or wheat-based farming systems. For CIMMYT's research to have rapid, lasting impacts on the lives of these poor producers, it is essential to consider the multiple contributions of wheat and maize to the diversified livelihoods of producers and consumers. This goes beyond grain yields, to reliable access to food through stable yields and nutritious grain, through sale or use of by-products for livestock or energy, through high-quality grain for niche markets, and—last but not least—the role of productive maize and wheat in fostering on-farm diversification, feeding the "livestock revolution," and local rural non-farm economy growth.

Through periodic strategic assessments of wheat and maize systems and sharing of knowledge, Project 11 will contribute to mission-effective maize and wheat improvement research by CIMMYT and partners. As the "easy" research gains have been achieved, and as CGIAR and MDG goals place greater emphasis on sustainable poverty reduction alongside global food security, the choice and efficient delivery of maize and wheat traits to small farmers is becoming increasingly difficult. The cultivar and knowledge needs of resource-poor farmers and the food preferences of poor consumers are complex and evolving rapidly against the background of changing trade regimes, the withdrawal of state services, the growth of agri-business, decentralization, the reduction of the agricultural research budgets, the increasing importance of social and economic factors (e.g., farm household costs and cash incomes), pervasive market and institutional failures, and the increasing socioeconomic marginalization of the deep poor in both well-watered and drought-prone environments. In parts of South Asia and the Middle East, the dominant role of wheat (and in some case, of maize) on small farms is changing from staple for home consumption to cash crop, not only to feed the livestock but also in high-value niche products (baby corn, friki, ethnic food markets, specialized breads, biofuel, and bioplastics, to name several). Despite the diversity of maize and wheat systems, relatively homogenous mega-environments, farming systems and research domains can be defined to guide priority setting and targeting. In support to other Projects, P11 develops a number of methodologies (e.g., socioeconomic-environmental characterization) which are international public goods. Moreover, the science knowledge contained in Cereal Systems Knowledge Portal

being developed as part of the IRRI-CIMMYT Alliance, as well as the knowledge bases of cultivar adoption, systems and poverty, and the reports of assessments of crop genetic diversity, conservation agriculture innovation systems and value chains are international public goods useful to a wide range of public and private research-for-development organizations. Global impact assessments are designed to draw lessons across multiple sites.

International public goods:

- Operational priority setting and targeting mechanisms in CIMMYT and selected NARSs, including contributions to debates on regional, commodity, and thematic priorities and methodologies and databases that include geo-spatial information, impact pathways, and livelihoods.
- Knowledge of ex post and ex ante impact assessments of priority biotic and abiotic stresses and socioeconomic issues.
- Socioeconomic assessments of key research issues; for example, the contribution of quality and nutrition to incomes from selected major wheat and maize value chains.
- Analysis, with partners, of sector and sub-sector policy options to scale up impacts of maize and wheat research.
- Knowledge of key networks and portals and a defined strategy for cereal (maize, rice, and wheat) systems knowledge management and sharing and institutional learning, to focus a functioning cereal systems knowledge bank linking maize, rice, and wheat, populated and fully operational at a global level.
- A periodically-updated geographic and thematic assessment of capacity building needs for maize and wheat research-for-development, to focus the strengthening of capacity of NARSs and partners through trained maize and wheat systems researchers.

Impact pathways and partnerships:

The immediate users of the products and services (essentially knowledge outputs) of P11 are CIMMYT managers and researchers, for the design and appraisal of their undertakings under P1 to P10. Beyond CIMMYT Projects, the knowledge outputs of P11 are developed with and flow to CIMMYT partners, especially NARSs socioeconomics and senior research managers and supporting science and technology businesses in developing countries.

Consider the specific impact pathway of the publication, *Wheat* (or *Maize*) *Facts and Futures*. After assembling, analyzing and interpreting data assembled jointly with NARSs (and seed companies in the case of maize), P11 provides maize and wheat status and scenarios information to NARSs for use in their strategic priority setting. The outcome, achievable in 3 to 5 years, will be improved knowledge of national research managers regarding commodity distribution, markets, and futures and the improved focus and effectiveness of national wheat improvement programs (this will occur more rapidly in strong NARSs such as India; more slowly in less well-resourced NARSs). In 3 to 10 years the effects could include better cultivars and faster adoption by poor farmers. In 10 to 15 years there could be significant people-level impacts, in improved livelihoods and reduced poverty of marginalized farmers, diversification of farms towards cash crop production (these could be maize or wheat), job creation in the rural non-farm economy, and increased food consumption by poor consumers. Given the nature of

knowledge outputs, the farm household benefits will be aligned with the CIMMYT priorities expressed as flagship products and the other Projects. There several assumptions which link these steps: the feasibility of assembling relevant data for the analysis; the availability and credibility of the results; the relevance to national science policy decisions; the effectiveness of crop improvement, seed distribution, and knowledge extension activities; the correspondence with farmers' goals; and the on-farm cost-effectiveness of a specific technology.

In regard to internal partnerships, the collaboration with CIMMYT Projects underpins the delivery of most outputs (especially for P3 to P10), which in turn lead to partnerships described under those respective Projects, as well as cooperation across the network of CIMMYT social scientists. These contribute to the development and delivery of certain international public goods, such as methodologies, guidelines, and knowledge bases, and add to the quality of outputs. Regarding external partnerships, P11 collaborates strategically with the CGIAR Science Council Standing Panel on Impact Assessment (SPIA) regarding impact assessment approaches. Project participants partner with other CGIAR centers to complement expertise in multi-disciplinary and micro-economic analyses of maize, wheat, and conservation agriculture: notably IFPRI, ICARDA, CIAT and ILRI in relation to targeting, environmental characterization, climate change, knowledge bases and impact assessment; IPGRI in relation to crop diversity; CIAT, IFPRI and ILRI for value addition and grain and stover quality; and the IRRI-CIMMYT Alliance as well as many other centers for the knowledge sharing and the Cereal Systems Knowledge Portal. In relation to Challenge Programs, P11 provides analyses of strategies for reaching end users and ex ante impact assessment for HarvestPlus, and with the System-wide Livestock Program in relation to the analysis of emerging maize-related feed gaps. P11 will collaborate closely with NARSs in several different types of partnerships. The development of data and knowledge bases requires cooperation in sharing data on cultivar adoption, financial and economic benefits, impact pathways, and innovation systems, including NARSs from Mexico, Brazil, Colombia, Ethiopia, Kenya, South Africa, India, China, Nepal and Bangladesh. Universities and NARSs support impact assessments and crop diversity studies. Joint activities with universities, NARSs, FAO, and NGOs are planned on value chain analysis. Active collaboration on the Cereal Systems Knowledge Portal is ongoing with IRRI, as well as a wide range of NARSs, universities, and other public and private sector organizations. P11 staff conduct joint research with advanced universities and also in the field with universities in developing countries.

CGIAR Eco-regional Program: The Rice-Wheat Consortium for the Indo-Gangetic Plains—A NARSs-led initiative facilitated by CIMMYT.

The Rice Wheat Consortium for the Indo-Gangetic Plains (RWC) includes the national agricultural research systems of Bangladesh, India, Nepal and Pakistan; several international centers of the CGIAR (CIMMYT, IRRI, ICRISAT, CIP, IWMI, and AVRDC) and various advanced international institutions (Cornell University, IAC, Wageningen, IACR, Rothamsted, CABI-UK, CSIRO, ACIAR, and the IAEA). The Consortium was established in 1994 as an Ecoregional Initiative of the CGIAR; in 1998 CIMMYT was assigned convening and leadership responsibilities; more recently, IRRI assumed co-convening responsabilities. The main goal of the RWC is to strengthen existing linkages and partnerships with national research programs,

other international centers, advanced institutions and the private sector working in the region to develop and deploy more efficient, productive and sustainable technologies for the diverse rice-wheat production systems of the Indo-Gangetic Plains. As quality land and water resources are being diverted to other sectors of national economies, the Consortium tests and promotes with farmers alternative practices for sustaining productivity growth. Work depends on many local partners—including local government agencies and NGOs—and the private sector, particularly input suppliers and agriculture equipment manufacturers.

Intensive cereal cropping systems are central to reducing poverty in Asia, home to the world's largest number of poor people. Such systems are usually irrigated and highly productive, featuring multiple crops, including large areas of rice, maize and wheat, and livestock production. These systems suffer from the unsustainable exploitation of water and soils, inefficient use of chemical inputs, and emerging or worsening disease and pest problems. Farmers tend to be more market-oriented and driven by the need to sustain local rural communities and neighboring urban areas. Regional demand for cereals is projected to rise dramatically, and should be met largely through increased yields, freeing land and other resources for diversification into high-value cropping/enterprises. Markets forces plus policies will drive the pace and form of sustainable diversification for enhanced income and employment generation in rural South Asia.

In line with recommendations from an external review of the RWC in 2004, CIMMYT and IRRI have strengthened farm-level socioeconomic analysis, an impact assessment study was completed for the Science Council SPIA, and new initiatives were taken to integrate the crop-livestock sectors and promote crop diversification and intensification of rice-wheat systems, as well as addressing issues of nutrient mining, particularly of potash. Rice-wheat research was also prioritized, and significant efforts made to develop year-round zero- or reduced-tillage systems for rice, wheat, and other crops. Water quality surveys at selected sites were completed to generate benchmark maps for monitoring groundwater pollution. Participants also developed a district-wise spatial database using socioeconomic indicators for poverty-prone areas.

<u>International public goods:</u>

- Conservation agriculture technologies appropriate for small- and medium-scale farmers and which address concerns such as yield plateaus, water shortages and declining water tables, resource fatigue, turn-around time for planting of winter crops after rice, climate change, and pollution.
- Zero-tillage or reduced-tillage options that allow farmers to produce more at lower costs, conserve land and water resources, and improve environmental quality.
- Improved practices that allow for expanding livestock and horticulture and their gains to both growers and consumers. The RWC "basket" of crop management option exhibit divisibility in application and utility for the farmers.
- Follow-up studies and research backstopping on diverse topics under the following themes: timely crop establishment, soil fertility and crop nutrition, water management, cropping diversification, integrated pest management, and socioeconomic and policy issues.

Impact pathways and partnerships:
(For a partial list of partners, see p. 7). The RWC has applied a new model for farm technology development and dissemination in South Asia, encouraging farmers, researchers, and extensionists to work as teams. This is helping to break down the hierarchical boundary once separating researchers from farmers. Farmers actively participate in testing, refining, and promoting promising innovations. They are encouraged and backstopped by researchers, who often go straight to farmers' fields with promising innovations, rather than spending years in sterile testing and refinement on a research farm. Researchers are beginning to take pride and pleasure in working with farmers and seeing their ideas actually put into practice or helping solve mutually-identified problems. As part of this, RWC researchers and extension agents interface with multiple actors—including farm implement manufacturers, input suppliers, and others—along complex innovation pathways. This has been crucial, for example, in the expansion of zero-tillage and raised-bed cropping, both of which require specialized sowing implement. The RWC facilitation unit has provided stability, continuity, effective coordination, and a non-partisan stance. Among other things, this has fostered the cross-fertilization of knowledge and practices across borders, even in times of regional or local conflict. Laser-leveling of fields—essential for efficient water use in irrigated areas—was first tested and applied in Pakistan, but has since spread to neighboring countries through the Consortium. Traveling seminars, where researchers and farmers from India and Pakistan visit each others' farm plots and experiment stations, have fostered the sharing of knowledge and helped ignite enthusiasm about new practices. The RWC plays a pivotal and innovative role as true facilitator, information provider, technology clearinghouse, and capacity builder.

In a typical scenario, RWC partners enter a new village. A large (11 member) family which to this point has lived in poverty, growing only a rice-wheat rotation on some six hectares of land, is introduced to zero-tillage for wheat after rice, using a seeder lent by the RWC. Relatives and neighbors scoff at the practice and the displeasing appearance of the field, during early establishment stages. But the harvest is equal to or better than that from traditionally cultivated wheat, and the farmer saves in seed, labor, diesel, farm equipment, and irrigation water—all of which represents a significant economic gain. The practice allows earlier sowing of wheat, so the farmer can introduce okra, tomato, gourd, potato, mungbean, or other crops, and grow green-manures to enrich the soil. Other farmers begin adopting the practice, and fight over use of the seeder or seek ways to purchase their own seeder, fueling the local farm machinery industry. Early purchasers contract their services out to neighbors who do not have the zero-tillage seeder, thereby earning extra income. Through a participatory varietal selection program supported by the RWC, farmers in the village gain access to the latest, high-yielding wheat varieties. Added income from all of the above may be used by farm families to further diversify, sink a well, conduct home improvement, purchase needed equipment, or underwrite a child's education. An ambitious farmer in the village may launch a seed production and marketing business or other enterprise. Throughout this process, RWC partners provide advice and research backstopping, as well as linking farmers with input suppliers, machine shops, market representatives, local administrators, other researchers, or knowledgeable farmers from other villages. The RWC will arrange for farmers from other villages to visit, talk to peers, and

observe the progress themselves. Zero-tillage tends to be adopted first by the better endowed farmers, but rental services have made the technology relatively scale-neutral and divisible. The RWC has a diverse basket of options—including animal-drawn and light-duty, modular power tillers, or surface seeding practices—which put zero-tillage within reach of the region's most disadvantaged farmers, and Consortium researchers work with farmers to adapt practices or devise new ones that fit particular circumstances.

Project Logframes

Project 1. Conservation, characterization and targeted access to maize and wheat related biodiversity.

	Output	Intended User	Outcome	Impact
Output 1	Methodologies for trait and gene-based identification of useful crop-related biodiversity	CIMMYT, NARSs and SME maize and wheat breeding programs globally	Trait-based identification of new genetic variation for priority traits in maize and wheat breeding	Improved efficiency of access and utilization of maize and wheat genetic resources in research and breeding programs worldwide
Output Target 2007	PCR-based markers within genes contributing to improved levels of beta carotenes in diverse maize germplasm, and, new haplotypes associated with different levels of increased beta carotenes	CIMMYT and Harvest Plus-affiliated maize breeders	Identification of new markers and haplotypes for new alleles of previously identified genes contributing to improvement of beta carotene levels in maize	Use of beta carotene precursor genes as proof of concept for development of association mapping-based strategies for identification of markers and haplotypes for new alleles of previously identified genes contributing to improvement of key oligogenic target traits
Output Target 2008	New sources of pest and disease resistance, and drought tolerance identified in diverse maize and wheat germplasm together with markers for respective key QTL using association mapping of the GCP mini-composite, full composite and beyond	CIMMYT and GCP-associated maize and wheat breeders	Additional alleles and genes affecting drought tolerance in diverse maize and wheat genotypes identified via association mapping, and PCR markers for these new alleles and genes optimized	Faster release of improved drought tolerant breeding materials for field testing
Output Target 2009	Use best available gene-based markers for gene mining of global maize and wheat genetic resources for key pest and disease resistance, and drought tolerance	Global community access to information relevant to International Public Goods collections	Large scale screening of genetic resources with multiplexes of the best trait-specific gene candidates to identify new allelic variation associated with enhanced pest and disease resistance, and drought tolerance in maize and wheat	Operationalization of a validated gene-mining methodology for drought tolerance in maize and wheat lead to an efficient trait-targeted approach of accessing maize and wheat genetic resources for improvement of complex traits
Output 2	Fully integrated, public-access, germplasm characterization information resources available	CIMMYT, NARSs, SME, IARC and ARI researchers and breeders worldwide	Global access to and analysis of CIMMYT's entire historical data reserves	Increase in utilization of CIMMYT genetic resources and improved germplasm for breeding by NARSs and SME partners and analysis by the global maize and wheat research community
Output Target 2007	Passport data and minimum characterization available for accessions in all in-trust collections of wheat and maize to underpin strategic core subset definition mechanisms	CIMMYT, IARCs, NARSs, ARI, SME researchers and breeders	Improved access to and utilization of novel traits with value for improving the resilience (to abiotic stresses), yield stability (under biotic stress pressure) and nutritional value	More accessible germplasm accessions provided for worldwide breeding programs

Output Target 2007	Statistical and heuristic techniques for forming mini-core subsets using passport, pedigree, generic marker and diversity, phenotypic and evaluation data	Germplasm bank collection managers worldwide, irrespective of crop species and GCP community	New methodologies for selecting trait-specific germplasm subsets, most important gaps and areas of redundancy in current collections identified	Improved efficiency of targeted access to global maize and wheat genetic resources and identification of genetically most unique material
Output Target 2008	A fully integrated web-based gene bank information, management and distribution system for all maize and wheat germplasm developed - Implementation of a basic gene bank management systems for maize and wheat at CIMMYT with linkages to ICIS GMS, DMS and GRIMS	CIMMYT and IRRI maize, wheat and rice scientists and their partners and global community with SGRP	More than 5 million passport and characterization data points available for maize and wheat gene bank accessions that can be interrogated through a range of web-based query and analysis tools - Improved access and use of gene bank information and data	More information available with easier access and analysis possible for wheat and maize germplasm users across the world
Output Target 2009	System-wide, web-based crop registry completed cataloguing maize or wheat collections held in common among centers	CGIAR collections' managers, SGRP, users of international public goods genetic resource collections, NARSs maize and wheat collections	Accession duplication, across collections, is recognized allowing rationalized distributed conservation	Improved utilization and security of global maize and wheat genetics resources
Output 3	Near-isogenic, introgression and substitution lines, enhanced gene pools, double haploid lines, synthetic polyploidy genotypes, genetic mapping populations and mutant stocks for trait-targeted genetic investigations characterized	NARSs and ARI maize and wheat researchers and breeders worldwide	Increase in the use of genetic stocks related to CIMMYT breeding material by the global maize and wheat research community, and, increased use of selected genetic stocks in CIMMYT and NARSs breeding programs	CIMMYT leveraging its opportunity for encouraging researchers worldwide to work on material of direct value to our developing country stakeholders
Annual Output Target 2007-2009	Introgression of secondary genepools including wild relatives into adapated maize and wheat primary genepools. Targeting expansion of genetic diversity for drought tolerance, pest and disease resistance, and quality traits in maize and wheat genetically enhanced populations	Global maize and wheat improvement communities	50 newly created primary synthetic hexaploid populations developed in wheat, 30 enhanced maize pools refined with introgressed Latin American landrace germplasm, all developed as International public goods	Continuous pipeline of better maize and wheat pre-breeding populations with trait-targeted improvements, and, increased value of those populations for maize and wheat breeding programs worldwide
Output Target 2008	Evaluate maize genetic stocks with mapped genes/alleles for drought tolerance for their suitability as sources with large effect for drought tolerance and for use in MAS projects	Global maize improvement communities	Upto 5000 RIL and 10,000 introgression lines screened for new major sources of drought tolerance in maize	Validated use of large-scale intensive phenotypic screening of genetic populations to identify major new favorable alleles and gene combinations for maize breeding

Output Target 2009	Enhanced use of maize and wheat landraces and wild relatives: Identify new genetic sources for drought tolerance amongst and within core landrace or wild relatives; use of candidates for trait targeted introgression to enhance primary maize and wheat genepools	Global maize and wheat improvement communities	NARSs breeders have access to elite inbred lines incorporating diverse drought tolerant alleles, and expressing 50% increased productivity under drought (ie. far beyond the drought tolerance in any released cultivar)	More diverse genetic variation for continuous improvement of breeding programs and breeding products
Output 4	Improved representation of global maize and wheat diversity plus enhanced and more systematic information available through targeted collection, conservation, characterization and distribution of crop-related bio-diversity	Maize and wheat international research and breeding community, and SGRP	Improved efficiency of maize and wheat ex situ conservation and distribution	Increasingly targeted access of maize and wheat germplasm users leading to enhanced access and improved efficiency of utilizaiton
Output Target 2007	ISO9000 accreditation for CIMMYT seed health inspection activities achieved	CIMMYT and recipients of seed shipments from CIMMYT-Mexico	Public confidence of seed health management issues is maintained. Procedures and protocols are transparently defined and applied.	Increased quality and efficiency of CIMMYT germplasm distribution
Output Target 2007	Optimized SNP genotyping platform and analysis tools for genetic diversity and molecular assisted breeding programs	CIMMYT, NARSs and SME maize breeders worldwide including researchers and breeding in the Maize Molecular Breeding Community of Practice	Optimized panels of SNP arrays for low density (384) and high density (1536) screening for diversity analysis and/or marker assisted breeding projects; improved integration of datasets from different labs into a common platform; improved cooperation in the Maize Molecular Breeding Community of Practice	More precise parental selection and increased pace of genetic gain using SNP-based for ground and background marker selection; decision support tools to assist in the efficient, economic and timely application of SNP-based genotyping
Output Target 2007	Crop-specific guidelines to both maintain germplasm free of transgenes and where needed conserve germplasm containing transgenes available	Maize and wheat international research community, and SGRP	Increased fidelity of all maize and wheat gene bank accessions driven by the need to effectively eliminate transgene movement between germplasm	Enhanced trust in control of transgenic germplasm, vis-à-vis conservation of maize and wheat genetic resources at CIMMYT, leading to increased utilization of CIMMYT germplasm
Output Target 2008	Actively defined core subsets from CIMMYT maize and wheat collections relevant to Africa, Asia, Latin America, CWANA or specific priority traits identified	CIMMYT, ICARDA or IITA regional programs with NARSs researchers and breeders and GCP	Greater depth and breadth of genetic resources utilization in regional maize and wheat breeding programs	Improved germplasm management and utilization through NARS and partners

Output Target 2008	Phenotype or evaluation data on at least 25,000 maize and 50,000 wheat accessions available for relevant passport or characterization traits up-to-date and integrated with molecular characterization of GCP composite subsets of maize and wheat available through web-enabled database	Global maize and wheat research and breeding community	A 5% increase in the number of requests for maize and wheat accessions	Improved utilization of maize and wheat genetic resources in research and breeding programs worldwide
Output Target 2009	Logistical and statistical improvements, and simulation models for efficient maintenance, regeneration and improvement of maize and wheat genetic resources	Germplasm bank collections, NARSs, ARIs	A 15% improvement in cost efficiency of gene bank operations and in the average viability of accessions	Better and more cost effective maintenance of maize and wheat genetic resources, and more rapid and targeted access by end-users to the most relevant germplasm
Output Target 2009	Development of a collaborative platform in support of best practices in the safe movement of germplasm is achieved including quarantine compendia, pathogen detection research plans and foresight of emerging relevant phytosanitary issues.	CGIAR plant genetic resource collections and recipients of germplasm and SGRP	Confidence enhanced of international public goods plant genetic resource collections, and access thereof	Increased quality and efficiency of CIMMYT germplasm distribution

Project 2. Technology-assisted tools and methodologies for genetic improvement.

	Output	Intended User	Outcome	Impact
Output 1	Integrated data management and analysis systems linking conventional and molecular breeding data with all other available sources of relevant data	CIMMYT, SME and NARSs researchers and breeders	Ability to compare and analize data from across the entire genetic resources, germplasm enhancement and breeding continuum	More efficient knowledge-led germplasm utilization and breeding systems
Output Target 2007	Wheat and maize historical breeding information and data onto ICIS-compatible databases migrated	CIMMYT, NARSs, SME and ARI researchers and breeders	Combined collections of gene bank, pedigree and phenotype data as the basis of developing new methodologies for crop improvement programs	Simplified, more efficient and more powerful scientific partnerships amongst maize, wheat and rice centers, their partners and stakeholders, and the GCP consortium
Output Target 2008	Spatial and temporal target environments for abiotic and biotic stresses as a key foundation of effective analysis of genotype-by-environment interaction in crop breeding programs characterized and classified	CIMMYT, NARSs, SME and ARI researchers and breeders	Improved comparative, simulation and modeling analysis of integrated databases	Proof-of-concept regarding the power and value of unified analysis of diverse datasets that have not previously been brought together
Output Target 2009	Required technology and define metadata standards for a comprehensive research data management system across all disciplines established. First version into research programs prior to scaling out to NARSs partners implemented	Researchers in IRRI and CIMMYT and their NARSs partners	Efficiency and focus of research improved by access to sound research informatics practices and relevant, high quality information and data from previous research	Increase in research and breeding advances through effective analysis of fully integrated data across all disciplines
Output 2	Technology-based breeding tools using tissue culture, transformation, biometrics, genomics, computational biology, translational and functional genomics, simulation and modeling developed	CIMMYT, SME and NARSs researchers and breeders	New technology-based tools for use in CIMMYT, NARSs and SME breeding programs	Improved efficiency, speed and precision of maize and wheat breeding systems
Output Target 2007	Systems for high-throughput genotyping using SSR (wheat), SNP (maize) and gene-based markers (maize and wheat) for molecular breeding built	CIMMYT, SME and NARSs researchers and breeders	Improve marker genotyping systems for high throughput low cost molecular breeding application in CIMMYT and partner breeding programs	Improved efficiency, speed and precision of maize and wheat molecular breeding systems
Output Target 2007	Key linked markers from consensus maps for drought tolerance in maize, and generation of bioinformatic resources to drive the next generation of gene-based markers validated	CIMMYT, SME and NARSs maize breeders	Validated markers available for genes contributing more than 15% of the phenotypic variation and providing a 2-fold increase in selective power for drought tolerance	More efficient marker-assisted selection of drought tolerance in maize

Output Target 2007	An efficient *Agrobacterium*-mediated transformation protocol routinely used for all wheat projects in Mexico	CIMMYT, MPB-CRC and partners	Improve product development pipeline for transgenic wheat	More rapid trait-targeted improvement in wheat breeding of priority traits
Output Target 2007	Statistical models for assessing gene-by-environment interactions in QTL analyses, microarray experiments and whole genome scans, and development of simulation tools to assist the manipulation of new alleles and genes in wheat available	CIMMYT, SME and NARSs researchers and breeders	Improved efficiency and scope of genetic improvement of complex traits, increased genetic gain in pedigree breeding systems, and, increased application of molecular breeding tools in CIMMYT, NARSs and SME breeding programs	Increased power to analyze and manipulate genotype-by-environment interaction in crop breeding programs
Output Target 2008	A platform for the rapid and routine conversion of non-PCR markers to PCR markers (wheat) established. PCR-based markers (wheat & maize) developed and gel-based markers converted to array-based markers (wheat and maize) established	CIMMYT, SME and NARSs researchers and breeders	Rapid evolution of research domain markers to high throughput low cost molecular breeding tools and effective platform for training NARSs and SME scientists and breeders	More efficient marker-assisted selection of a range of priority traits in maize and wheat, and meaningful training facilities
Output Target 2008	An efficient *Agrobacterium*-mediated transformation protocol effective for a range of maize genotypes implemented in BECA, Kenya	CIMMYT, SME and NARSs maize researchers and breeders	Improve product development pipeline for transgenic maize	More rapid trait-targeted improvement in maize breeding of priority traits
Output Target 2008	An efficient double haploid protocol developed for maize implemented in Mexico and Africa, and better definition of heterotic groups for tropical maize	CIMMYT, SME and NARSs maize researchers and breeders	Improved speed, enhanced genetic gain and increase hybrid vigour of maize breeding programs	More rapid and efficient development of new maize cultivars
Output Target 2008	Statistical models for assessing association of phenotypic traits with molecular marker data, and for predicting the breeding values of genotype using coefficient of parentage, using wheat and maize historical trial data developed	CIMMYT, SME and NARSs maize researchers and breeders	Improved knowledge of the short and long-term effects of plant breeding selection using fully integrated databases across disciplines	Improved efficiency, speed and precision of maize and wheat molecular breeding systems
Output Target 2009	Powerful yet simple to use molecular breeding decision-support tools based on advanced simulation and modeling analysis available	CIMMYT, SME and NARSs maize and wheat researchers and breeders	Ergonomic decision support software systems to improve the efficiency with which breeding programs utilize crop information in breeding priority target traits providing a potential 2-fold improvement in cost, time and selective power	Enhance speed, precision and efficiency of wheat and maize breeding programs to generate market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and, conserve natural resources

Output 3	Technology-assisted germplasm enhancement strategies (including use of transgenic, genomic, informatic and socioeconomic tools and methodologies) for the development of improved flagship products available	CIMMYT and NARSs partner breeders	Increased efficiency in germplasm development with target traits captured.	Better wheat and maize cultivars for sustainable production systems
Annual Output Targets 2007-2009	Development of more precise higher throughput phenotyping systems for dissecting complex abiotic stresses including drought tolerance	CIMMYT and NARSs partner breeders	Increased efficiency of genetic analysis and improvement of complex abiotic stress tolerance traits	More rapid and efficient development of new maize and wheat cultivars with improved levels of abiotic stress tolerance
Annual Output Targets 2007-2009	Molecular and phenotypic characterization of cornerstone maize and wheat populations for genetics and breeding providing a mechanism for linking diversity analysis, mapping and molecular breeding	CIMMYT, NARSs and ARI researchers and breeders	Precision phenotyping and high density genotyping of near-isogenic lines (NILs), substitution lines, recombinant inbred lines (RILs), and mutants in maize and wheat	New sources of abiotic stress tolerance and the tools to manipulate them developed in maize and wheat
Annual Output Targets 2007-2009	Efficient molecular breeding strategies and systems for wheat and maize developed for and applied in resource-limited environments, combining genotype, multi-environment phenotype and coefficient of parentage - including the use structural equations, simulation models and artificial neural networks for predicting performance of breeding lines under stress conditions	CIMMYT, NARSs and SME breeders	Development of molecular breeding strategy to increase the efficiency of current breeding methodologies in wheat and maize for resource-limited environments, including new methodologies for manipulating genotype-by-environment interaction for complex agronomic traits and for using new understanding of the genetic basis of complex agronomic traits and their interaction with the environment	Improved efficiency and pace of wheat and maize breeding product development through combining phenotype, genotype and pedigree data
Annual Output Targets 2007-2009	At least 50 single copy events for more than 10 new constructs contributing to drought tolerance and disease resistance in wheat available	CIMMYT, CRC and partner breeding programs	Multilocational field quantification of the positive effect of single gene insertions for drought tolerance and disease resistance in wheat	More rapid development of market preferred cultivars that reduce farmer risks and vulnerabilities through enhanced drought tolerance and disease resistance
Annual Output Targets 2007-2009	New informatics methodologies applied to assist with the efficient identification, investigation and manipulation of alleles and genes contributing to priority target traits in maize and wheat	CIMMYT, NARSs and ARI researchers and breeders	Targeted methodologies available for the efficient identification and investigation of alleles and genes contributing to at least 5 priority traits in wheat and in maize	More efficient methodologies for identifying, validating and manipulating useful alleles and genes for improvement of priority traits identified by end-users through linking diversity analysis, mapping and molecular breeding

Annual Output Targets 2007-2009	Decision-support tools (based on statistical, simulation and modeling methodologies) applied to assist with the efficient development and deployment of maize and wheat molecular breeding programs	CIMMYT, NARSs and SME breeders	Improved efficiency, speed and precision of trait-targeted breeding programs through linking genetic, crop growth and whole plant physiology modeling analyses	Improved efficiency and pace of wheat and maize breeding product development
Output Target 2008	Routine application of a low density SNP-based platform for high throughput, rapid turnaround, low cost molecular breeding of maize and wheat at CIMMYT and partners	CIMMYT, NARSs and SME breeders	At least 50% of CIMMYT molecular breeding applications achieved through SNP-based out-sourced genotyping - with the remainder achieved in-house for complex and specialist tasks	Highly optimized high throughput genotyping pipeline providing CIMMYT and NARSs breeders with a rapid and cost effective molecular breeding tool
Output Target 2009	Routine application of validated fast-track breeding techniques based on the integration of technologies such as marker-aided introgression, marker-assisted selection, marker-accelerated backcross breeding, and double haploids in maize and wheat	CIMMYT, NARSs and SME breeders	A 75% reduction in the unit cost and a 10-fold increase in the throughput of molecular breeding applications at CIMMYT and shuttle breeding partners. A substantial commitment to the use of double haploids in the maize and wheat breeding programs of CIMMYT and partners	More efficient and rapid methodologies for breeding market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and conserve natural resources
Output Target 2009	Useful maize and wheat germplasm with enhanced abiotic stress tolerance, resistance to pests and diseases, and improved nutritional quality generated	CIMMYT, NARSs and SME breeders	More than 75% of the CIMMYT elite maize and wheat breeding products with a landrace or wild species present in their pedigree providing enhanced abiotic stress tolerance and/or biotic stress resistance	More market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and conserve natural resources
Output 4	Capacity building and technological backstopping to assist NARSs, SME and CIMMYT wheat and maize breeders to make best use of genetic resources and new technology-assisted germplasm enhancement tools and methodologies in the generation of maize and wheat elite germplasm and new cultivars	CIMMYT, NARSs and SME researchers and breeders	Newly identified genetic resources, latest innovations in germplasm management, novel technology-assisted germplasm enhancement tools and methodologies routinely adopted by CIMMYT, NARSs and SME breeding programs	Increased pace, quantity and value of market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and conserve natural resources
Annual Output Targets 2007-2009	Information, skills and technological backstopping provided through a targeted and tailored approach in the core areas of germplasm management and utilization, biometrics, data management and bioinformatics, and, tissue culture, genomics and transgenics	NARSs, SME and CIMMYT researchers and breeders	Latest innovations in germplasm management and utilization adopted. Enhanced quality of research, improved publication record, increased efficiency and impact of breeding programs	Increased flow of more targeted maize and wheat germplasm with greater impact. More market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and, conserve natural resources

Annual Output Target 2007-2009	At least 50 NARSs, SME or CIMMYT staff trained in at least one new technology or methodology per year, plus CIMMYT researchers providing consultancy in core areas of biometrics, data management and bioinformatics	CIMMYT, NARSs, and SME research and breeding programs	Latest innovations in germplasm management and utilization adopted by CIMMYT and partners.	Global access to current information technology that facilitates data management and product delivery
Output Target 2008	Internet based collaboration tools deployed to facilitate consultation and dissemination of best practices in the application of research informatics for germplasm conservation and utilization	Global germplasm conservation and germplasm improvement community with SGRP	Improved speed, scope and depth of uptake of new best practices in IRRI, CIMMT and their partners	CIMMYT as a global leader, linking and strengthening our diverse partners, in the management of bioinformatics and biodiversity
Output Target 2009	Molecular breeding communities of practice generating cooperatively designed and developed seed-based technologies in each mega-environment targeted for maize or wheat	CIMMYT regional programs with NARSs and SME research and breeding program partners working in-house or through regional hubs in Latin America, Africa and Asia	A 2-fold increase in the number of NARSs and SME breeding programs actively participating in these networks driving the application of a range of technology-assisted germplasm enhancement tools and methods	More rapid and efficient development of market preferred cultivars that reduce farmer risks and vulnerabilities, improve farming household livelihoods and health, and conserve natural resources

Project 3. Stress tolerant maize.

	Outputs	Intended User	Outcome	Impact
Output 1	Abiotic stress tolerant germplasm incorporating highest priority and often intractable traits in maize	Breeders in NARSs, private seed companies and at IITA	Increased use of elite maize germplasm carrying traits relevant to resource-poor farmers	Increased food and income security for resource-poor farm families, and decreased vulnerability to recurrent droughts and climate change, and need for food aid
Annual Output Targets 2007-2009	Four CIMMYT Maize Lines (CMLs) developed and announced carrying an improved expression of tolerance to drought, N stress, low soil pH announced	Breeders in NARSs, private seed companies and at IITA	Increased use of elite maize germplasm carrying traits relevant to resource-poor farmers	
Output Target 2007	Identification of drought tolerant inbred lines in lowland tropical yellow germplasm	NARSs breeders in Asia, collaborating in the Asian Drought Network	Drought tolerant germplasm product development by NARSs breeders in Asia	
Output Target 2009	Double-haploid technology used for extraction of abiotic stress tolerant inbred lines	Intermediary outputs - mostly CIMMYT breeders	Accelerated breeding progress for abiotic stress tolerance	
Output 2	Knowledge on new methods for improving abiotic stress tolerance in maize, and their impact on farmers livelihoods	NARSs and private seed company breeders, decision makers and scientific community at large	More effective development and targeting of abiotic stress tolerant maize cultivars	Accelerated productivity Increases in farmers fields, decreased vulnerability to recurrent droughts and climate change and need for food aid
Output Target 2007	Pilot study on factors influencing the adoption of drought tolerant maize cultivars completed	Decision makers	More effective targeting of drought tolerant cultivars	
Output Target 2007	Value of Southern Africa landraces as potential sources for drought and N stress tolerance assessed	NARSs breeders in Malawi, Zambia and Zimbabwe	More effective use of maize genetic resources in stress breeding projects	
Output Target 2007	General and specific combining ability for phosphorus use efficiency in lowland tropical maize documented	Scientific community	More effective use of maize genetic resources in stress breeding projects	
Output Target 2007	Relationship between acid soil tolerant cultivars and callose content established	NARSs and private sector breeders targeting acid soil conditions	Accelerated selection for acid soil tolerance	
Output Target 2008	Morpho-phenological diversity of Southern Africa maize landraces for abiotic stress tolerance documented	Scientific community	More effective use of maize genetic resources in stress breeding projects	
Output Target 2008	Elite germplasm aiming an annual breeding progress under drought or N stress or soil acidity of about 3%	Breeders in NARSs, private seed companies and at IITA	Productivity increases in drought-prone environments	
Output Target 2008	Inheritance of callose content in tropical maize documented	Scientific community	Information available for better use of breeding	

			methods.	
Output Target 2009	Molecular characterization of landraces linked to abiotic stress tolerance	Plant breedesr and scientific community	More effective use of abiotic stress tolerance in maize genetic resources	
Output 3	Host plant resistant germplasm incorporating highest priority and often intractable traits in maize	Breeders in NARSs, private seed companies and at IITA	Increased use of elite maize germplasm carrying traits relevant to resource-poor farmers	Increased food and income security for resource-poor farm families, decreased vulnerability to pests and health risks, and improved opportunities for trade
Annual Output Targets 2007-2009	Improvement in the conventional host plant resistance of tropical maize germplasm for stem borers and post harvest pests	Intermediary outputs - mostly CIMMYT breeders	Improved genetic basis for conventional resistance to insect pests	
Output Target 2007	Six *Striga* resistant CML lines available	Breeders in NARSs, private seed companies and at IITA	*Striga* resistant germplasm product development by NARSs and private sector breeders in Africa	
Output Target 2007	Weevil and large grain borer resistance of recommended highland OPVs and hybrids assessed	Breeders and seed producers in highlands of Mexico and Central America	Use of existing variety differences for storage pest management	
Output Target 2007	Aflatoxin resistant sources identified in drought or insect resistant germplasm	Intermediary outputs - mostly CIMMYT breeders	Sources for aflatoxin resistance which are most appropriate given conditions under which aflatoxin contamination occurs	
Output Target 2008	A minimum of 100 *Striga* resistant hybrids and OPVs for evaluation by partners available	Breeders in NARSs, private seed companies and at IITA	Access to a suite of elite germplasm which are adapted to all major agro-ecologies in Africa	
Output Target 2008	Aflatoxin resistant sources used in the development of germplasm targeted at affected areas in Southeast Asia and Africa	Intermediary outputs - mostly CIMMYT breeders	Sources for aflatoxin resistance which are most appropriate given conditions under which aflatoxin contamination occurs	
Output Target 2009	Hybrids incorporating Bt resistance which is effective against *Busseola fusca* developed	Breeders at KARI and CIMMYT	Humanitarian access to Bt events which are effective against all major African stem borers	
Output 4	Knowledge on new methods for improving host plant resistance in maize, and their impact on farmers livelihoods.	NARSs and private seed company breeders, decision makers and scientific community at large	More effective development and targeting of stress tolerant maize cultivars	Accelerated productivity increases in farmers fields, decreased vulnerability to pests and health risks, and improved opportunities for trade
Output Target 2007	New events with potential effectiveness against *Busseola fusca* assessed	Breeders at KARI and CIMMYT	Bt events which are effective against all major African stem borers	
Output Target 2008	Four slow-release formulations to be used in combination with *Striga* resistant [IR] maize cultivars tested	Seed producers	Recommendation for large quantity seed production of *Striga* resistant maize	

Output Target 2008	GIS-based prediction of maize production areas affected by aflatoxin contamination	Decision makers	More effective targeting of resistance breeding strategies	
Output Target 2009	Adoption and benefit sharing assessment conducted for *Striga*-resistant maize showing benefit sharing between farmers, public and private sector	Decision makers	Conditions which improve farmers' benefits of proprietary technology better understood	
Output 5	Capacity building of partners	NARSs and private seed company breeders	Increased effectiveness of NARSs researchers in addressing developing stress tolerant maize cultivars	
Annual Output Targets 2007-2009	Skills of 20 NARSs and private scientists improved through workshops, visiting scientist fellowships and graduate research projects	NARSs scientists	Increased effectiveness of NARSs scientists in addressing developing stress tolerant maize cultivars	

Project 4. Nutritional and specialty traits for maize.

	Outputs	Intended Users	Outcomes	Impacts
Output 1	Micronutrient-enriched maize for improved nutrition, health and agricultural productivity.	Researchers of NARSs, private companies, IARCs and ARIs	Nutritious maize germplasm is used and incorporated in breeding and research programs, resulting in biofortified cultivars being availed to maize farmers and consumers.	Improved vitamin A,. Fe, and Zn nutrition in selected countries
Annual. Output Targets 2007-2009	Initiate at least 20 new breeding populations (mainly bi-parental crosses) to develop new germplasm with enhanced pro-vitamins A concentration; and continue breeding and selection for populations formed in previous years	Researchers of NARSs, private companies, IARCs and ARIs	Greatly expanding genetic base of provitamins A-enhanced germplasm	
Output Targets 2007	Yield potential, pro-vitamins A concentration, agronomic performance and genotype by environment interaction for these traits evaluated for hybrids of early generation mid-altitude-adapted maize lines	Researchers of partner NARSs and IARCs	Suitability of the "first generation" of enhanced pro-vitamins A maize germplasm will inform further strategy development	
	Yield potential, zinc concentration, agronomic performance and genotype by environment interaction for these traits evaluated for hybrids of highland-adapted maize lines	Researchers of partner NARSs and IARCs	Suitability of the "first generation" of maize germplasm with enhanced zinc concentration will inform further strategy development	
	Agronomic performance, yield potential and pro-vitamins A concentrations of three cycle-one enhanced pro-vitamins A experimental open pollinated cultivar (OPV) evaluated by partners in Africa.	Researchers of NARSs	Suitability of the "first generation" of enhanced pro-vitamins A maize germplasm will inform further strategy development	
	At least 25 advanced tropics-adapted inbred lines and 4 synthetic populations available for use by researchers as high pro-vitamins A source germplasm	Researchers of NARSs, private companies, IARCs and ARIs	Researchers will have access to tropically-adapted pro-vitamins A enhanced source germplasm	
	New, simplified laboratory methods for analysis of tryptophan, iron (Fe), or zinc (Zn) concentration in maize grain developed or validated	Researchers of NARSs, private companies, IARCs and ARIs	Greatly simplified laboratory methods will facilitate QPM and micronutrient breeding and quality monitoring by researchers	
Output Targets 2008	Yield potential, pro-vitamins A concentration and agronomic performance evaluated for three-way and other advanced hybrids among mid-altitude-adapted enhanced pro-vitamins A maize lines	Researchers of NARSs	Best available hybrids will be identified and characterized, enabling decisions whether to proceed to on-farm validation and promotional trails or to await better products	

	Yield potential, Zn concentration and agronomic performance evaluated for three-way and other advanced hybrids among highland-adapted maize lines; an enhanced Zn, highland-adapted experimental OPV evaluated in Ethiopia and elsewhere	Researchers of NARSs	Greatly expanding genetic base of Zn-enhanced germplasm	
	Analysis and interpretation of carotenoids mapping studies for two maize populations and gene expression studies of enzymes involved in the carotenoid synthesis pathway	Researchers of NARSs, private companies, IARCs and ARIs	Recommendations about use of molecular markers in breeding for enhanced pro-vitamins A concentrations in maize	
	Analysis and interpretation of studies of the effectiveness of various inbred maize lines as donors (sources) of enhanced pro-vitamins A for maize breeding projects New, simplified laboratory methods for analysis of provitamin A in maize developed or validated	Researchers of NARSs, private companies, IARCs and ARIs Researchers of NARES, private companies, IARCs and ARIs	Recommendations about selection of donor lines will enhance effectiveness of researchers breeding for enhanced pro-vitamins A concentrations in maize. Greatly simplified laboratory methods and cheaper will facilitate Provitamin A breeding by researchers	
Output Targets 2009	Yield potential, pro-vitamins A concentration, agronomic performance and genotype by environment interaction for these traits evaluated for hybrids of second generation (recycled) mid-altitude-adapted maize lines	Researchers of NARSs, private companies and IARCs	Progress from 3 years of breeding will be assessed, informing decisions about future strategy and likelihood of success	
	Enhanced pro-vitamins A OPVs evaluated at multiple locations, especially in Africa	Researchers of NARSs, private companies and NGOs	Assessment of the suitability of enhanced pro-vitamins A OPVs will enable decisions whether to proceed to on-farm validation and promotional trails or to await better products	
	Announce first set of elite, enhanced pro-vitamins A and enhanced Zn inbred lines	Researchers of NARSs, private companies, IARCs and ARIs	Greatly expanding genetic base of nutrient-enhanced germplasm available to researchers worldwide	
	New, simplified laboratory methods for analysis of tryptophan, Fe, or Zn concentration in maize grain validated and adopted by partners in at least five countries	Public and private laboratories	Capacity and efficiency of biofortification partner researchers greatly enhanced	

Output 2	Quality protein maize (QPM) for improved agricultural productivity and health.	Researchers of NARSs, private companies, IARCs and ARIs	Nutritious maize germplasm is used and incorporated in breeding and research programs, resulting in biofortified cultivars being availed to maize farmers and consumers	Increased maize productivity,. reduced risk of. protein malnutrition, especially among. women and children
Annual Output Targets 2007-2009	Initiate at least 60 new breeding populations (mainly bi-parental crosses) to develop new QPM germplasm; and continue breeding and selection for populations formed in previous years	Researchers of NARSs, private companies, IARCs and ARIs	Continually expanding genetic base of QPM germplasm will enable sustained progress by partners developing and promoting QPM	
	Four QPM CIMMYT Maize Lines (CMLs) developed and announced carrying an improved expression of tolerance to drought, N stress, low soil pH announced	Researchers of NARSs, private companies, IARCs and ARIs	Elite, stress tolerant QPM lines will enable sustained development of high yielding, agronomically excellent QPM cultivars	
Output Targets 2007	Performance of 8 new QPM experimental OPVs and 10 hybrids evaluated in international trials	Researchers of NARSs, private companies, IARCs and ARIs	Characterized germplasm available for use and possible promotion by partners	
	Results and interpretation completed for testcross trials of early generation MSV- and imazapyr-resistant QPM lines in eastern Africa	Researchers of NARSs, private companies & IARCs	QPM germplasm suitable for *Striga*-infested areas of eastern Africa	
	Results and interpretation completed for yield trials of advanced, acid soil tolerant QPM lines in Colombia	NARSs, private companies	QPM germplasm suitable for vast, acid-soil regions of South America	
	Meta analysis of QPM nutrition studies completed and freely available.	Agriculture & nutrition scientific communities	This information will help to inform decisions about continued investment in QPM	
Output Targets 2008	QPM version (conversion) of popular Ethiopian hybrid 'BH660' available and tested in direct comparison with the original non-QPM hybrid Results and interpretation completed for yield trials of advanced, highland-adapted QPM lines in Ethiopia New generation of three-way cross QPM hybrids available for on-farm testing	Ethiopian researchers, seed industry and farmers NARSs, private companies & NGOs NARES ,seed industry	An agronomically improved, nutritious version of this already-popular hybrid will be available for evaluation and possible promotion QPM germplasm suitable for highlands New alternatives for hybrids with enhanced yield and quality protein	
	QPM seed available for 250,000 hectares in eastern and southern Africa	Farmers, seed companies	Conducive conditions for enhanced maize production by farmers and improved nutrition of consumers.	
	At least four farmer-grown maize cultivars replaced with QPM versions of the same cultivars	Farmers, seed companies	Increasing area of maize grown to QPM cultivars	

	Strategy to monitor the quality of QPM cultivars developed and validated with partners in at least three countries with commercial QPM cultivars Conversion of at least 4 QPM CMLs to blue color (antioxidant nutraceutic compounds).	NARSs, seed companies, agribusinesses Researchers of NARES, breeders, seed companies	Simplified quality assurance strategy will facilitate the promotion, commercialization and impact of QPM Researchers will have access to anthocianin enriched QPM source lines	
Output Targets 2009	Marker-assisted selection for downy mildew resistance implemented for at least 10 QPM breeding populations in India New floury QPM variety available for testing on farmer fields	NARSs & IARCs Researchers of NARES, private companies and farmers in the Andean region	Enhanced agronomic value of QPM germplasm for Asian farmers Improved floury germplasm tolerant to ear rot	
Output 3	Dual-purpose, or specialty maize for improved livelihoods and income generation	Researchers of NARSs, private companies, IARCs and ARIs	Maize with value-added traits or uses is incorporated in breeding and research programs, resulting in cultivars with increased income-generating potential being availed to maize farmers and markets.	Increased.production. and income. Improved livelihoods. of adopters of this. output
Output Targets 2007	Stover quality assessed for at least 50 genotypes in Africa, and prediction formulae developed for rapid screening of maize stover quality	Researchers of NARSs, private companies, IARCs and ARIs	This preliminary assessment of available genetic variation and of rapid screening methods for maize stover quality will inform decisions about future investments in this objective	
	Association of stover quality with primary agronomic traits, and implications for breeding dual-purpose maize will be documented	Researchers of NARSs, private companies, IARCs and ARIs	New knowledge will inform decisions by CIMMYT and other maize researchers whether to invest in developing and promoting food/stover dual-purpose maize	
	Analysis completed prioritizing potential areas for impact for improved food-feed maize in agro-ecological zones and countries	Researchers of NARSs, private companies & IARCs	New knowledge will inform decisions by CIMMYT and other maize researchers whether to invest in developing and promoting food/stover dual-purpose maize	
	Yield and agronomic performance of experimental yellow maize hybrids will be assessed in about 400 "strip test" plots across four states of Mexico	Mexican NARSs, seed companies, policy-makers	Recommendations will be made about suitable yellow maize hybrids for various regions of Mexico, and breeder's seed of these will be availed to farmers' groups and seed companies.	Farmers can enjoy. increased income by supplying yellow. maize to poultry and. other industries
Output Targets 2008	Analysis of farmer perceptions of best, high stover quality maize genotypes, and of influence of fodder traits on cultivar choice in Ethiopia and Tanzania	Researchers of NARSs, IARCs; and policy-makers	New knowledge will inform decisions by CIMMYT and other maize researchers whether and how to invest in developing and promoting food/stover dual-purpose maize	

	Ex-ante impact assessment and prioritization of investments in specialty maize completed in at least one country in Latin America and one in Asia	Researchers of NARSs & IARC; policy-makers; donors	Recommendations will be made about investments in specialty maize germplasm enhancement and/or market chain development	
	Dual-purpose maize cultivars identified for use in maize-livestock systems in eastern Africa	NARSs, farmers	Farmer acceptance and value attribution to dual-purpose maize will inform future investments.	
Output Targets 2009	Source maize germplasm will be described and publicly availed for at least one high-priority specialty maize type in Asia and one in Latin America	Researchers of NARSs, private companies & IARCs	Partners and other actors will be empowered to enhance their research and/or promotion efforts with dual-purpose or specialty maize	

Project 5. African livelihoods: Global solutions for maize food and income security in eastern and southern Africa.

	Outputs	Intended User	Outcome	Impact
Output 1	Stress tolerant, more nutritious maize cultivars that increase food and income security among resource-poor farmers in eastern and southern Africa	Resource-poor farmers through NARSs and private seed companies	Maize cultivars become available that address livelihood concerns of resource-poor farmers in eastern and southern Africa	Increased food and income security for resource-poor farmers and countries in eastern and southern Africa
Annual Output Targets 2007-2009	Six regionally important OPVs or hybrids developed and announced targeting the main agro-ecologies in eastern and southern Africa, and carrying an improved expression of traits relevant to resource-poor farmers	NARSs and private seed companies	Increased use of elite maize germplasm carrying traits relevant to resource-poor farmers. Availability of elite CIMMYT germplasm and hybrids fosters emergence of small seed entrepreneurs in eastern and southern Africa	
Annual Output Targets 2007-2009	Regional trial results documenting the performance of new hybrids and OPVs developed by the private and public sector in eastern and southern Africa for traits relevant to resource-poor farmers	NARSs, NGOs, private seed sector, organizations involved in seed relief	Increased awareness and use of new maize cultivars carrying traits that are beneficial to resource-poor farmers	
Output Targets 2007	Through collaboration with NARSs and local seed companies, disease resistant drought tolerant, N-use efficient, responsive maize hybrids and farmer-selected OPVs are released in several eastern and southern African countries	Farmers in stress prone-environments in eastern and southern Africa	Reduced impact of drought on maize yields and national maize production Emerging seed entrepreneurs focusing on stress-prone areas become more viable	
Output Targets 2007	In collaboration with KARI, maize cultivars with conventional stem borer resistance meet release requirements in Kenya	Farmers in Kenya	Technology option for areas with high stem borer incidence in Kenya	
Output Targets 2007	In collaboration with KARI, environmental safety assessment of Bt maize in Kenya and insect resistance management plan developed	Government of Kenya, seed producers and farmers deploying Bt maize cultivars	Safe deployment of Bt maize technology under smallholder farmer conditions	
Output Targets 2008	More productive, farmer-selected maize highland cultivars meet release requirements in two Eastern African countries	Resource-poor farmers in the highlands lacking access to improved and more productive maize cultivars	Improved cultivars with earlier maturity and increased disease resistance become available in the highlands of Eastern Africa	
Output Targets 2007	In collaboration with KARI, potential benefits and risks of Bt maize for Kenya and impact on regional seed and grain trade assessed	Government of Kenya, COMESA	Informed decisions the use of Bt maize in East Africa	
Output Targets 2008	In collaboration with NARSs, first drought tolerant quality protein maize (QPM) cultivars enter cultivar release system in eastern and southern African countries	NARSs and private seed companies	Technology option with impact on food security and malnutrition of population groups most at risk	

Output Targets 2008	Through collaboration with NARSs, local seed companies and AATF, adapted *Striga* resistant (IR) maize cultivars meet release requirements in a minimum of four eastern and southern African countries	Resource-poor farmers in *Striga*-affected areas in eastern and southern Africa	*Striga* resistant maize cultivars become available in an increasing number of eastern and southern African countries	
Output Targets 2009	In collaboration with KARI, Bt hybrids with resistance against *Busseola fusca* tested in open quarantine facilities		Technology option for areas with *Busseola fusca* incidence in Kenya	
Output 2	Maize based options that increase marketing options for smallholder farming products and, through partnerships with other research institutions, are integrated and scaled-out into livelihoods systems in eastern and southern Africa	Public and non-governmental extension staff and farmers	Farm-level productivity increases, environmental sustainability and diversification of maize based systems in eastern and southern Africa	Economic development of poor rural maize-growing communities in Eastern and Southern Africa
Output Targets 2007	Study highlighting the effects of QPM on community health indicators and impact for small-scale poultry and piggery units in selected target regions in eastern and southern Africa. Basic seed production of QPM cultivars with focus on quality assurance enhanced	NARSs, NGOs, policy-makers, donors, farmers, seed companies	Targeted use of QPM in food relief programs and as livestock feed. Recognition of QPM maize as a mean for reducing hunger and malnutrition	
Output Targets 2007	In collaboration with ILRI and NARSs, dual-purpose maize cultivars identified among existing maize germplasm for use in maize-livestock systems in Eastern Africa	NARSs, farmers in maize-livestock systems	Use of existing variety differences for optimizing benefits from dual purpose maize	
Output Targets 2008	In collaboration with NARSs, local seed companies and NGOs, QPM seed is available for 250,000 ha in eastern and southern Africa. Quality control labs and field focus on quality assurance operating in target countries	Farmers interested in contract farming and live-stock maize systems. Seed companies	Contract production of QPM grain for food relief (incl. school-feeding and HIV/AIDS-programs) and as stock feed. Increased farm level productivity from QPM-fed non-ruminants	
Output Targets 2008	In collaboration with ILRI and NARSs, influence of livestock related factors on farmers choice of maize genotypes determined in selected communities in Eastern Africa	NARSs and IARCs	Defined strategies for further genetic enhancement and adoption of dual-purpose maize in maize-livestock systems in eastern and southern Africa	
Output Targets 2009	Resistance breeding strategy to decrease mycotoxin contamination of maize grown in eastern and southern Africa implemented	NARSs and IARCs	Reducing mycotoxin contamination of maize grain	
Output 3	Risk-averting, productivity-enhancing management practices that restore natural resources in maize-based systems of eastern and southern Africa	Public and non-governmental extension staff and farmers	Wider use of sustainable management practices by smallholder farmers in eastern and southern Africa	Environmental sustainability and increased productivity of maize-based systems in eastern and southern Africa

Annual Output Targets 2007-2009	In collaboration with Challenge Programs (CPWF, SSA-CP), networks and consortia (ECAMAW, SOFECSA), and advanced research institutions, technical and financial backstopping provided to NARSs and NGOs in a minimum of eight ESA countries to develop, demonstrate and scale-out productivity-enhancing, risk-averting maize cropping practices	NARSs and NGOs	Increased use and farmer-experimentation with productivity-enhancing, risk-averting maize cropping practices	
Output Targets 2007	Recommendation domains for improved conservation agriculture practices in four countries in eastern and southern Africa defined	NARSs, NGOs, IARCs, ARIs	Methods to facilitate the scaling up and adoption of conservation agriculture practices	
Output Targets 2007	In collaboration with SOFECSA member institutions, economic and financial assessment and policy briefs on best-bet soil fertility technologies published and promoted	Decision makers	Wide spread promotion of financially viable/profitable and sustainable integrated soil fertility management practices	
Output Targets 2008	New specific conservation agriculture practices identified which are better adapted to the circumstances of well-defined smallholder farmer groups in eastern and southern Africa	Smallholder farmers in maize-based systems in ESA	Resource-conserving crop management practices	
Output Targets 2008	In collaboration with the CPFW, appropriate financially viable water-conserving technologies which increase crop productivity in smallholder farming communities in the Limpopo basin identified,	NARSs, NGOs, IARCs, ARIs	Promotion of water-conserving technologies among smallholder farmers in the Limpopo basin	
Output Targets 2008	Through collaboration with partners in the CPWF, appropriate and financially viable water-conserving technologies promoted in the Limpopo basin through field days, field schools, and information brochures	Smallholder farmers in the Limpopo basin	Smallholder farmers in the Limpopo basin use and further experiment with water-conserving technologies	
Output Targets 2009	Recommended conservation agriculture practices adapted to smallholder farmer groups in eastern and southern Africa scaled up utilizing existing networks in the region (e.g. ACT, SOFECSA, RELMA).	Smallholder farmers in maize-based systems in eastern and southern Africa	Resource-conserving crop management practices	
Output 4	Public-private partnerships for increased dissemination of maize seed to stress-prone environments	NARSs, small-scale seed entrepreneurs, NGOs, policy-makers	More sustainable production and marketing of seed in stress-prone areas	Sustainable reduction of poverty and hunger
Annual Output Targets 2007-2009	In collaboration with NARSs and the private seed sector, breeder and foundation seed production of regionally relevant public maize OPVs	NARSs, NGOs, seed producers	Breeder and foundation seed of regionally relevant public maize OPVs	

Annual Output Targets 2007-2009	Technical and financial backstopping of National Coordination Units in six eastern and southern African countries strengthening stakeholders' cooperation in the maize seed sector	NARSs, small-scale seed entrepreneurs, NGOs, policy-makers	Agreed and coordinated public-private strategies that increase farmers' access to improved maize seed in outlying areas	
Output Targets 2007	In collaboration with SADC and other IARCs, technical backstopping of regional cultivar release in SADC	NGOs, donors and decision makers	More appropriate choice of strategies that increase farmers' access to improved seed and foster seed sector development	
Output Targets 2008	15 small-scale seed entrepreneurs trained in practical skills relevant to successful maize seed production and dissemination in eastern and southern Africa	Small-scale seed entrepreneurs	Increase success rate among emerging seed entrepreneurs	
Output Targets 2009	Value chain analysis quantifying the impact of institutional and market-driven bottlenecks in the delivery of maize seed to stress-prone environments	Decision makers and local seed companies	Increase success rate among emerging seed entrepreneurs	
Output 5	Capacity building of partners involved in the maize research-extension-marketing continuum, prioritized in the frame of sub-regional networks and consortia	NARSs, small-scale seed entrepreneurs, NGOs, policy-makers	Institutions and collaboration among development partners in eastern and southern Africa strengthened that increase the productivity and sustainability of maize-based systems in both sub-regions	Sustainable reduction of. poverty and hunger
Annual Output Targets 2007-2009	Skills of 50 NARSs researchers improved through workshops, visiting scientist fellowships and graduate research projects	NARSs researchers	Increased effectiveness of NARSs researchers in addressing high priority needs of resource-poor maize farmers in eastern and southern Africa	
Annual Output Targets 2007-2009	In collaboration with NARSs, eight training courses conducted annually exposing NGO and extension staff to know-how on new, relevant and sustainable technologies and approaches that increase productivity in maize- based systems	NARSs and NGOs	Competence to promote and adjust relevant and sustainable technologies and approaches that increase productivity in maize-based systems	More farmers achieve food and. income security
Annual Output Targets 2007-2009	In collaboration with NARSs, simple regionally relevant information, teaching and decision tools relevant to maize systems developed and disseminated to farmer-support groups	NARSs and NGOs	Local professionals and input suppliers provide information that address resource-poor farmers' needs	More farmers achieve food and. income security
Annual Output Targets 2007-2009	In collaboration with ARIs, regulatory skill development for deployment of GM crop cultivars in Kenya	Regulatory authorities in Kenya	Increased competence to assess GM technology options for potential use in Kenya	

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Project 6. Maize for Asia and Latin America.

	Outputs	Intended Users	Outcomes	Impacts
Output 1	Regionally-adapted stress tolerant and nutritious maize for enhanced food security and crop diversification, and improved nutrition and health	Researchers of NARSs, private companies, IARCs and ARIs	Stress tolerant maize germplasm is used and incorporated in breeding and research programs, resulting in cultivars with higher average yield being availed to maize farmers	Increased maize. production and. decreased livelihood vulnerability of maize farmers
Output Targets 2007	Managed drought stress screening sites established, and collaborative regional drought trials including best CIMMYT germplasm grown in at least four countries of southeast Asia	Researchers of NARSs and private companies of 5 Southeast Asian countries	Enhanced capacity by partners to develop drought tolerant germplasm, and new germplasm identified for promotion or research	
	Promising, new agricultural technologies developed or identified by researchers' networks in southeast Asia, Nepal, Bangladesh, India, Colombia and Central America.	Researchers of NARSs, private companies, NGOs	Technologies identified that enhance productivity, sustainability, profitability, diversification and other benefits to maize farmers and consumers.	
	Promising, new agricultural technologies validated and identified for promotion via farmer-participatory research implemented by networks of researchers, extensionists and other partners in southeast Asia, Nepal, Colombia and Central America.	NARSs, Private companies, farmers' organizations, NGOs	Documented farmers' perceptions will guide decisions about promotion of best germplasm for cultivar release and priorities for further research	
Output Targets 2008	Analysis of yield and agronomic performance of diverse maize germplasm grown under 2 to 3 widespread rice-maize cropping systems	NARSs, IARCs, private companies	Preliminary recommendations about maize cultivars and germplasm traits suitable for rice-maize systems	
	New collaborative project initiated in Asia addressing impacts of climate change on intensive maize production	Researcher of NARSs, IARCs	Regional collaboration enhanced, addressing priority concerns and developing solutions or regional impact	
	Promising, new agricultural technologies developed or identified by researchers' networks in India, Colombia and Central America. One QPM tropical white hybrid and one synthetic variety released in Nicaragua and El Salvador	Researchers of NARSs, private companies, NGOs Researchers of NARES, private companies, IARCs and ARIs, Farmers	Technologies identified that enhance productivity, sustainability, profitability, diversification and other benefits to maize farmers and consumers. Extensive promotion of QPM cultivars	
	Promising, new agricultural technologies validated and identified for promotion via farmer-participatory research implemented by networks of researchers, extensionists and other partners in SE Asia, Nepal, Colombia and Central America.	NARSs, Private companies, farmers' organizations, NGOs	Documented farmers' perceptions will guide decisions about promotion of best germplasm for cultivar release and priorities for further research	
Output Targets 2009	Breeding and/or selection protocols implemented and developing maize tailored to rice-maize systems at least at three sites.	Researchers of NARSs, private companies and IARCs	Enhanced effectiveness of researchers to develop or select maize suitable for rice-maize systems.	

	One QPM tropical white hybrid and one synthetic variety released in Guatemala, Honduras, and Mexico.	Researchers of NARES, private companies, IARCs and ARIs, Farmers	Extensive promotion of QPM cultivars	
Output 2	Strengthened impact pathways for maize research products in Asia and Latin America	Researchers of NARSs, private companies, IARCs and ARIs	Nutritious maize germplasm is used and incorporated in breeding and research programs, resulting in biofortified cultivars being availed to maize farmers and consumers	Increased number of beneficiaries of. Output 1
Annual Output Targets 2007-2009	At least 300 partners and stakeholders in Asia and Latin America participate in targeted workshops, courses or other pertinent capacity building activities.	Researchers of NARSs, private companies, farmers, NGOs & others	Partners and other actors effectively produce, use and deliver Project outputs, thereby enabling achievement of the desired impact	
	New project-developed maize technologies available to and adopted by farmers in at least one country each of Asia and Latin America	Farmers, private companies	Conditions exist for achieving Project impact.	
Output Targets 2007	Analysis of current and potential extent of rice-maize systems in Asia; knowledge gaps identified, especially on potential problems or threats of the rice-maize system to the sustainability of the natural resource base and the environment, and establish research to fill knowledge gaps.	Researchers of NARSs, private companies, IARCs and ARIs	This "groundwork" analysis will lead to or accompany the formation of a research network(s) addressing productivity, profitability, sustainability and other key aspects of this rapidly-expanding cropping pattern.	
	New partnerships and increased participation of seed producers and agribusinesses in at least three countries each of Asia and Latin America	Stakeholders of NARSs, NGOs, private companies, and farmers	Market chains strengthened; increased likelihood of Project impact	
	Analysis and interpretation of farmer-participatory maize landrace improvement project in Mexico	Partners in NARSs, NGOs	New methods of reaching marginalized farmers with improved technologies validated, thereby informing decisions about future investments	
Output Targets 2008	Analysis of the importance of maize genotype x management interaction for rice-maize systems	Researchers of NARSs, private companies	Results will inform priority setting by researchers developing maize cultivars for use in rice-maize cropping systems.	
	New partnerships and increased participation of seed producers and agribusinesses in at least two countries each of Asia and Latin America	Stakeholders of NARSs, NGOs, private companies, and farmers	Market chains strengthened; increased likelihood of Project impact	
Output Targets 2009	Top leaders in Cental America (Presidents and Ministers of Agriculture) recognize QPM as a technology to reduce hunger and malnutrition	Policy-makers and national leaders	QPM technologies promoted by governments in the region	

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Project 7. Water productive wheat.

	Outputs	Intended user	Outcome	Impact
Output 1	Spring and winter bread and spring durum wheat with increased water productivity and heat tolerance, multiple resistance against the complex of soil-borne and foliar diseases and appropriate end use quality distributed through differnet mechanism including International Nursery Network	Farmers, household consumers, food processors, NARSs, IARC ARI, NGOs, Private sector	Measurable increase in productivity and genetic diversity in farmers' fields. Reduced losses from diseases and increased stability of grain yield. Enhanced input efficiency.	Increased national food security. Reduced vulnerability of farm families whose livelihood depends on income from wheat based farming systems. Improved agricultural productivity, better quality of wheat products and more sustainable utilization of natural resources. Risk for disease epidemics reduced.
Annual Output Target 2007–2009	Advanced spring bread and durum wheat and Triticale lines (750) and segregating populations (300) with tolerance to abiotic (drought, heat), and multiple disease resistance to biotic stresses (rusts, *Septoria*, *Fusarium*, soil-borne disease complex) with enhanced seedling vigor and better end-use quality		Valuable lines and segregating populations used in breeding programs. Data from International Wheat Improvement Network available to co-operators.	Improved and genetically diverse wheat germplasm used by breeders. Faster development of improved cultivars. Participation in global and regional wheat improvement networks increases. Global monitoring and pre-emptive screening against new diseases and new virulences before major epidemics occur.
	At least 150 advanced wheat lines tested by partners in multilocational yield trials		Cultivars characterized for relevant traits. Lines and data used for wheat improvement. Cultivars evaluated by farmers through participatory varietal selection	Germplasm and information sharing and analysis lead to faster deployment of improved cultivars and increased productivity
	Elite spring wheat lines (25) evaluated in national cultivar registration trials. Seed multiplication for formal and informal distribution initiated.		Ten cultivars released and adopted by farmer for areas affected by erratic rainfall.	Farmers and consumers benefit from new wheat cultivars. Enhanced drought and heat tolerance of these cultivars buffer against possible negative effects from climate change
	Parental lines with desirable quality for diverse end-uses identified and deployed. Sprouting-tolerant (high falling number value) lines identified and distributed		New lines with better quality properties available to wheat breeders	Cultivars with improved end use quality and beter marketability; farmers have higher income

	Advanced winter wheat lines - developed by the joint Turkey/CIMMYT/ICARDA winter wheat program - (150) and segregating populations (100) with tolerance to abiotic (drought, heat, cold, Zn-deficient soils), and biotic stresses (rusts, soil-borne disease complex) and better end-use quality.		Valuable lines and segregating populations used in breeding programs. Data from International Wheat Improvement Network available to co-operators.	Improved and genetically diverse wheat germplasm used by breeders. Faster development of improved cultivars. Participation in global and regional wheat improvement networks increases. Global monitoring and pre-emptive screening against new diseases and new virulences before major epidemics occur.
	At least 30 advanced wheat lines tested by partners in multilocational yield trials.		Cultivars characterized for relevant traits. Lines and data used for wheat improvement. Cultivars evaluated by farmers through participatory varietal selection.	Germplasm and information sharing and analysis lead to faster deployment of improved cultivars and increased productivity.
	Elite winter wheat lines (10) evaluated in national cultivar registration trials. Seed multiplication for formal and informal distribution initiated.		Three cultivars released and adopted by farmer for areas affected by erratic rainfall	Farmers and consumers benefit from new wheat cultivars Enhanced drought and heat tolerance of these cultivars buffer against possible negative effects from climate change
	High end-use quality parental lines identified and deployed to combine desirable traits in the Winter Facultative wheat growing areas of CWANA. Quality desirable genotypes identified from winter/ facultative wheat lines sent to cooperators in the CWANA		New lines with better quality properties available to wheat breeders	Cultivars with improved end use quality and better marketability; farmers have higher income
Output 2.	Wheat germplasm characterized for stress-adaptive traits with emphasis on drought and heat and resistance to diseases, with emphasis on soil-borne diseases	NARSs, IARCs, ARIs	New valuable gene(s) identified and incorporated into breeding lines	Livelihood of farmers living in marginal areas enhanced through more drought tolerant and stress resistant cultivars. Measurable increase in productivity, genetic diversity in farmers' fields
Annual Output Target 2007–2009	Understanding and identification of main physiological and morphological traits associated with drought and heat tolerance in synthetics, landraces and various mapping populations		Enhanced knowledge and applied tools. Increased selection efficiency. Wheat cultivars with improved drought tolerance based on novel gene combinations	Better drought and heat tolerant cultivars delivered faster to farmers
Annual Output Target 2007–2009	New sources (5) of wheat root disease resistance to nematodes and root rots prevalent primarily in rainfed wheat systems identified per year, and 30 lines resistant to soil-borne diseases distributed		Use by partners and stakeholders that lead to increased productivity and sustainability	Rainfed wheat producers benefit from an increased and more stable production in particular in years with severe water stress.

Output target 2007	Winter wheat lines combining tolerance to zinc deficient soils and resistance to nematodes distributed to co-operators		Increased yield stability and availability of wheat germplasm for NARSs researchers in drught prone areas	Livelihood of farmers living in marginal areas enhanced through more drought tolerant and stress resistant cultivars. Measurable increase in productivity, genetic diversity in farmers' fields
Output target 2008	Genetic stocks (700) phenotyped for stress related traits (drought, physiological traits, zinc efficiency, disease resistance) by CIMMYT and partners		Wheat genetic stocks, mostly with introgressions from wild wheat relatives in improved backgrounds, evaluated for drought relevant traits	Broadened access to genetic stocks of wheat; common platform for sharing stocks and derived phenotypic and genotypic data New genetic sources utilized globally for wheat improvement and research
Output target 2009	QTL that are associated with heat or drought adaptive traits through analysis of phenotypic data measured on mapping populations identified		Knowledge on gentics of heat and drought tolerance; Increased breeding efficiency	More drought or heat tolerant cultivarsd available to farmers; farmers' production less vulnerable to abiotic stresses
Output 3	Selection methodologies to improve wheat for drought and heat stressed environments	Breeders in NARSs, IARCs, ARIs	More efficient selection methods and better classified parents	Livelihood of farmers living in marginal areas enhanced through more drought tolerant and stress resistant cultivars. Measurable increase in productivity, genetic diversity in farmers' fields. Breeding methods with increased efficiency and effectiveness
Annual Output Target 2007–2009	MAS procedures optimized to increase number of assays by 50% annually to 100 000 in 2009		Lower cost assay systems for MAS applications.	Increased efficiency and effectiveness in cultivar development
Output Target 2007	Molecular markers identified for canopy temperature depression and stem carbohydrates		Increased selection efficiency for drought tolerance associated traits.	Better drought and heat tolerant cultivar delivered faster to farmers
	Characterize bread and durum wheat mapping populations for heat, drought and N-use efficiency in durum		Enhanced knowledge and applied tools. Increased selection efficiency.	
Output Target 2008	QTL identified for water use efficiency, heat tolerance in bread and durum wheat mapping populations and for N-use efficiency in durum population		Increased efficiency to select for drought and heat tolerance associated traits	Better drought and heat tolerant cultivar delivered faster to farmers
	MAS strategies optimized by using computer simulations validated with real data.		Enhanced selection efficiency for breeding new cultivars and populations	Better drought and heat tolerant cultivars delivered faster to farmers.

Output Target 2009	Genomic regions associated with heat adaptive traits through analysis of phenotypic data measured on mapping populations		Increased efficiency to select for drought heat tolerance associated traits	Better drought and heat tolerant cultivar delivered faster to farmers
	Physiological trait-based breeding for heat tolerance implemented		More heat tolerant germplasm developed faster and more efficient; methodology shared with NARSs resulting in increased breeding efficiency	Better drought and heat tolerant cultivar delivered faster to farmers
	Genotype x tillage practice interactions understood and extended to global environments		Wheat cultivars adapted to zero-tillage systems	Cultivars that can fully exploit the benefits from CA with higher yield and reduced production costs that lead to incrased farmer income
Output 4	Regional capacity building for breeding, pathology, quality, physiology, and conservation agriculture	NARSs	At least 50 NARSs staff trained per year. Increased effectiveness of partners and CIMMYT research	Partner's research-for-development capacity strengthened to improve livelihood of people depending on income from rainfed wheat systems.
Annual Output Target 2007–2009	Wheat lines selected/developed by NARSs evaluated in regional nurseries (Caucasus, high latitude wheat, Eurasian winter wheat region); germplasm resistant to soil-borne diseases evaluated through global network on this theme		Better utilization of NARSs bred wheat lines in neighboring countries. Pre-emptive disease screening for new diseases and their virulence	More genetic diversity in farmers fields that result in more stable and higher production

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Project 8. Enhanced wheat for more durable resistance to diseases and enhanced production potential.

	Outputs	Intended user	Outcome	Impact
Output 1	Genetically diverse wheat germplasm with enhanced consumer and market oriented quality, high yield potential, resistant to biotic stresses and buffered to tolerate climatic change	Farmers, household consumers, food processors, NARSs, IARC ARI, NGOs, Private sector	Measurable increase in productivity and genetic diversity in farmers' fields. Reduced losses from diseases and increased stability of grain yield. Enhanced input efficiency.	Increased national food security. Reduced vulnerability of farm families whose. livelihood depends on income from wheat. based farming systems. Improved. agricultural productivity, better quality of. wheat products and more sustainable. utilization of natural resources. Risk for. disease epidemics reduced.
Annual Output Target 2007 - 2009	Advanced spring and facultative/winter wheat and durum wheat germplasm (ca. 750 lines) and Triticale and segregating populations (300) for irrigated environments with durable disease resistance, N use efficiency, high and stable yield, and end use quality distributed.	Global Wheat Breeding community	Sustained growth in wheat productivity by release of new spring bread wheat cultivars from germplasm distributed through international nurseries and use of improved germplasm by NARSs in their breeding programs.	Improved and genetically diverse wheat. germplasm used by breeders. Faster. development of improved cultivars. Participation in global and regional wheat. improvement networks increases. Global. monitoring and pre-emptive screening. against new diseases and their virulence.
Annual Output Target 2007 - 2009	At least 150 advanced wheat lines tested by partners in multilocational yield trials.		Cultivars characterized for relevant traits. Lines and data used for wheat improvement. Cultivars evaluated by farmers through participatory varietal selection.	Germplasm and information sharing and. analysis lead to faster deployment of improved. cultivars and increased productivity
Annual Output Target 2007 - 2009	Elite spring wheat lines (25) evaluated in national cultivar registration trials. Seed multiplication for formal and informal distribution initiated.		Ten cultivars released and adopted by farmer for areas affected by erratic rainfall.	Farmers and consumers benefit from new. wheat cultivars. Enhanced drought and heat. tolerance of these cultivars buffer against. possible negative effects from climate change
Annual Output Target 2007 - 2009	New sources of resistance to stem rust race Ug99 identified and distributed worldwide through the International Stem Rust Resistance Screening Nursery	Global Wheat Breeding community	Diverse sources of spring and winter bread wheat germplasm with information on resistance genes against Ug99 made available to NARSs for either direct release or for use in their breeding program	Development of cultivars resistant to Ug99. reduce risk of a stem rust pandemic

Output Target 2008	100 bread wheat lines adapted to Sichuan and Yunnan Provinces of China enhanced with durable resistance to yellow rust and evaluated for yield potential	Academy of Agricultural Sciences of Sichuan and Yunnan, CAAS	Sustained productivity growth in Sichuan and Yunnan Provinces of China through the release of high yielding spring bread wheat cultivars with durable resistance to yellow rust	Livelihood of farmers improved through. increased food security and income
	At least 40 new heat tolerant early maturing lines with resistance to *Helmintosporium* leaf blight and leaf rust identifed and developed for Eastern Gangetic plains	NWRP/NARC-Nepal, WRC/BARI-Bangladesh, DWR/BHU/AAU/BAU-India, CIMMYT breeders	Genetic stocks with combined resistance to these stresses, as well as with yield stability, made available for further genetic diversification	Reduced vulnerability of farmers through. enhanced wheat productivity and stability for. tolerance to the effects of climate change and. diseases
	Wheat cultivars resistant to *Fusarium* head scab by using MAS and hot-spot shuttle breeding with China, Korea, Japan and the Southern Cone	GFI, USWBSI, China, INIA-Uruguay	Increased availability of wheat germplasm resistant to scab	Reduced toxin content in wheat results in. improved health of wheat consumers
	At least 5 elite wheat lines resistant to Ug99 and adapted to target areas identified and large-scale seed multiplication begun.	Seed producers in Kenya and Ethiopia	Mitigating the threat from Ug99 race of stem rust to safeguard food security and livelihoods in Africa, Middle East and Asia	Reduced vulnerability of farmers in target. areas; increased food security through reduced. risk of a global stem rust pandemic
Output Target 2009	Adapted wheat cultivars from Africa and Asia and elite genotypes enhanced with diverse and durable sources of resistance to Ug99 race of stem rust pathogen	Seed producers in Kenya, Ethiopia and Asia	High acceptance of stem rust resistant cultivars by farmers since resistance to Ug99 introgressed into currently widely grown cultivars	Reduced vulnerability of farmers in target. areas; increased food security through reduced. risk of a global stem rust pandemic
Output 2	Basis of durable disease resistance characterized and genetic diversity enhanced to reduce genetic vulnerability in farmers fields			
Annual Output Target 2007 - 2009	New race-specific rust resistance genes in 40 to 50 bread and durum wheat cultivars Understanding of the genetic basis of durable resistance to three rusts in 4 or 5 bread and durum wheat	NARSs, ARI	Better understanding of genetic resistance to three rust diseases of wheat. Enhanced genetic diversity for rust resistance in farmers fields	Increased national and regional food security; reduced vulnerability of farmers and increased farm income;.
Annual Output Target 2007 - 2009	Identification of genomic regions (QTL) in bread and durum wheat populations for fine mapping of rust resistance genes and marker development	NARSs, ARI	Increased selection efficiency; wheat germplasm with durable resistance to rust	Increased national and regional food security; reduced vulnerability of farmers and increased farm income.
Annual Output Target 2007 - 2009	Identification of resistance-related genes to scab and development of DNA markers	NARSs; Cooperators in Global *Fusarium* Initiative'	Increased selection efficiency and availability of scab resistant germplasm	Reduced toxin content in wheat results in. improved health of wheat consumers
Output Target 2007	New candidate rust resistance genes (RLG) from rice identified and expression analysis of RLG genes	NARSs with biosafety regulations, ARI	Rust resistant wheat germplasm with rust resistance from rice	Reduced vulnerability for farmers from rust. epidemic

Output Target 2008	Confirmation of RLG as non-host resistance genes in rice Validation of RLG as yellow rust resistance genes in wheat	NARSs with biosafety regulations, ARI	Rust resistant wheat cultivars with rust resistance from rice	Reduced vulnerability for farmers from rust. epidemic
Output 3	Global networks to monitor distribution, evolution and migration of pathogens for an early warning of threats			Farmers less vulnerable to losses from. pathogen epidemics, thereby increasing. their productivity, food security, wealth. and health
Annual Output Target 2007 - 2009	Early warning networks to alert and to reduce losses from new races of rust pathogens of wheat.	NARSs in Asia, America, Africa., USDA-ARS, Sydney University, Ag. Canada	Risks from current and emerging races of three rust pathogens of wheat reduced. Enhanced information on diversity in rust populations.	Increased regional and national food security;
Output Target 2008	Multi-purpose International *Fusarium* Nursery with FHB and crown rot resistance and informative genetic stocks such as NILs for 3BS screened in FHB/crown rot hotspots worldwide; data analyzed and made available	Members of GFI, NARSs, USWBSI,	Knowledge of the nature and distribution of FHB and crown rot causing Fusaria species (including knowledge of new means of describing pathogenic Fusaria- chemotype, DNA based lineages, etc.)	Reduced toxin content in wheat products. results in improved health of wheat consumers
Output Target 2009	Species and chemotype of pathogen isolates (scab and crown rot) from nursery determined.		Nature and distribution of FHB and crown rot causing *Fusaria* species determined	Reduced losses from *Fusaria* species and healthier wheat products
Output 4	Regional capacity for genetically enhancing wheat against pathogens and pests		Better informed NARSs and farmers	Partner's research-for-development. capacity strengthened to improve livelihood. of people depending on income from the. wheat crop whose risk from rust epidemics. decreased
Output Target 2007	Enhanced laboratory and field capacity of KARI (Kenya) and EIAR (Ethiopia) to conduct rust, in particular stem rust research	Kenyan and Ethiopian researchers	Better capacity of Kenya and Ethiopia to monitor rust pathogens and breed for resistance to stem rust.	Increased income of farmers in Ethiopia and Kenya due to reduced losses from rust

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Project 9. Grain enriched for health and profitability.

	Outputs	Intended users	Outcome	Impact
Output 1	Germplasm developed with enhanced genetic variability for increased iron, zinc and protein concentration, reduced susceptibility to mycotoxin contamination, and/or improved value-added, end-use quality	Resource poor producers and consumers of wheat; wheat researchers	Wheat germplasm with acceptable nutritional and end-user traits identified and used	Improved and safer nutrition from grain consumption for rural and urban poor. Enhanced wheat grain market opportunities for farmers
Annual Output Target 2007-2009	Biofortified germplasm distributed, and genotype x environment performance determined	NARSs of India, Pakistan, China, Iran, Turkey and Kazakhstan	Germplasm and information sharing	Enhanced food and nutritional security
	Germplasm characterized for value-added, market-oriented quality traits (including Pin genes, over-expressed glutenins, granule bound starch synthase, high protein) or food safety traits (e.g. DON)	CIMMYT and NARSs breeders	Enhanced breeding efficiency through well characterized parental germplasm	More tasty and healthy food reaching rural and urban consumers
Annual Output Target 2007-2008	Germplasm development (>150 crosses + >150 segregating populations) for biofortified, enhanced iron or zinc concentration	NARSs and CIMMYT breeders	Biofortified germplasm development	Improved wheat germplasm contributes to improved farmer and consumer livelihoods
Output Target 2008	Wheat genetic resources screened for iron and zinc concentration	NARSs, ARI and CIMMYT breeders	Enhanced genetic variability for biofortified grain improvement	Genetic diversity contributes to nutritional security
Annual Output Target 2008-2009	Farmer participatory evaluation of biofortified wheat germplasm	Farmers in India and Pakistan	Improved wheat cultivars reach farmers	Enhanced food and nutritional security
Output Target 2009	Biofortified wheat germplasm evaluated through farmer participatory trials and seed multiplication of selected lines initiated	NARSs of India, Pakistan	Improved wheat cultivars reach farmers	Enhanced food and nutritional security
Output 2	Assessment agronomic or grain processing on grain micronutrient retention and bioavailability in consumed products		High yielding and better nutritional quality wheat germplasm	Improved health of wheat consumers
Annual Output Target 2007-2009	Micronutrient fertilizer application to enhance grain Zn concentration assessed	Farmers	Crop management options for biofortification of grain identified	Improved health of wheat consumers
Annual Output Target 2007-2009	Micronutrient bioavailability determined for biofortified processed grain products	Consumers	Optimized processing methods defined to retain nutritional value of biofortified grain	Improved health of wheat consumers

Project 10. Conservation agriculture for maize and wheat cropping systems.

	Outputs	Intended users	Outcome	Impact
Output 1	Better understanding of resource-conserving technologies for maize and wheat systems	Farmers	Practices of conservation agriculture, including zero and reduced tillage, mulch systems, and green manure cover crops, used widely in maize and wheat systems	Poverty reduced, livelihoods improved, soil and water conserved, fuel use reduced, soil organic carbon loss slowed or reversed, climate change mitigated
Annual Output Target 2007-2009	Effects of conservation agriculture practices on system productivity, water use efficiency, soil degradation and erosion quantified	Farmers and NARSs in Asia	Appropriate conservation agriculture systems for smallholder farmers that improve agro-ecosystem productivity adopted	Improved profitability of grain production and improvement of rural livelihoods plus better soil fertility
	Bed-planting technology for wheat production in cotton-wheat irrigated systems tested	Farmers in Central Asia	Reduced water erosion, reduced use of water, increased stability of grain production	Improved profitability of grain production and improvement of rural livelihoods plus better soil fertility
	Improved understanding obtained from long-term trials of CA system sustainability and environmental consequences	Global wheat agronomy community	Conservation agriculture compared to current farmer practices	Best-bet, farmer-owned options identified and used
	Sustainability of soil physical, chemical and biological properties understood in CA systems	Global wheat agronomy community	Tools to monitor the sustainable performance of different management practices	Soil fertility improved, agricultural sustainability ensured
Annual Output Target 2007-2008	Remote sensing technology used to access production input efficiency	Agronomists and policy-makers	More skilled human ccapacity becomes available on new technologies	Improved research and policy effectiveness
Output 2	Transfer of appropriate, farmer oriented CA production technologies to safeguarding soils while increasing water productivity and resource use efficiency	Farmers	Practices of conservation agriculture used widely in maize and wheat systems	Poverty reduced, livelihoods improved, soil and water conserved, fuel use reduced, soil organic carbon loss slowed or reversed, climate change mitigated
Annual Output Target 2007-2009	New prototype conservation agriculture implements evaluated through farmer experimentation with the involvement of multiple stakeholders	Farmers and Small Machinery Makers	Multi-crop seed drills manufactured by private entrepreneurs	Livelihoods of farming communities improved
	Improved best-practice knowledge grained about methods for developing and scaling up conservation agriculture	Farmers and Extension Services	Information collated and exchanged to promote conservation agriculture	Visibility of the national efforts for promoting conservation agriculture improves globally
	Options for cereal based crop diversification, including residue management for more sustainable and economic livestock-cereal systems defined	Farmers	Farmers have access to more sustainable production systems	Farmers exposed to less risk to environmental degregation and crop failure
Output Target 2009	Nitrogen status sensor tool used by farmers to manage nitrogen use efficiency in irrigated wheat production systems	Farmers	Farmers have access to precision agriculture technologies	Enhanced economic productivity with reduced environmental pollution

Project 11. Knowledge, targeting, and strategic assessment of maize and wheat farming systems.

	Outputs	Intended Users	Outcomes	Impacts
Output 1	Strategic targeting mechanisms and knowledge for priority setting	CIMMYT and System-wide Program researchers and managers, NARSs, makers, donors	Better knowledge of impacts and enhanced targeting of research and policy for maize and wheat systems, especially for poor farmers	Increased effectiveness of maize and. wheat system research-for-. development for improvement. of rural livelihoods, food security. and reduced poverty
Output Targets 2007	• Expansion of spatial knowledge bases and strategic assessments, including Asian Maize Facts and Futures and Wheat Facts and Futures. • Specification of impact pathways for two maize and two wheat Projects. • Improved characterization of maize and resource management environments in sub-Saharan Africa. • Guidelines for quality assurance for ex post impact assessment at CIMMYT	CIMMYT and system-wide program researchers and managers, NARSs, makers, donors.	Strengthened base for designing and assessing research and scaling up results in CIMMYT Programs, in selected NARSs in two regions. Improved understanding and geo-spatial data for key abiotic stress environments and vulnerability of farmers. Increased capacity for impact assessment in NARSs.	Increased reliance on internal expertise for impact assessment in NARSs. Improved targeting and priority setting of technologies for abiotic stress-prone environments. More efficient and effective development and deployment of conservation agriculture technologies in Southern Africa. Improved information and knowledge sharing.
Output Targets. 2008	• Populated spatial knowledge bases for selected hotspots including drought areas; and improved temporal and spatial characterization of maize or wheat environments. • Specification of impact pathways for two maize and two wheat Projects. • Two ex post and ex ante impact assessments of maize and wheat interventions including innovation systems and impact pathways, e.g., Ethiopia/Uganda, Central America, China • Key policy bottlenecks and required improvements for cereal adoption and marketing available in two developing regions	CIMMYT researchers and managers, NARSs, CGIAR managers, investors.	Better understanding of the environments and role of drought tolerant germplasm in risk management in marginal areas. Improved knowledge of livelihoods impact pathways in two areas in two regions. Enriched policy dialogue on impact pathways for maize germplasm and technologies in two regions.	More effective maize and wheat breeding for drought tolerance. Improved impact and innovation pathways for maize and wheat research. Improved policy environment for wheat value chains. More effective targeting of germplasm and technologies to specific environments and improved efficiency of breeding programs.

Output Targets. 2009	• Enriched spatial knowledge bases in two further priority regions hotspots; and Global Maize Facts and Futures. • Specification of impact pathways for two genetic resources Projects. • Appraisals of climate change impact on maize and wheat farming systems initiated. • Two documented ex post and ex ante impact assessments in two East African countries. • Global synthesis of conservation agriculture across Asia, Africa and Latin America, or CIMMYT global impact on poverty	Managers and researchers in NARSs, CIMMYT, CGIAR and associated partners, agricultural policy makers and donors.	Better understanding of the environments and impact pathways for maize Lessons from ex post and ex ante assessments. Lessons from conservation agriculture in selected regions.	More efficient and effective Project monitoring and evaluation. Improved priority setting for germplasm enhancement including intermediate genetically enhanced materials.
Output 2	Analyses and valuations of maize and wheat genes, gene discovery and genetic diversity	CIMMYT researchers, NGOs, NARES, local development agencies	Better understanding of the value of genes, gene discovery and crop diversity in selected wheat and maize based farming systems	Improved conservation, management and utilization of maize and wheat genetic resources and diversity
Output Targets 2007	Analysis of household valuation and choice and local crop genetic diversity in maize systems in Mexico; review of the valuation of genes; briefs prepared on impacts of markets on crop diversity	Policy makers (Ministries of Agriculture and Environment), NGOs, CGIAR and NARES researchers	Deeper understanding of household incentives, feasibility of *in situ* maize genetic resources conservation and management based on Mexican experience	Improved interventions for *in situ* conservation and management of maize genetic resources
Output Targets 2008	Analysis of choice and management of crop diversity: household valuation and choice and local crop genetic diversity in wheat ; assessments of community seed systems in poor areas of selected regions	NGO and Ministry development agents, and NARES researchers	Deeper understanding of household incentives, feasibility of *in situ* wheat genetic resources conservation and arrangement with due regard to the performance of local seed systems	Improved interventions for *in situ* conservation and management of maize genetic resources
Output Targets 2009	Valuation of intermediate products from genetic improvements and advancements developed with respect to maize. Assessments maize seed systems in East and Southern Africa; synthesis of markets and diversity.	Farmers, NARES, University and CGIAR researchers, policy makers of Ministry of Agriculture & Water Resources, Challenge Programs	Estimates of gene valuation to guide the utilization of genetic diversity; knowledge of the interactions between seed markets and diversity	More efficient utilization of ex situ and in situ maize and wheat genetic diversity, including considerations of seeds markets in the latter case

Output 3	Analyses of the roles of grain quality and value chains in the improvement of livelihoods of the poor	CIMMYT researchers, private sector, policy makers, partners (including NGOs), CGIAR centers.	Improved interventions based on high protein maize cultivars, micro-nutrient enriched wheat cultivars and improved value-added chains in selected maize and wheat farming systems.	Enhanced human nutrition through. micronutrient-enriched grain and. increased incomes and employment. through improvements in value. chain coordination and efficiency in. poor wheat and maize areas
Output Targets. 2007	• Documented value chains for maize systems in poor areas of Meso America (building on CIAT's agro-enterprise research). Market access methodology development initiated for maize seed and inputs markets in Southern Africa. Identified price premia and trends in demand for wheat quality in selected important wheat producing countries. • Review of economic analysis methodologies and results for the impacts of maize (QPM) and wheat (various) nutritional quality on health	CIMMYT researchers, CGIAR Centers, business (livelihood) service providers, NGOs,. International Labor Organization (ILO), HarvestPlus.	Better understanding of the role of quality in value chains and human nutrition and how those value and nutrition chains can be made to work for effectively and efficiently for farmers and value-added enterprises e.g. agro-processing.	Improved value chains leading to. increased financial capital for. smallholder farmers and others in the. value chains. Improved health for different end-users.
Output Targets. 2008	• Documented value chains for poor wheat areas in South Asia, and poor maize area in South and Southeast Asia. Identified means to increase impacts of micronutrient-enriched wheat cultivars on micro-nutrient deficiency in South Asia. • Methodology developed and tested to assess potential benefits of QPM in selected poor regions of Central America	CIMMMYT researchers, NARSs, CGIAR centers. private sector, small. enterprise and market. development sectors, NGOs	Greater understanding of constraints and opportunities within the value and nutrient chains. Identification of service providers to make value chains work better.	Improved functioning of value chains. leading to increased financial capital. for value chain actors, especially. smallholder farmers.
Output Targets. 2009	• Assessment of QPM maize in Central America. • Documented value chains for marginal wheat systems	Health and education. (school meals) policy. makers, partners	Identification of potential health and other. livelihood benefits from improved functioning of wheat value and nutrient chains	

Output 4	Strengthened partners involved in research and development of maize and wheat based systems.	CIMMYT researchers, NARSs, CGIAR, NGOs, policy makers, universities, agri-business	Strengthened professional capacity to improve maize- and wheat-based farming systems. Accessibility and impact knowledge and technology developed by CIMMYT and partners enhanced.	Strengthened partners' capacity to. conduct appropriate research-for-. development towards improved. livelihoods and poverty reduction
Output Targets. 2007	• Cereal Systems Knowledge Portal (with IRRI and perhaps other centers). • Coordinated knowledge sharing: implementation of CGIAR system-wide geo-spatial information portal implemented. • Updated geographical and thematic working strategy for capacity building and knowledge sharing	CIMMYT and CGIAR researchers, NARSs, universities, international organizations	Identified and analyzed conditions for improved information and knowledge sharing (within and outside CIMMYT) and networking CIMMYT partners' scientific capacity enhanced through functional information flow and efficient collaboration. CIMMYT capacity building strategy and ensuing plan updated – targeting, prioritization, efficiency	Increased research effectiveness of. CIMMYT and its partners especially in. the key regions. Improved information and knowledge. sharing and networking
Output Targets. 2008	• Cereal Systems Knowledge Portal (CSKP) populated and operational • Functional knowledge sharing: • Promotion of CSKP through in-country workshops and courses	NARSs, NGOs, universities, investors, policy makers	Improved access to CIMMYT dta and information and greater capacity of partners. Improved communication between scientists through CSKP including rice, wheat and maize	Increased research effectiveness of. CIMMYT and its partners especially in. the key regions. Improved information and knowledge. sharing and networking
Output Targets. 2009	• Supporting community of CSKP users – networks. • Distance learning (e-courses) program in collaboration with IFPRI and other CGIAR centers functioning.	CIMMYT researchers, NARSs	Strengthened pool of scientists in area of wheat, maize systems, livelihoods and poverty reduction	Increased research effectiveness of. CIMMYT and its partners especially in. the key regions. Improved information and knowledge. sharing and networking

Eco-regional Program. Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains.

Goal	Conserve natural resources, improve livelihoods, and alleviate poverty through sustainable increase in productivity of rice-wheat systems in South Asia			
Purpose	Strengthen existing linkages and partnerships with NARSs, IARCs, ARIs and local private sector working to develop and deploy more efficient, productive and sustainable technologies for the diverse rice-wheat production systems of the Indo-Gangetic Plains so as to produce more food at less cost and improve livelihoods of those involved with agriculture and as a consequence to decrease poverty			
	Outputs	Intended Users	Outcomes	Impact
Output 1. Develop technologies and policies to improve water productivity, soil health and enhanced diversity of the rice-wheat systems				
Output Targets 2007	• Legumes and winter maize in eastern Gangetic plains introduced. • Mungbean and cowpea in lowland fallows tested. • Diversification practices that promote sustainability developed. • Multi-crop zero-till seed drills and bed planter in eastern Gangetic plains developed, tested and refined. • N management practices using GreenSeeker technology developed. • Rice crop establishment practices for direct seeded rice refined. • Laser leveling technologies demonstrated at large scale. • GPS surveys, geo-referenced databases for RCTs adoption sites available	Farmers in South Asia, private seed sector, NARSs, other research centers.	More diversified systems in Eastern Gangetic plains. Maize seed systems available. More pulses and fodder produced. Farmers adopted new machines for seeding into loose residues. Saving on water and improving input use efficiency. Reliable in-season forecasting of wheat and rice yields.	Zero-till drill manufacturing units cross 150, and appear in the eastern sector for enhanced adoption of conservation agriculture for improved livelihoods, human and animal health and quality of the environment.
Annual Output Targets 2008-2009	• New drills for seeding into loose residue placed in the hands of the farmers to implement at their fields extensively. • Rice crop establishment practices developed, co-culturing of rice with green manure crops established, intercrops, dual purpose wheat, maize and legumes promoted. • Laser leveling technology promoted at farmers' fields. • N-response curve at farmers' fields validated.	Farmers in South Asia, private sector, NARSs, other research centers.	Acreage of zero-till or reduced- till, laser leveling, dual purpose wheat, QPM and direct-seeded rice expands in parts of IGP. Farmers adopt new machines for seeding into loose residues. Soil surface covered become increasingly popular practice for saving irrigation water	Diversified rice-wheat systems. produce more at less costs and generate new sources of income and employment. Knowledge and experiences shared among stakeholders. Farmers shift to double No-till systems in sizeable area in rice-wheat cropping systems

Output 2. Accelerate adoption of resource-conserving technologies. All stakeholders involved for accelerating the pace of development and adoption of RCTs in farmer participatory research mode in the IGP				
Output Targets 2007	• Resource conservation technology (RCT) options and diversification practices refined and promoted among farmers. • Weeds in direct-seeded rice cropping for northwestern and eastern IGP managed. • Geo-referenced databases for targeting RCTs in underutilized lands of selected sites generated	NARSs, CGIAR researchers, farmer associations	Farmers gain understanding on benefits of RCT and on weed management for direct-seeded rice. Underutilized lands of selected sites benefit from technology targeting.	Greater acceptance of direct-seeded rice practices doing away with puddled transplanted rice.
Annual Output Targets 2008-2009	• RCTs for risk-prone areas (flood or drought) of the IGP fine-tuned for up-scaling to risk prone areas. • Agronomic and crop management practices to climate change adapted. •	NARSs, farmers, CGIAR and other researchers	Rental services of new customized machines of RCTs increasingly become popular in IGP. Seed village concept for QPM Maize and grain legumes take roots in East and northwest. Better understanding of global conservation agriculture practices in a changing world	Stakeholders adopt a knowledge-sharing and networking culture. More innovative cropping system practiced in IGP that could appropriately address climate change
Output 3. Prudent management of the Rice-Wheat Consortium by strengthening the capacity of partners to conduct research for sustainable intensification and diversification of rice wheat systems and make RCT information available to users				
Annual Output Targets 2007-2009	• Spatial knowledge database for bio physical and socio economic indicators created. • GIS, remote sensing techniques and socioeconomic techniques for targeting the RCTs in different rice eco-systems in IGP tested. • Web-based weed database to identify and control weeds extended		Knowledge shared among stakeholders. Information disseminated through publications, training materials, website, Radio, TV and press. RCT farmers and manufacturers directory created on the web for on-line surveys, interviews for impact assessment	Line departments in NARSs base their local developmental plans on the new RCTs and begin to use techniques for enhancing productivity in risk prone areas

Annex

Progress Report on Implementation of Recommendations,

5th CIMMYT EPMR

Dates of EPMR Report Presentation and Discussion:	March 2005
Science Council:	April 2005
Executive Council:	May 2005
CGIAR Annual General Meeting:	December 2005

Status of Implementation of 5th EPMR recommendations.

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
1) The Panel recommends that management and programme directors undertake a much more rigorous process to define goals for the new strategy that provide a framework within which to organize projects and activities and against which progress in meeting the goals can be measured. In addition to strengthening the implementation of the new strategy, the process will enable the programme directors as a team to identify a set of goals that are congruent across the Center.	CIMMT agrees with the recommendation and plans to implement the required actions with immediate effect. The Center, in its *Seeds of Innovation* document, already has planned for such as set of goals and milestones to be developed during 2005 and for there to be a Center led review of the implementation by late 2006. *Seeds of Innovation* should be perceived as a vision document for the new strategy that is being implemented and will be complemented, as originally planned, by a supplemental plan document entitled *From vision to implementation*.	Recommendation to be addressed through development of business plan for the period 2006-2010 by January '06.	Business plan formally adopted, Jan '06.	N/A
2) The Panel recommends that CIMMYT develop a business strategic plan that will support the successful implementation of the new strategy in the face of a dynamic financial environment.	CIMMYT agrees with the recommendation and sees the value in a business style strategic plan document. As with recommendation 1, the Center will begin implementation of this recommendation with immediate effect. A business strategic plan that brings into full operation the *Seeds of Innovation* vision will clearly and explicitly state program goals, milestones, deliverables, focus and balance. The document will also show clear linkages between the setting of institutional and program goals, resource mobilization and program budgets.	Business plan for the period 2006-2010 developed and adopted by January '06.	Achieved.	N/A

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
3) To facilitate the establishment of a multidisciplinary approach to conducting ex ante impact studies, the Panel recommends that increased integration through time allocation be secured between ITA staff and non-social scientists in the other programmes.	CIMMYT agrees with the recommendation and notes that a multi-disciplinary approach to research, embracing bio-physical and social scientists, is emphasized in *Seeds of Innovation*.	Two workshops to be held: impacts framework (May '05); and targeting (August '06) Annual work plan meetings to specifically address this recommendation.	Fully implemented through workshops, thematic meetings and annual work plan meeting; the latter held in Jan '06.	N/A
4) The Panel recommends that ITA, in cooperation with the eco-regional programmes, collect data on the variables that explain the heterogeneity of the existing production functions and thus, of yields (both potential and actual) that express differences attributable to productivity gaps within the same agroecological region, due to constraints that limit the adoption of improved technology.	CIMMYT agrees with the recommendation and considers this approach to be part of a planned wider research effort to assemble and analyse information on factors determining pathways for technology adoption, livelihood impacts and poverty reduction in major maize- and wheat-based farming systems of developing countries.	Spatial meta knowledge of impact pathways to be developed for 2 macro-systems: i) mixed maize farming systems in sub-Saharan Africa; and ii) rice-wheat farming systems across Pakistan and Bangladesh.	In progress for 2006 work plan	Dec '06
5) The Panel recommends that ITA initiate macroeconomic studies by 2006 in close cooperation with IFPRI and other CGIAR Centers. The highest priority should be assigned to sub-Saharan African countries.	CIMMYT agrees with the recommendation insofar as it refers to analyzing sectoral and rural development policy determinants of maize- and wheat-based farming systems improvement and to identify and advocate appropriate policy and institutional responses.	Discussions and meetings to be held with IFPRI during '05 (May-June)	Meetings held, and very productive dialogue on-going. Continuing cooperation a part of the '06 work plan including finalization of joint book *Maize policies in Asia* and joint work to monitor macro-economic indicators, identify pathways, and foster agricultural policy dialogue on maize in east and southern Africa.	N/A

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
6) The panel recommends that maize research in CIMMYT identify the high priority Marginal Maize Production Areas (MMPAs) in each mega-environment. Based on such MMPAs, a seed delivery system for improved cultivars should be developed jointly with partners as a vehicle to make CIMMYT's upstream maize research results available to resource-poor farmers.	CIMMYT accepts the recommendation to focus on low-yielding areas caused by abiotic, biotic and socioeconomic constraints. CIMMYT has a comparative advantage in the development of germplasm for low to very low yielding environments to which much of our germplasm development efforts in sub-Saharan Africa have been directed. We agree that seed delivery systems require further development and, towards this aim, CIMMYT has recently hired a seed systems specialist for our Africa Livelihoods Program.	MMPAs verified during '05 Recruit maize molecular breeder to focus on low yielding environments with emphasis on the following traits: quality; and, host plant resistance using non-transgenic approaches.	Achieved Maize molecular breeder recruited, Feb '06.	N/A N/A
7) The Panel recommends that maize breeding and research efforts in the following areas be intensified:				
a) *Grain quality characteristics of high priority to end users in MMPAs, combined with more systematic research and breeding to reduce mycotoxin contamination on the grain;*	CIMMYT agrees with this recommendation however notes the need for additional, sustainable resources to ensure that new initiatives have a medium to longer term outlook. In the meantime, CIMMYT will explore opportunities for collaborative work in this area with IITA.	Discussions and joint project proposals with IITA initiated by June '06. Joint project on mycotoxins to be funded by Dec '07.	Joint project proposals under development; additional funding sources yet to be identified.	Dec '07.

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
b) *Testing and evaluation of breeding materials directly in the MMPAs, for identification of the best material for release;*	CIMMYT notes this recommendation and observes that it is routine procedure for experimental materials to be tested in their target environments. CIMMYT has made very significant progress in MMPAs using farmer-participatory "Mother-baby" trials (> 1M ha in southern Africa sown with improved maize using this approach) and acknowledges the recommendation as being a strong endorsement of this approach.	A routine and on-going aspect of our work.	N/A	
c) *Non-transgenic host plant insect resistance research to speed up the process of integration of the highly resistant CIMMYT germplasm into new cultivars;*	CIMMYT notes this recommendation. CIMMYT has invested in host plant resistance work for at least 30 years and considerable progress has been made however increasingly transgenic approaches to insect resistance are providing significant gains. We will continue to work on an integrated pest management strategy that is reflected in a number of on-going projects.	N/A		

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
d) *Application of fast track breeding techniques (doubled haploid, MAS, NIR techniques) in all maize breeding activities in CIMMYT;*	CIMMYT partially agrees with this recommendation as the value of these technologies should be assessed on a case-by-case basis. CIMMYT has routinely been using MAS for traits where MAS is more cost-effective than field-based techniques. Recently, CIMMYT has commenced the use of NIR for assessing stover quality in maize and we expect to expand this work. The use of double haploids in maize is a relatively new technique and its utility for marginal and low input environments is yet to be proven. As for our response to 8a) CIMMYT notes the need for additional resources of a medium to longer term nature to implement areas of research of strategic importance.	MAS to be adopted when several traits may be selected at once and double haploids and NIR to be implemented if and when additional resources may be found. Capacity to be developed in partnership with ARI' during the period July'06-June '07.	A maize molecular breeding position has been filled; the incumbent commenced April '06.	Further review in June '07.
e) *Acquisition, storage and management of maize breeding data to eliminate the current back-log.*	CIMMYT agrees with this recommendation and notes that decisions have already been made to allocate more resources to the acquisition, storage and management of maize breeding data within CIMMYT during the next two years.	Additional funds to be allocated in the '05 budget	165K of additional funding allocated for '05. Further efforts underway through the joint program (CRIL) with IRRI.	Dec '06

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
8) The Panel recommends that:				
a) Crop management research in (the) TES (Program) in the regions be strengthened by allocating NRM (Crop and Resource Management) staff time from other programmes, particularly IAP, to TES;	CIMMYT agrees with the recommendation and notes that there are at least two avenues to be pursued: a) additional financial resources are needed for the TES Program; and b) increasing the overall staffing and cross program assignments of Crop and Resource Management scientists generally.	Reallocation and/or additional staff time as and when extra resources become available.	Additional resources not yet available.	Further review by Dec '06
b) CIMMYT, TES in particular, seek collaboration with other CGIAR Centers in the region, including shared appointments of agronomists and other natural resources specialists;	CIMMYT agrees in principle with the recommendation. We will follow up on some initial discussions that have already been held with three other Centers and also on emerging collaboration among Centers within the Water and Food Challenge Program.	Development of at least one joint program by June '06.	The IRRI-CIMMYT alliance program on intensive cropping systems for Asia has developed a work plan and is in the process of recruiting a program leader.	Program leader appointed by Dec '06
c) The Crop and Resource Management Group, TES and other eco-regional programmes enhance strategic research on natural resource management, particularly for improved water and nutrient use efficiency.	CIMMYT agrees with the recommendation. Already there is an increased emphasis on more strategic research through two recent appointments and we plan to enhance this approach in future projects.	Recruitment of additional staff by June '05	Achieved	N/A

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
9) The Panel recommends that the IAP breeding teams work closely with crop management and social science groups to develop cultivars that are suitable for conservation agriculture, use water efficiently and are resistant to storage losses.	CIMMYT notes the recommendation and observes that activities in the RWC have embraced genotype by management (conservation agriculture) interactions for some time. The plant breeding programs in both maize and wheat, in recent years, have aimed at the development of germplasm with an emphasis on input use efficiency (water) and resistance to storage losses (maize) and the development of materials suited to conservation agriculture. The breeding programs in Mexico run a parallel selection program under conservation agriculture and conventional conditions.	N/A		
10) The Panel recommends that IAP undertake long term experiments to evaluate cropping system sustainability with the results being fully utilized for strategic research as well as for demonstration purposes.	CIMMYT agrees with the recommendation insofar as it relates to long-term trials conducted on CIMMYT's experimental stations in Mexico and notes that trials over the past 10 years in Mexico have provided an excellent platform for strategic research and demonstration. In regional locations, CIMMYT collaborates with research partners to effectively design, manage and utilise long-term crop management trials.	N/A		
11) The Panel recommends that IAP increase its research in maize cropping systems and their development.	CIMMYT agrees with the recommendation and we expect to focus attention on the maize producing regions of Asia where demand is increasing at the fastest rate.	Increased research activity in this area by June '06	The IRRI-CIMMYT alliance program on intensive cropping systems for Asia has developed a work plan and is recruiting a program leader.	Program leader appointed by Dec '06
12) The Panel recommends that the data acquisition, data management and gene bank user interface be upgraded in the CIMMYT gene bank for both wheat and maize as a matter of urgency.	CIMMYT agrees with the recommendation and notes that significant steps are already underway through several different system-wide initiatives to develop a range of integrated modules to fully computerise data acquisition, genebank management, germplasm evaluation and database query across both crops.	Allocation of additional funding to the genebank in '05 and attendant work plan	CRISCO work plan implemented in '05; IRRI-CIMMYT joint program for research informatics established with a program leader (G McLaren, IRRI).	Dec '06

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
13) *The Panel recommends that:*				
a) Training coordinator position be relocated to an independent Unit reporting directly to the DDG-R;	CIMMYT notes the recommendation. As set forth in the CIMMYT strategy, training and capacity building activities are an integral part of the knowledge management and sharing activities of the ITA Program. These activities are closely related to broader ITA thrusts on the orientation of CIMMYT and its partners to livelihoods and poverty reduction; support to the use of best practices; priority setting and impact assessment; and, advocacy of effective policies to foster impact on the ground.	CIMMYT has retained the training coordinator within the ITA unit for a number of strategic reasons.	N/A	
b) The Training Unit working together with programme directors develop a priority setting tool, both thematic and geographical. The resulting priorities should then be used to allocate resource to the programmes;	CIMMYT agrees in principle with the recommendation for training purposes and will implement a priority setting tool as part of the enrichment of the Resource Allocation Tool developed during strategic planning, noting that priorities for capacity building need to be determined within and across programs.	Development of capacity building strategy during '05. Targeting workshop for CIMMYT researchers to be held August '05 to develop mechanisms for priority setting and targeting of training.	Capacity building strategy developed and workshop held.	N/A
c) CIMMYT develop innovative alternative funding schemes for training	CIMMYT agrees in principle with the recommendation and is actively exploring a variety of options internally and with external stakeholders, including private sector support. Fellowship programs, both internally and externally funded, will be implemented to facilitate capacity building.	Alternate funding mechanisms to be actively pursued in 2005; further review of funding of training by Dec '06.	Some funding support from the private sector for training has been provided.	Dec '06
14) To help ensure that CIMMYT builds and sustains high functioning Boards, the Panel recommends the establishment of a governance committee with responsibility for a range of activities essential to Board effectiveness, including defining more clearly the role of the board, developing a more strategic process for identifying and recruiting	The Board is committed to fulfilling its role to the highest possible standards, and will reduce its size to no more than seven appointed members, while maintaining the appropriate mix of skills, and will enhance the roles of the Audit and Finance and Administration Committees as agents of the Board. Rather than create a separate governance committee, CIMMYT will engage	New governance model (policies and procedures) for the CIMMYT Board to be in place by March '06	CIMMYT Board workshop on governance held, March '05; Schedule for the reduction of Board size (currently 8 appointed members) implemented; Executive Committee of the Board established	March '07

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
board members, assessing board performance on a formal basis, evaluating the performance of members before re-election, recommending improvements to board practice, such as meeting design and preparation, information flow and communication, and developing an orientation and ongoing education program for members to enhance their performance	a specialist consultant to help the Board and its committees clarify their roles and put in place a more strategic process for identifying and recruiting Board members, assessing Board performance and evaluating the performance of members before re-election. The consultant will advise on designing and preparing meetings, information flow, and communications, and will work with the Board to develop an orientation and ongoing education program for trustees. Finally, the consultant will review (annually at first) the Board's effectiveness. In the future, the Board as a whole will explicitly address governance functions, in lieu of a committee.		and functioning; Audit and Finance and Administration Committee functions separated; formal Board self-assessment procedures implemented; improved practices for meetings and out-of-session handling of business matters implemented.	
15) The Panel recommends that a dedicated staff person in the DG's office be identified to serve as the Board Secretary. This position should have sufficient status within the organization, clear responsibility and also adequate time to provide support and coordination for the board.	CIMMYT agrees with the recommendation and has already (effective March 2005) implemented this recommendation.	N/A		

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
16) The Panel recommends that management review the staff survey results in detail with special attention to staff morale, communication of policies, clarity of goals, performance recognition, and staff evaluation, and take appropriate corrective action as a matter of urgency.	CIMMYT agrees with the recommendation. Clearly, CIMMYT is in a period of transition and it is inevitable that staff morale has been affected over the past 2 years and with the staff downsizings. CIMMYT will work extremely hard to ensure that all staff have clarity on the future and an important aspect of this will be a new One Staff policy that is already agreed in principle by the Board. Consistent with recommendations 1) and 2) we fully expect that communication of roles and responsibilities to staff, with attendant policies and procedures, will greatly assist staff function and morale.	Staff morale "indicator" improved as of June '06; staff work plans clearly communicated by Jan '05; revised HR policy (OneStaff) implemented by Dec '06.	With the development of the business plan for CIMMYT, all staff have a clear sense of direction of the Center. The launch of the plan in January '06 during a very successful 'science week' and attendant research planning meetings has added further coherence to our agenda including the role of staff as we move forward. All staff appraisals in Jan-Feb '05 included plans of work for '05; similarly for '06, with an emphasis on merit-based recognition (salary increases) of performance. Range of institutional improvements implemented to assist in development of the social health of the Center, including clarification of some key personnel policies; improved communication (open fora, monthly meetings with staff committees, weekly newsletter). The centre's improved financial health and overall performance ("A" for World Bank 2005 indicators) have helped improve staff morale.	Dec '07

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
17) The Panel recommends that management give priority to reforming financial management at the Center, including budget, staffing and related systems, with highest priority given to the development of a computerized financial management system that provides real on-time financial information to users; and urgently develop (in consultation with programme staff) a transparent resource allocation process consistent with needs of the matrix management system.	CIMMYT agrees with the recommendation. We have already commenced the implementation of the following systems which are the initial building blocks for the development of a more comprehensive financial management system: • An integrated human resource information system (HRIS); the first phase of this project will be implemented by the end of March '05 and the complete staff database will be finalized by the end of June '05. • CIAT's project manager application. We plan to have an effective project management system in place during the 3rd quarter of '05. The issues surrounding the development and implementation of a completely new financial management information system are being currently reviewed and we are evaluating options of moving to a shared service with another CGIAR Center as a first priority.	Integrated human resources information system functional by June '05 Project Manager system implemented by Dec '05 New financial management information system in place by June '06	A complete staff database (IRS, NRS) has been finalized as of June '05 Project Manager system not implemented; instead, Axapta, a Microsoft product which has project management capabilities is being implemented and will be tested during June '06 with the aim for it to become the basis of our financial system in the second half of '06.	Dec '06

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
18) The Panel recommends that management carefully examine the correctness of the net assets (equity) balance for 2004 attributable to the increase in 2003 (of approximately US$ 2.0 million) from fixed assets write-off and revaluation.	CIMMYT notes the recommendation and has reviewed it with our external auditors who have confirmed that while the detail that was presented in the 2003 financial statements was less than clear, the treatment is correct. The disclosure issue has been clarified in the 2004 financial statements and the relative balances of CIMMYT's net asset categories are correctly stated.	N/A		
19) The Panel recommends that the Board and management develop a set of financial indicators for measuring the Center financial performance and health. The indicators should supplement those developed by the CGIAR System in close consultation with CGIAR Secretariat and Center Finance Directors.	CIMMYT agrees with the recommendation. We have discussed and agreed upon a set of financial indicators at the March '05 Board meeting. These indicators are based on those developed by the CGIAR.	N/A		
20) The Panel recommends that a full cost recovery/pricing system for support services be implemented to recover the full costs from projects and users of services. This will reduce the pressure on unrestricted funding and make it available for other high priority activities at the Center, including building the working capital to the required level.	CIMMYT agrees with the recommendation and has already implemented changes within the '05 budget that will lead to full cost recovery from projects and users of services. It is expected that through a combination of restructuring of our internal costing practices and improved project costing when submitting proposals to donors, we will be able to substantially improve our performance in this area.	Implementation of project costing template by Jan '06 Full recovery of indirect costs by Jan '09, as scheduled in the business plan with an intermediate target of 50% recovery by Jan '07	Achieved 52% of total indirect costs were recovered in '05. The main focus to date has been on attribution of depreciation costs and charging out ICT costs. For '06, all field station costs in Mexico have been fully apportioned to users of the facilities.	Dec '08

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
21) The Panel recommends that Board and management:				
a) *Make substantial efforts and allocate adequate time for the careful review of the external audit (at headquarters and regional operations), management letters and the audited financial statements with the notes;*	CIMMYT agrees that the external audit function is crucial to the fiduciary oversight of the Center by the Board and asserts that its Audit Committee takes its roles in relation to the External Auditors seriously. The CIMMYT Board Audit Committee and full Board will continue to commit substantial time and effort for the careful review of external audit reports for headquarters and regional offices. The Committee annually receives audit plans, and will review the external audit scope to reflect management's and the Board's assessment of risks, taking into account the changing nature of the Center's programs at headquarters and in the regions. The Audit Committee will develop and implement a formal plan for assessment of the External Auditors prior to renewal or selection of new auditors.	BOT Audit Committee to develop an agenda for audit at CIMMYT including the development of an MTP, by Nov '05 BOT Audit Committee to use CGIAR best practice in the (re)appointment of external auditors, commencing March '06	Achieved- Internal audit MTP 2006-08 approved by the BOT. Achieved.	N/A
b) *Carefully review the annual audit plans and scope of external audit for headquarters and regional operations;*				
c) *Formally assess annually the performance of the external auditors before deciding on their re-appointment.*				

Recommendation	Center response	Implementation		
		Milestones	Progress achieved	Target date for completion
22) The Panel recommends that Board and management review the scope of internal audit work and the capabilities of the senior internal auditor and make the required changes to strengthen this important function.	The CIMMYT Board and Management agree that CIMMYT must have a strong internal audit function. The scope and capabilities of the internal audit function will continue to be under review and all necessary and appropriate actions will be taken.	Review of internal auditor in '05	In addition to the development of an internal audit MTP, CIMMYT has been actively involved in the recruitment and placement of the CGIAR IAU Associate Director for the Americas who is now based at CIMMYT with approx. 25% of his time dedicated to CIMMYT-specific audit issues.	N/A

Budget Tables

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Table 2. CIMMYT-cost allocation: allocation of project costs to CGIAR system priorities, 2005-2009 (US $ million).

Project	System Priorities	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Project 1 - Conservation, characterization and targeted access to maize and wheat related diversity					
	Priority 1A	1.885	1.915	1.973	2.032
	Priority 2A	1.179	1.198	1.234	1.271
	Priority 2B	1.179	1.198	1.234	1.271
	Priority 2C	0.471	0.479	0.493	0.508
	TOTAL BY PROJECT	4.714	4.790	4.934	5.082
Project 2 - Germplasm enhancement tools and methodologies					
	Priority 2A	0.730	0.909	0.937	0.965
	Priority 2B	1.217	1.516	1.561	1.608
	Priority 2C	0.487	0.606	0.624	0.643
	TOTAL BY PROJECT	2.434	3.031	3.122	3.216
Project 3 - Stress tolerant maize					
	Priority 2B	3.126	4.096	4.219	4.345
	TOTAL BY PROJECT	3.126	4.096	4.219	4.345
Project 4 - Maize - nutrition and speciality traits					
	Priority 1A	0.487	0.406	0.418	0.431
	Priority 2C	1.706	1.421	1.464	1.508
	Priority 3A	0.244	0.203	0.209	0.215
	TOTAL BY PROJECT	2.437	2.030	2.091	2.154
Project 5 - African livelihoods					
	Priority 4D	0.811	1.208	1.244	1.281
	Development Activities	0.811	1.208	1.244	1.281
	Stand-alone Training	0.811	1.208	1.244	1.281
	Priority 2B	0.810	1.208	1.244	1.282
	Priority 2C	0.810	1.207	1.244	1.282
	TOTAL BY PROJECT	4.053	6.039	6.220	6.407
Project 6 - Maize for Asia and Latin America					
	Priority 4D	0.922	0.889	0.916	0.943
	Priority 2A	1.382	1.333	1.373	1.414
	TOTAL BY PROJECT	2.304	2.222	2.289	2.357
Project 7 - Wheat with enhanced water productivity					
	Priority 1A	0.439	0.381	0.393	0.404
	Priority 2A	0.877	0.762	0.785	0.809
	Priority 2B	2.631	2.287	2.354	2.426
	Priority 2C	0.439	0.381	0.393	0.404
	TOTAL BY PROJECT	4.386	3.811	3.925	4.043
Project 8 - Wheat with durable disease resistance					
	Priority 1A	0.381	0.331	0.341	0.351
	Development Activities	0.381	0.331	0.341	0.351
	Priority 2A	0.761	0.661	0.681	0.702
	Priority 2B	1.903	1.653	1.702	1.753
	Priority 2C	0.381	0.331	0.341	0.351
	TOTAL BY PROJECT	3.807	3.307	3.406	3.508
Project 9 - Biofortified wheat					
	Priority 1A	0.422	0.416	0.428	0.441
	Development Activities	0.211	0.208	0.214	0.221
	Priority 2A	0.211	0.208	0.214	0.221
	Priority 2B	0.211	0.208	0.214	0.221
	Priority 2C	1.054	1.040	1.072	1.103
	TOTAL BY PROJECT	2.109	2.080	2.142	2.207

Table 2. (Cont'd)

Project	System Priorities	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Project 10 - Conservation agriculture					
	Priority 4D	0.402	0.338	0.348	0.358
	Development Activities	2.816	2.364	2.435	2.509
	Priority 2A	0.805	0.676	0.696	0.717
	TOTAL BY PROJECT	4.023	3.378	3.479	3.584
Project 11 - Knowledge, targeting, and strategic assessment					
	Priority 5A	0.846	1.186	1.221	1.258
	Priority 5B	0.422	0.592	0.610	0.628
	Priority 5C	0.211	0.296	0.305	0.314
	Development Activities	0.211	0.296	0.305	0.314
	Stand-alone Training	0.422	0.592	0.610	0.628
	TOTAL BY PROJECT	2.112	2.962	3.051	3.142
	TOTAL BY CENTER	35.505	37.746	38.878	40.045
SUMMARY OF TABLE 2					
Priority 1A		3.614	3.449	3.553	3.659
Priority 2A		5.945	5.747	5.920	6.099
Priority 2B		11.077	12.166	12.528	12.906
Priority 2C		5.348	5.465	5.631	5.799
Priority 3A		0.244	0.203	0.209	0.215
Priority 4D		2.135	2.435	2.508	2.582
Priority 5A		0.846	1.186	1.221	1.258
Priority 5B		0.422	0.592	0.610	0.628
Priority 5C		0.211	0.296	0.305	0.314
Development Activities		4.430	4.407	4.539	4.676
Stand-alone Training		1.233	1.800	1.854	1.909
TOTAL		35.505	37.746	38.878	40.045

Table 3. CIMMYT-undertakings, activities and sectors, 2005-2009 (US $ million).

ndertakings, activities, and sectors	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Increasing Productivity				
Germplasm Enhancement & Breeding	14.202	15.099	15.550	16.018
Production Systems Development & Management				
Cropping systems	7.101	7.549	7.776	8.009
Livestock systems	0.000	0.000	0.000	0.000
Tree systems	0.000	0.000	0.000	0.000
Fish systems	0.000	0.000	0.000	0.000
Protecting the Environment	1.775	1.887	1.944	2.002
Saving Biodiversity	1.775	1.887	1.944	2.002
Improving Policies	1.775	1.887	1.944	2.002
Strengthening NARS				
Training and Professional Development	3.551	3.775	3.888	4.005
Documentation, Publications, Info. Dissemination	1.775	1.887	1.944	2.002
Organization & Management Counseling	0.000	0.000	0.000	0.000
Networks	3.551	3.775	3.888	4.005
TOTAL BY CENTER	35.505	37.746	38.878	40.045

Table 4. CIMMYT-cost allocation: allocation of project costs to CGIAR regions, 2005-2009 (US $ million).

Project	Regions	2005 (actual)	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Project 1 - Conservation, characterization and targeted access to maize and wheat related diversity.						
	SSA	0.968	0.943	0.958	0.987	1.016
	Asia	0.968	0.943	0.958	0.987	1.016
	LAC	1.452	1.414	1.437	1.480	1.525
	CWANA	1.453	1.414	1.437	1.480	1.525
	TOTAL BY PROJECT	4.841	4.714	4.790	4.934	5.082
Project 2 - Germplasm enhancement tools and methodologies						
	SSA	0.413	0.609	0.758	0.781	0.804
	Asia	0.413	0.609	0.758	0.781	0.804
	LAC	0.412	0.608	0.758	0.780	0.804
	CWANA	0.412	0.608	0.757	0.780	0.804
	TOTAL BY PROJECT	1.650	2.434	3.031	3.122	3.216
Project 3 - Stress tolerant maize						
	SSA	2.681	1.876	2.458	2.531	2.607
	Asia	0.894	0.625	0.819	0.844	0.869
	LAC	0.894	0.625	0.819	0.844	0.869
	CWANA	0.000	0.000	0.000	0.000	0.000
	TOTAL BY PROJECT	4.469	3.126	4.096	4.219	4.345
Project 4 - Maize - nutrition and speciality traits						
	SSA	1.511	0.975	0.812	0.837	0.862
	Asia	1.133	0.731	0.609	0.627	0.646
	LAC	0.755	0.487	0.406	0.418	0.431
	CWANA	0.378	0.244	0.203	0.209	0.215
	TOTAL BY PROJECT	3.777	2.437	2.030	2.091	2.154
Project 5 - African livelihoods						
	SSA	3.326	4.053	6.039	6.220	6.407
	TOTAL BY PROJECT	3.326	4.053	6.039	6.220	6.407
Project 6 - Maize for Asia and Latin America						
	Asia	1.349	1.152	1.111	1.144	1.178
	LAC	1.349	1.152	1.111	1.145	1.179
	TOTAL BY PROJECT	2.698	2.304	2.222	2.289	2.357
Project 7 - Wheat with enhanced water productivity						
	SSA	0.570	0.439	0.381	0.393	0.404
	Asia	2.280	1.754	1.524	1.570	1.617
	LAC	0.570	0.439	0.381	0.393	0.404
	CWANA	2.281	1.754	1.525	1.569	1.618
	TOTAL BY PROJECT	5.701	4.386	3.811	3.925	4.043
Project 8 - Wheat with durable disease resistance						
	SSA	0.393	0.381	0.331	0.341	0.351
	Asia	1.965	1.904	1.654	1.703	1.753
	LAC	0.786	0.761	0.661	0.681	0.702
	CWANA	0.786	0.761	0.661	0.681	0.702
	TOTAL BY PROJECT	3.930	3.807	3.307	3.406	3.508
Project 9 - Biofortified wheat						
	SSA	0.000	0.000	0.000	0.000	0.000
	Asia	0.655	1.054	1.040	1.071	1.103
	LAC	0.131	0.211	0.208	0.214	0.221
	CWANA	0.523	0.844	0.832	0.857	0.883
	TOTAL BY PROJECT	1.309	2.109	2.080	2.142	2.207

Table 4. (Cont'd)

Project	Regions	2005 (actual)	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Project 10 - Conservation agriculture						
	SSA	1.157	1.207	1.013	1.044	1.075
	Asia	1.157	1.207	1.013	1.044	1.075
	LAC	0.384	0.402	0.339	0.347	0.359
	CWANA	1.157	1.207	1.013	1.044	1.075
	TOTAL BY PROJECT	3.855	4.023	3.378	3.479	3.584
Project 11 - Knowledge, targeting and strategic assessment						
	SSA	0.499	0.528	0.741	0.763	0.786
	Asia	0.499	0.528	0.741	0.763	0.786
	LAC	0.498	0.528	0.740	0.763	0.785
	CWANA	0.498	0.528	0.740	0.762	0.785
	TOTAL BY PROJECT	1.994	2.112	2.962	3.051	3.142
	TOTAL BY CENTER	37.550	35.505	37.746	38.878	40.045
SUMMARY OF TABLE 4 BY REGION						
SSA		11.518	11.011	13.491	13.897	14.312
Asia		11.313	10.507	10.227	10.534	10.847
LAC		7.231	6.627	6.860	7.065	7.279
CWANA		7.488	7.360	7.168	7.382	7.607
TOTAL		37.550	35.505	37.746	38.878	40.045

Table 5. CIMMYT-expenditures, 2005-2009, object of expenditure (US $ million).

Object of expenditures	2005 (actual)	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Personnel	15.623	16.449	17.200	17.710	18.250
Supplies and services	12.091	11.056	11.786	12.158	12.525
Collaboration/ Partnerships	6.176	5.000	5.600	5.760	5.930
Operational Travel	1.907	1.600	1.760	1.810	1.860
Depreciation	1.753	1.400	1.400	1.440	1.480
TOTAL BY CENTER	37.550	35.505	37.746	38.878	40.045

Table 6. CIMMYT-financing, 2005-2007 (US $ million).

Members/Non-members	2005 (actual)	2006 (estimated)	2007 (proposal)
Unrestricted Grants			
MEMBERS			
Australia	0.506	0.567	0.567
Canada	0.946	0.932	0.932
China	0.130	0.130	0.130
Denmark	0.438	0.438	0.438
France	0.143	0.140	0.140
Germany	0.162	0.146	0.146
India	0.113	0.300	0.300
Japan	1.297	1.176	1.176
Korea, Republic of	0.050	0.050	0.050
Mexico	0.025	0.025	0.025
Netherlands	0.842	0.500	0.500
New Zealand	0.252	0.176	0.176
Norway	0.303	0.290	0.290
Philippines	0.007	0.007	0.007
Sweden	0.345	0.299	0.299
Switzerland	0.491	0.455	0.455
Thailand	0.011	0.011	0.011
United Kingdom	1.541	1.565	1.565
United States	3.956	3.441	3.441
World Bank	1.750	2.000	2.000
TOTAL MEMBERS	13.308	12.648	12.648
NON-MEMBERS			
TOTAL BY CENTER	13.308	12.648	12.648
Restricted Contributions for 2006 and 2007			
MEMBERS			
ADB		0.361	0.360
Australia		0.920	0.746
Austria		0.001	0.000
Belgium		0.009	0.000
Canada		0.790	0.780
Denmark		0.143	0.120
European Commission		1.806	1.798
FAO		0.054	0.000
Germany		0.952	0.632
IFAD		0.628	0.660
India		0.280	0.280
Iran		0.154	0.155
Japan		0.962	0.942
Korea, Republic of		0.023	0.025
Mexico		0.451	0.455
Netherlands		0.009	0.000
OPEC Fund		0.054	0.000
Peru		0.032	0.000
Rockefeller Foundation		2.013	1.966

Table 6. (Cont'd)

Members/Non-members	2006 (estimated)	2007 (proposal)
South Africa	0.035	0.035
Spain	0.415	0.400
Sweden	0.011	0.050
Switzerland	0.957	0.913
Turkey	0.027	0.050
United Kingdom	0.301	0.113
United States	2.100	1.210
World Bank	0.117	0.000
SUBTOTAL	13.605	11.690
NON-MEMBERS		
Agrovegetal	0.107	0.000
BASF, Germany	0.155	0.155
Bolivia	0.015	0.015
CIAT	0.006	0.010
CONACYT, Mexico	0.085	0.085
Cornell University	0.072	0.070
CRC for Molecular Plant Breeding, Australia	0.052	0.050
FENALCE	0.135	0.150
Fundacion Guanajuato Produce A.C.	0.055	0.065
Generation/CP	1.615	1.617
Global Diversity Fund	0.090	0.200
GRDC	0.843	0.735
HarvestPlus/CP	1.108	1.088
ICAMEX	0.027	0.030
ICARDA	0.067	0.070
ICRISAT	0.080	0.080
ILRI	0.202	0.200
IPGRI	0.005	0.000
IWMI	0.007	0.010
Kazakhstan	0.070	0.070
Nippon Foundation	0.656	0.300
Others	0.348	0.355
Patronata Sonora	0.007	0.010
Pioneer	0.040	0.050
Sehgal Family Foundation	0.100	0.100
Societa Produttori, Italy	0.069	0.070
Stanford University	0.007	0.010
Unidentified	1.309	6.860
US Dept of Agriculture	0.318	0.100
Washington State University	0.053	0.120
Water & Food/CP	0.510	0.500
SUBTOTAL	8.213	13.175
SUBTOTAL-RESTRICTED	21.818	24.865
TOTAL ALL DONORS	34.466	37.513

Table 7. CIMMYT-Financing: Allocation of Members/Non Members Grants to Projects, 2005-2007 (US $ million).

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 1 - Conservation, characterization and targeted access to maize and wheat related biodiversity	MEMBERS		
	European Commission	0.597	0.597
	Japan	0.239	0.239
	United States	0.040	0.050
	World Bank	0.117	0.000
	TOTAL MEMBERS	0.993	0.886
	NON-MEMBERS		
	Generation/CP	1.038	1.038
	Global Diversity Fund	0.090	0.200
	Others	0.220	0.220
	Unidentified	0.300	0.300
	TOTAL NON-MEMBERS	1.648	1.758
	TOTAL MEMBERS + NON-MEMBERS	2.641	2.644
	Unrestricted + center inc	2.073	2.146
	TOTAL BY PROJECT	4.714	4.790
Project 2 - Germplasm enhancement tools and methodologies	MEMBERS		
	Australia	0.119	0.120
	Germany	0.000	0.021
	Korea, Republic of	0.023	0.025
	Rockefeller Foundation	0.419	0.419
	United States	0.189	0.015
	TOTAL MEMBERS	0.750	0.600
	NON-MEMBERS		
	CRC for Molecular Plant Breeding, Australia	0.052	0.050
	Generation/CP	0.399	0.399
	GRDC	0.099	0.100
	Unidentified	0.550	1.300
	TOTAL NON-MEMBERS	1.100	1.849
	TOTAL MEMBERS + NON-MEMBERS	1.850	2.449
	Unrestricted + center inc	0.584	0.582
	TOTAL BY PROJECT	2.434	3.031

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 3 - Stress tolerant maize	MEMBERS		
	ADB	0.351	0.350
	Germany	0.022	0.000
	IFAD	0.398	0.400
	India	0.080	0.080
	Rockefeller Foundation	0.755	0.751
	Switzerland	0.313	0.313
	United States	0.050	0.050
	TOTAL MEMBERS	1.969	1.944
	NON-MEMBERS		
	BASF, Germany	0.155	0.155
	FENALCE	0.036	0.050
	Pioneer	0.040	0.050
	Unidentified	0.000	1.000
	TOTAL NON-MEMBERS	0.231	1.255
	TOTAL MEMBERS + NON-MEMBERS	2.200	3.199
	Unrestricted + center inc	0.926	0.897
	TOTAL BY PROJECT	3.126	4.096
Project 4 - Maize - nutrition and speciality traits	MEMBERS		
	Austria	0.001	0.000
	Canada	0.774	0.770
	Germany	0.277	0.280
	OPEC Fund	0.054	0.000
	TOTAL MEMBERS	1.106	1.050
	NON-MEMBERS		
	HarvestPlus/CP	0.443	0.450
	Nippon Foundation	0.358	0.000
	Others	0.000	0.000
	Unidentified	0.000	0.000
	TOTAL NON-MEMBERS	0.801	0.450
	TOTAL MEMBERS + NON-MEMBERS	1.907	1.500
	Unrestricted + center inc	0.530	0.530
	TOTAL BY PROJECT	2.437	2.030

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 5 - African livelihoods	MEMBERS		
	Canada	0.009	0.000
	European Commission	0.226	0.220
	Germany	0.642	0.321
	Rockefeller Foundation	0.796	0.796
	United Kingdom	0.083	0.083
	United States	0.180	0.040
	TOTAL MEMBERS	1.936	1.460
	NON-MEMBERS		
	ICRISAT	0.080	0.080
	Unidentified	0.750	3.250
	TOTAL NON-MEMBERS	0.830	3.330
	TOTAL MEMBERS + NON-MEMBERS	2.766	4.790
	Unrestricted + center inc	1.287	1.249
	TOTAL BY PROJECT	4.053	6.039
Project 6 - Maize for Asia and Latin America	MEMBERS		
	Mexico	0.097	0.095
	Peru	0.032	0.000
	Switzerland	0.644	0.600
	TOTAL MEMBERS	0.773	0.695
	NON-MEMBERS		
	Bolivia	0.015	0.015
	CONACYT, Mexico	0.052	0.055
	FENALCE	0.099	0.100
	Others	0.100	0.100
	TOTAL NON-MEMBERS	0.266	0.270
	TOTAL MEMBERS + NON-MEMBERS	1.039	0.965
	Unrestricted + center inc	1.265	1.257
	TOTAL BY PROJECT	2.304	2.222

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 7 - Wheat with enhanced water productivity	MEMBERS		
	Australia	0.589	0.441
	Canada	0.007	0.010
	European Commission	0.318	0.318
	South Africa	0.035	0.035
	Spain	0.002	0.000
	Turkey	0.027	0.050
	United States	0.071	0.090
	TOTAL MEMBERS	1.049	0.944
	NON-MEMBERS		
	Agrovegetal	0.107	0.000
	Fundacion Guanajuato Produce A.C.	0.025	0.030
	Generation/CP	0.178	0.180
	GRDC	0.305	0.335
	ICARDA	0.067	0.070
	Others	0.131	0.135
	Societa Produttori, Italy	0.069	0.070
	Unidentified	0.250	0.000
	US Dept of Agriculture	0.078	0.000
	Washington State University	0.053	0.120
	TOTAL NON-MEMBERS	1.263	0.940
	TOTAL MEMBERS + NON-MEMBERS	2.312	1.884
	Unrestricted + center inc	2.074	1.927
	TOTAL BY PROJECT	4.386	3.811
Project 8 - Wheat with durable disease resistance	MEMBERS		
	Australia	0.185	0.185
	Belgium	0.009	0.000
	European Commission	0.080	0.080
	India	0.200	0.200
	Iran	0.154	0.155
	Japan	0.723	0.703
	Mexico	0.071	0.070
	Sweden	0.011	0.050
	United Kingdom	0.218	0.030
	United States	0.092	0.080
	TOTAL MEMBERS	1.743	1.553

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 8 - Wheat with durable disease resistance			
	NON-MEMBERS		
	GRDC	0.439	0.300
	ICAMEX	0.007	0.010
	US Dept of Agriculture	0.239	0.100
	TOTAL NON-MEMBERS	0.685	0.410
	TOTAL MEMBERS + NON-MEMBERS	2.428	1.963
	Unrestricted + center inc	1.379	1.344
	TOTAL BY PROJECT	3.807	3.307
Project 9 - Biofortified wheat	MEMBERS		
	Denmark	0.118	0.120
	Mexico	0.283	0.290
	Spain	0.384	0.370
	TOTAL MEMBERS	0.785	0.780
	NON-MEMBERS		
	Fundacion Guanajuato Produce A.C.	0.030	0.035
	HarvestPlus/CP	0.638	0.608
	ICAMEX	0.008	0.010
	TOTAL NON-MEMBERS	0.676	0.653
	TOTAL MEMBERS + NON-MEMBERS	1.461	1.433
	Unrestricted + center inc	0.648	0.647
	TOTAL BY PROJECT	2.109	2.080

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 10 - Conservation agriculture	MEMBERS		
	ADB	0.010	0.010
	Australia	0.027	0.000
	European Commission	0.052	0.050
	Germany	0.011	0.010
	IFAD	0.206	0.200
	Spain	0.029	0.030
	United States	1.346	0.780
	TOTAL MEMBERS	1.681	1.080
	NON-MEMBERS		
	CONACYT, Mexico	0.033	0.030
	Cornell University	0.072	0.070
	ICAMEX	0.012	0.010
	ILRI	0.202	0.200
	Others	0.067	0.070
	Patronata Sonora	0.007	0.010
	Stanford University	0.007	0.010
	Unidentified	0.009	0.010
	US Dept of Agriculture	0.001	0.000
	Water & Food/CP	0.510	0.500
	TOTAL NON-MEMBERS	0.920	0.910
	TOTAL MEMBERS + NON-MEMBERS	2.601	1.990
	Unrestricted + center inc	1.422	1.388
	TOTAL BY PROJECT	4.023	3.378

Table 7. (Cont'd)

Project	Members/Non-members	2006 (estimated)	2007 (proposal)
Project 11 - Knowledge, targeting and strategic assessment	MEMBERS		
	Denmark	0.025	0.000
	European Commission	0.533	0.533
	FAO	0.054	0.000
	IFAD	0.024	0.060
	Netherlands	0.009	0.000
	Rockefeller Foundation	0.043	0.000
	United States	0.132	0.105
	TOTAL MEMBERS	0.820	0.698
	NON-MEMBERS		
	CIAT	0.006	0.010
	HarvestPlus/CP	0.027	0.030
	IPGRI	0.005	0.000
	IWMI	0.007	0.010
	Nippon Foundation	0.298	0.300
	Unidentified	0.000	1.000
	TOTAL NON-MEMBERS	0.343	1.350
	TOTAL MEMBERS + NON-MEMBERS	1.163	2.048
	Unrestricted + center inc	0.949	0.914
	TOTAL BY PROJECT	2.112	2.962
	TOTAL BY CENTER	35.505	37.746

Table 8. CIMMYT staff composition: internationally and nationally recruited staff, 2005 – 2009.

Staff type	2005 (actual)	2006 (estimated)	2007 (proposal)	2008 (plan 1)	2009 (plan 2)
Internationally-recruited staff (IRS)	87	88	87	87	86
Other staff	592	561	556	553	552
TOTAL BY CENTER	679	649	643	640	638

Table 9. CIMMYT-financial position: currency structure of expenditures, 2005-2007 (US $ million).

	2005 (actual)			2006 (estimated)			2007 (proposal)		
Currency	Amount	US$ value	% share	Amount	US$ value	% share	Amount	US$ value	% share
Euro (EUR)	0.000	1.000	2.430%	0.000	0.900	2.535%	0.000	1.000	2.649%
Indian Rupee (INR)	0.000	2.000	4.860%	0.000	2.000	5.633%	0.000	2.000	5.299%
Kenyan Shilling (KES)	0.000	2.000	4.860%	0.000	2.000	5.633%	0.000	2.000	5.299%
Mexican Peso (MXN)	0.000	9.200	24.302%	0.000	9.500	26.757%	0.000	9.800	25.963%
Others (Others)	0.000	1.000	2.430%	0.000	0.800	2.253%	0.000	0.900	2.384%
US Dollar (USD)	0.000	21.350	58.687%	0.000	19.405	54.654%	0.000	21.146	56.022%
Zimbabwe Dollar (ZWD)	0.000	1.000	2.430%	0.000	0.900	2.535%	0.000	0.900	2.384%
TOTAL BY CENTER		37.550	100%		35.505	100%		37.746	100%

Table 10. CIMMYT statement of activities for the year ended December 31, 2005 (US $ million).

	Unrestricted	Restricted		Total	Total
		Temporary	Challenge Programs	2005	2004
Revenue and Gains					
Grant Revenue	13.308	21.864	2.848	38.020	37.400
Other revenue and gains	1.531	0.000	0.000	1.531	1.320
Total revenue and gains	14.839	21.864	2.848	39.551	38.720
Expenses and Losses					
Program related expenses	8.666	22.783	2.848	34.297	31.965
Management and general expenses	6.253	0.245	0.000	6.498	7.271
Other losses expenses	0.354	0.000	0.000	0.354	0.862
Sub Total expenses and losses	15.273	23.028	2.848	41.149	40.098
Indirect cost recovery	-3.599	0.000	0.000	-3.599	-2.778
Total expenses and losses	11.674	23.028	2.848	37.550	37.320
Net Surplus / (Deficit) from ordinary activities	3.165	-1.164	0.000	2.001	1.400
Extraordinary Items	0.000	0.000	0.000	0.000	0.000
NET SURPLUS / (DEFICIT)	3.165	-1.164	0.000	2.001	1.400
Object of Expenditures					
Personnel	6.327	8.566	0.730	15.623	16.870
Supplies and services	2.609	8.240	1.242	12.091	13.531
Collaboration/ Partnerships	1.312	4.252	0.612	6.176	5.742
Operational Travel	0.699	1.045	0.163	1.907	1.858
Depreciation	0.727	0.925	0.101	1.753	2.097
TOTAL BY CENTER	11.674	23.028	2.848	37.550	40.098

Table 11. CIMMYT statement of financial position, December 31, 2005 (US $ million).

	2005	2004
A S S E T S		
Current Assets		
Cash and cash equivalents	13.052	14.119
Investments	0.000	0.000
Accounts receivable		
Donor	8.104	6.480
Employees	0.000	0.000
Other CGIAR Centers	0.000	0.000
Others	1.252	1.141
Inventories	0.374	0.109
Prepaid expenses	0.010	0.004
TOTAL CURRENT ASSETS	22.792	21.853
Non-Current Assets		
Property, Plant and Equipment	14.952	15.307
Investments	0.000	0.000
Other Assets	0.000	0.062
TOTAL NON-CURRENT ASSETS	14.952	15.369
TOTAL ASSETS	37.744	37.222
LIABILITIES AND NET ASSETS		
Current Liabilites		
Overdraft/Short term Borrowings	0.000	0.000
Accounts payable		
Donor	6.202	7.913
Employees	1.190	0.000
Other CGIAR Centers	0.000	0.000
Others	7.076	7.950
Accruals	0.572	0.608
TOTAL CURRENT LIABILITIES	15.040	16.471
Non-Current Liabilities		
Accounts payable		
Employees	0.535	0.583
Deferred Grant Revenue	0.000	0.000
Others	0.000	0.000
Total non-current liabilities	0.535	0.583
TOTAL LIABILITIES	15.575	17.054
Net Assets		
Unrestricted		
Designated	14.952	15.307
Undesignated	7.217	4.861
TOTAL UNRESTRICTED NET ASSETS	22.169	20.168
Restricted	0.000	0.000
TOTAL NET ASSETS	22.169	20.168
TOTAL LIABILITIES AND NET ASSETS	37.744	37.222