CIMMYT Business Plan 2006-2010

Translating the Vision of *Seeds of Innovation* into a Vibrant Work Plan

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Executive Summary

Translating the Vision of *Seeds of Innovation* into a Vibrant Work Plan

This Business Plan shows how CIMMYT will deliver key products that improve the livelihoods of the poor through maize and wheat research and production in the developing world over the next five years—meeting needs that cannot or will not be met by other organizations. The plan is global in scope and client focused, setting achievable targets; meeting them will result in positive impact. Its purpose is to implement the vision presented in *Seeds of Innovation*, CIMMYT's long-term strategy, through a clear, viable operational plan for 2006-2010.

Central pillars from *Seeds of Innovation*

The strategic plan *Seeds of Innovation* provides a strong vision for CIMMYT. The 2006-2010 Business Plan emphasizes the role of 11 impact–oriented Projects for creating maize and wheat technology that fosters both poverty reduction and food security while contributing to resource conservation and sustainable development. The central pillars of the vision that are embodied in the Business Plan are:

- A focus on people and their needs in maize and wheat.
- The conservation and use of the genetic wealth contained in CIMMYT's maize and wheat germplasm bank.
- Work that builds on core competence in crop improvement in an integrated manner to ensure adoption and impact.
- Decentralized research for increased efficiency and an improved client orientation.
- Implementation of effective knowledge management systems.
- Strengthened partnerships to enhance impact.

CIMMYT: The developing world's maize and wheat center

A detailed analysis of trends and needs in wheat and maize production across the developing world shows that CIMMYT can address the need for food security and develop products to improve the well-being of the marginalized who depend on maize or wheat. Our defining criteria in doing so are:

- Strategic products as global public goods.
- Partnership-based activities for product development and delivery.
- Linking scientific excellence for the benefit of target beneficiaries.
- Seeking solutions for global problems.
- Mobilizing science.
- Research for impact on the lives of the world's marginalized.

- Building capacity so that national agricultural research systems (NARSs)[1] can effectively apply knowledge in their work.

The document also defines the Center's position as a global maize and wheat research organization for development in the developing world and describes a set of "flagship products" that CIMMYT and its partners will work to develop over 2006-2010.

Portfolio of flagship products

Flagship products we intend to produce during 2006-2010 include the following:

- Stress tolerant maize for enhanced food security and crop diversification.
- Wheat with enhanced water productivity and appropriate quality profiles.
- Rust resistant wheat.
- Biofortified maize and wheat for improved nutrition and health.
- New traits through allele and gene mining of global, crop genetic resources.
- Improved methodologies and tools for genetic improvement.
- Capacity building in national agricultural research systems and small- and medium-enterprise breeding programs (SMEs).
- Resource conservation technologies for maize and wheat cropping systems.
- Special trait maize that will lead to increased income generation options for the poor.

Streamlined research management

To produce and deliver flagship products effectively to its beneficiaries, CIMMYT will refine its management structure and streamline administrative procedures. Projects will be the primary budgeting and output entities of the organization, and these will be clustered into programs and units. To maximize efficiency within units and programs, Projects will be led by Program/Unit Directors. The Business Plan is intimately related to the Medium-term Plan (MTP) process and effective use will be made of MTPs to flesh out clear milestones, plausible impacts, and measurable performance indicators.

Partnership: A core component for the delivery of flagship products

CIMMYT will work with a wide range of partners to produce and deliver products. These partners will range from advanced research institutes to non-government organizations, from national research programs to the private sector, including the national private sector and SMEs. Partnerships may vary by geography, where the nature of product delivery may also be different. During the next 3-5 years we envisage continuing to evolve our efforts to build multidisciplinary, critical-mass teams focused on these appropriate product areas. It is clear that we must make a substantial new commitment to proactive capacity building for national agricultural research systems.

[1] Understood here to include public national agricultural research programs, ministries of agriculture, universities, seed testing and regulation agencies, non-government organizations, farmer associations, small and medium-size seed companies, and other actors who participate in and influence the agricultural sector.

This approach is already being applied in our wheat and maize breeding programs where NARSs and some seed companies have become a critical component in our crop improvement activities. This represents a fundamental change in the way we interact with our partners: a shift from a simple hand-over of knowledge and materials to a highly interdependent relationship based on the collaborative generation of joint products, appropriate to the strength of partners. Our deliverables are commodities—improved maize and wheat varieties, cropping systems, and related knowledge—that have beneficial impacts on livelihoods and are conceived and delivered within an eco-regional context.

Finance and administration

A financial plan to support the investments necessary to implement the Business Plan has been developed, based on the likely funding scenarios for the next five years. During this period, total income is projected to increase by 6.5% pa on average with indirect cost recovery, as a direct offset to program expenses, scheduled to increase from its current level—a third of the agreed 25% level—to close to full recovery by 2009. Together, these projections will result in CIMMYT meeting its CGIAR mandated financial indicators very early in the life of the plan, while ensuring that program objectives are met.

Scientific core competencies and critical mass

CIMMYT will enhance its core expertise and will add a number of senior positions over the lifetime of the plan. Such additions are being achieved through limiting growth of activities in other areas, stopping areas of low priority, and continuing to strive for increased efficiencies.

CIMMYT Business Plan 2006-2010
Translating the Vision of *Seeds of Innovation* into a Vibrant Work Plan

Introduction

The International Maize and Wheat Improvement Center (CIMMYT) develops facilitating methodologies and technologies, enhanced germplasm and the associated knowledge and crop management practices, which will improve the lives of people in the developing world who depend on maize or wheat. These two cereals alone provide nearly half the food by weight and a quarter of the calories for the 4.9 billion people of the developing world.

During the more than 35 years that CIMMYT has served the people of the developing world, much has changed. Breeding technologies at the base of our work have advanced and CIMMYT must embrace and put them to their best use. Delivery channels and pathways to get technologies and germplasm into the hands of those who need them most have to be enhanced. CIMMYT embodied its vision of those changes in a strategic planning document called *Seeds of Innovation.*

The new strategy *Seeds of Innovation* provides a strong vision for CIMMYT while 2006-2010 Business Plan emphasizes the role of 11 impact–oriented Projects for creating maize and wheat technology that fosters both poverty reduction and food security, while contributing to resource conservation and sustainable development. The process by which the Business Plan was crafted involved both the Board of Trustees and Center staff. It reflects input from development investors and partners, as well as other stakeholders, provided through the participatory process that led to *Seeds of Innovation.*

The Projects are built around a set of international public goods (see list below) that were defined after careful priority setting, relying on the eco-regional approach for delivery of impacts outlined in *Seeds of Innovation.* Projects will catalyze interdisciplinary research, through a decentralization of undertakings across locations where CIMMYT and partners operate, while partnerships are used to leverage capacity and help accelerate results and impacts. Each Project is a research operational unit that is shaped by clearly defined goals. Its main undertakings are driven through priority setting that facilitates both resource mobilization and allocation. Targeted research areas by eco-region and priority traits aiming at reducing poverty and ensuring global food supplies are defined for each Project.

As defined in the Business Plan, CIMMYT Projects and the innovations they bring are enhanced by knowledge of relevant impact pathways. Within the context of the CGIAR Science Council priority setting and Millennium Development Goals, CIMMYT's impact pathways lead from our most valuable resource, maize and wheat genetic diversity and enhanced germplasm, to poverty reduction for poor rural households. Along the way, priority setting and targeting focuses crop improvement and other technology

development activities on traits and problems to produce maximum impact. Permanent feedback and participation will be sought throughout the innovation pathways from our stakeholders to fine tune the targeting and priority setting and add to our resource base of knowledge on maize and wheat, on their cropping systems, and on commodity and value chains.

This Business Plan shows how CIMMYT—one of the world's leading, science-based, research for crop improvement and development institutions—will deliver key products that meet real needs in the developing world over the next five years; needs that cannot or will not be met by other organizations. It is client-focused and practical, setting achievable targets that, when reached, will produce impacts. The plan has been informed by the recommendations of the 5th EPMR report (see Annex 1) and feedback from various stakeholders.

CIMMYT is the developing world's maize and wheat center

An analysis of trends and needs in wheat and maize (See Annex 2: Historical data and trends and analysis of needs) shows that CIMMYT can address the need for food security and develop products to improve the well-being of the marginalized who depend on maize or wheat. Our unique expertise lets us focus on:

Research for impact on the lives of the world's marginalized: 42% of all maize area and 32% of all wheat area is planted in countries where farmers' incomes average less than 1 USD per capita per day. Many farm marginal land in areas under high stress from pests and diseases and other unfavorable growing conditions. CIMMYT has engaged in many focused partnerships both to develop and deliver improved and more appropriate cultivars and production practices with and for resource-poor farm families. These networks have strengthened partners' capabilities in addressing farmers' needs. They have also resulted in new genetic enhancement, seed delivery, and crop management approaches that are more effective and relevant in resource-constrained environments and for farmers in traditional farming systems.

Strategic products as global public goods: CIMMYT produces global public goods that are freely available to clients. The types of global public goods to be produced under the Business Plan include: trait-based products (for example, drought tolerant maize and wheat, rust resistant wheat, quality protein maize, and biofortified maize and wheat); utilization of crop genetic resources; strategic research (knowledge and products resulting from long-term strategic research that requires systematic and persistent efforts, such as quality protein maize; wheat wide crosses, or conservation agriculture); and knowledge of the impact pathways to improved livelihoods under improved maize- and wheat-based cropping systems and related value chains.

Partnership-based activities for product development and delivery: CIMMYT understands the value of applying good science and has an extraordinary complement of more than 300 partnerships with NARSs[2] and advanced research institutes (both public and private); sister centers (including collaborative efforts under the auspices of system-wide programs); sub-regional organizations; community based organizations; to name a few. CIMMYT is also an active participant in several CGIAR challenge programs and host center for the Generation Challenge Program. Global partnerships and networks are also crucial to identify threats to the global wheat and maize food supply, as has recently been shown through collaboration with African partners in identifying the threat of a new strain of stem rust.

Linking scientific excellence to help target beneficiaries: CIMMYT will continue to be a world leader in applying science to maize and wheat improvement. An example of this unique role is the development of the new global rust initiative, which brings together researchers and laboratories from the USA, Australia, Ethiopia, Kenya and Uganda, along with many other countries in Africa, Asia, and Latin America. CIMMYT recognizes that a holistic approach to genotype by environment by management interactions is of paramount importance for enhancing the relevance and value of products. The Center will continue with the successful model of international nurseries and networks for germplasm evaluation, in collaboration with NARSs.

Seeking solutions for global problems: CIMMYT links components of basic and strategic research with appropriate field evaluation across a diverse range of environments. For example, the creation and application of linkages among gene identification, plant breeding, crop management practices, and livelihood outcomes across multiple sites and cropping systems are unparalleled in public plant breeding programs for developing countries. As just one illustration, CIMMYT is using molecular markers developed in the USA and Europe to pyramid different sources of fusarium head blight resistance (Brazil, China, Japan) for evaluation in disease hot spots such as Uruguay and China.

Building capacity in partners: The demand for training from NARSs, non-governmental organizations (NGOs), and small to medium enterprises (SME) in developing countries is strong, especially for the practical courses in maize and wheat science for which CIMMYT is well known. As Norman Borlaug has said, without trained scientists there would never have been a Green Revolution. Strong, skilled agricultural scientists are just as necessary in the 21 century. The effectiveness of CIMMYT's global nursery system owes much to the professional capacity of the collaborators who grow the trials and analyze and return data; in many cases, training at CIMMYT has contributed significantly to that capacity. Over the years the nature of capacity building has changed greatly. Many strong NARSs partners work closely with CIMMYT to ensure broad knowledge sharing networks that also include training of staff who require enhanced skills in specific disciplines.

[2] Understood here to include public national agricultural research programs, ministries of agriculture, universities, seed testing and regulation agencies, non-government organizations, farmer associations, small and medium-size seed companies, and other actors who participate in and influence the agricultural sector.

A livelihoods approach and ecoregional framework

As highlighted in *Seeds of Innovation*, CIMMYT recognizes that the diverse livelihood strategies and vulnerabilities of farm women and men influence their needs for and ability to adopt and benefit from various improved traits and crop management knowledge. To better understand these needs, CIMMYT staff seek out and listen to farmers, including resource-poor farmers, and the Center systematically applies the knowledge acquired to enhance priority setting and impacts.

In consultation with partners and networks, CIMMYT will continue to identify farmers' needs for improved and appropriate cultivars and production practices. Through this process, CIMMYT will detect and understand the impact and innovation networks through which farmers' needs are met by improved maize and wheat germplasm and knowledge. Farmers and local institutions can be grouped into relatively homogenous farming or livelihood systems, "target domains," with similar constraint and opportunity sets. These target domains, within contrasting eco-regions, provide a systematic basis for the differentiated assessment of farmers' needs and potential adoption patterns and people-level impacts for released cultivars, together with the anticipated impacts of new traits under consideration.

Use of target domains and tapping into impact and innovation networks places CIMMYT well to design and tailor research Projects according to eco-regional needs. (The project portfolio of the Business Plan reflects this and is graphically depicted in Figure 2, p. 17).

CIMMYT flagship products portfolio

CIMMYT has focused its agenda around nine flagship products. Nearly all represent genetically enhanced, seed-embedded technologies developed by multidisciplinary teams charged with the generation of products reflecting integrated solutions for target end-users. The products have specific impact pathways and were chosen for their great potential impact on poverty and livelihoods. The flagship products fit well into the overall project portfolio, which facilitates the setting of milestones and impact assessments. CIMMYT continues to use eco-regions as a basis for planning its research role in wheat and maize cropping systems, partnership development, and certain aspects of product delivery. Some products are tailored to a specific eco-region, whereas others are global in reach.

The flagship products described below form an exciting portfolio backed by world class expertise and developed through consultation with and analysis of the needs of our clients:

1) **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 poorest farmers, who often have few options other than to obtain their food and income from agriculture. Achieving food security is the incentive for many to allocate a disproportionately large part of their land to maize, leaving little area to other crops such as legumes or cash crops. Human malnutrition and soil degradation are frequent and few escape the "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. 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.

2) **Wheat with enhanced water productivity and appropriate quality profiles**
   Nearly half the wheat cultivated 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 their livelihoods often depend solely on income from wheat production. Moreover, in these areas wheat is a staple food, providing around half the daily caloric requirement, and also constitutes an important source of fodder for livestock. The growing scarcity of water in irrigated areas is increasing the pressure to apply and use water more effectively, as well as driving the need for water-efficient germplasm. CIMMYT will enhance its focus on the development of wheat germplasm with enhanced input use efficiency. Water use efficiency (or drought tolerance) is a highly complex trait genetically, but CIMMYT is well positioned to address this issue. Effective conservation agriculture practices will further enhance the value of water use efficient wheat cultivars. Finally, suitable grain quality is an increasingly important requirement for farmers who move beyond subsistence farming to surplus-based farming. CIMMYT will work with partners, applying its considerable experience in assessing and improving industrial quality and other key quality traits.

3) **Rust resistant wheat**
   Rust diseases pose one of the most significant and ever-present threats to wheat production worldwide. Losses to rust of only a few percent globally would spike prices and harm the world's poorest consumers disproportionately. Production increases from use of disease resistant semidwarf wheat varieties have averted potentially disastrous shortfalls in world food stocks since the 1970s. CIMMYT will drawn upon its extensive germplasm resources, deep genetic improvement knowledge, network of collaborators, and modern bioscience innovations to create with its partners a new generation of stable, resilient, and profitable wheat germplasm possessing durable resistance to the rust diseases.

4) **Bio-fortified maize and wheat for improved nutrition and health**
Poor people often survive on high intakes of inexpensive cereals, a dietary imbalance that can often result in malnutrition. 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. Iron deficiency is widespread, the WHO ranked zinc deficiency as the fifth-leading health risk factor in developing countries. Diversified diets are desirable, but vegetables, legumes, and meat are often too costly for many 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 60-100% more lysine and tryptophan than normal maize, and thus has nearly equal biological value to that of milk. CIMMYT is working with consortia of partners in Africa, Asia, and Latin America to develop and deliver stress-tolerant, agronomically-competitive QPM for use as food or feed, and to identify sustainable delivery chains that ensure impacts on human malnutrition and income generation. CIMMYT and partners have also made excellent progress in breeding for improved zinc uptake and content in wheat, and will build on and extend relevant advances and products, as well as enhancing iron content in the grain.

5) **New traits through gene discovery to best use of global crop biodiversity**
Crop genetic resources are the founding asset of the CGIAR and the basic raw material for the international breeding programs of CIMMYT. Our emerging area of comparative advantage is to develop and apply bioscience-assisted methodologies to efficiently identify genetic variation underlying target, value-added traits, to enhance tolerance to abiotic stresses, yield stability under biotic stress, nutritional quality for human and animal consumption, and profitability of maize and wheat varieties. This will include production of value-added international public goods such as structured and well-characterized germplasm subsets; internet-based information management and decision-support systems; generation and analysis of trait-specific genetic stocks, introgression lines, enhanced gene pools, genetic mapping populations, and mutant stocks; and methodologies for allele and gene mining of global germplasm collections. These value-added public goods will be fully integrated into CIMMYT's commodity improvement efforts.

6) **Improved methodologies and tools for genetic improvement**
CIMMYT has a pivotal role to play in the global research community in bridging upstream, innovation generators with downstream, product development and delivery providers. CIMMYT will continue to develop and validate new methodologies and tools for more efficient manipulation of new alleles and genes for traits prioritized by end-users in CIMMYT regional activities and in NARSs and SME breeding programs. We will give considerable emphasis to the systemic integration into these programs of a range of fast-track breeding techniques, including molecular genetic fingerprinting, marker-assisted selection, double haploids, genetic transformation, advanced biometrics, and simulation-based decision support tools. In addition, we will focus on targeted germplasm enhancement through development of integrated knowledge sharing solutions for genetic improvement of the flagship breeding product areas.

7) **Capacity building in NARSs and SME breeding programs**
   Impacts at the NARSs and farmer level can be achieved only if adequately trained people manage the process. CIMMYT is committed to providing improved germplasm appropriate to the capacity of national breeding programs in target regions. The growing strength of some NARSs and the emergence of a commercial seed sector in several countries brings opportunities for closer, more interactive, and synergistic partnerships. By the same token, we must also address the decline in the capacity of many other NARSs. As part of its evolving capacity-building strategy, CIMMYT will give greater emphasis to emerging entrepreneurs and thereby assist in the development of a strong commercial seed sector. In this context, 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 target regions.

8) **Resource conservation technologies for maize and wheat cropping systems**
   In partnership with NARSs, agri-business, and international centers, CIMMYT undertakes research on conservation agriculture and resource conserving technologies for wheat and maize cropping systems. Agronomy work at CIMMYT will focus strongly on conservation agriculture principles and approaches, which improve rural incomes and livelihoods through sustainable management of agro-ecosystem productivity and diversity, while minimizing unfavorable environmental impacts. CIMMYT will examine the potential of plant pests and diseases in such systems and look at germplasm enhancements that 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.

9) **Specialty maize for income generation**
   An increasingly globalized world has left smallholder farmers in the developing world with few comparative advantages for income generation. CIMMYT is using the wealth of maize genetic resources in its germplasm bank collections and will seek avenues that give farmers new income-generating options through specialty traits and value-added or multi-purpose uses of maize. Market potential and benefits of feed and specialty maize will be assessed, and we will analyze alternate suppliers and incentive-based value chains to identify opportunities and recommend priorities for research investments in Asia, Africa, and Latin America. Present options include quality protein maize for smallholder farmers and poultry producers in Africa or Asia, special maize types for food and feed in maize-livestock systems, or specialty maize produced in Central America for sale in US markets. These will offer new income opportunities and a competitive edge to poor and often land-constrained maize farmers, where other opportunities are few.

The above products will be developed within the framework of CIMMYT's integrated approaches to crop improvement and its ongoing commitment to research to improve yield potential in maize and wheat. This will involve appropriate socio-economic inputs and impact monitoring throughout the cycle.

Partnerships: A core component for the delivery of flagship products

Appropriate, new maize and wheat germplasm remains CIMMYT's overarching product development focus. This said, the Center clearly needs to continue working with diverse partners to define, produce, and deliver its products effectively. These partners will range from advanced research institutes to non-governmental organizations, from NARSs to private companies. Partnerships will vary by geography, often according to the nature of product delivery. During the next 3-5 years we will continue to evolve our portfolio to build multidisciplinary teams that contain a critical mass of researchers focused on appropriate product areas. It is clear that we must make a substantial new commitment to proactive capacity building in NARSs and SME breeding programs, to ensure that the pace of change is appropriate.

This approach is already being applied in our wheat and maize breeding programs, where NARSs and some seed companies have become a critical component in crop improvement activities. This represents a fundamental change in the way we interact with our partners: a shift from a hand over of knowledge and materials, to a highly interdependent relationship based on the collaborative generation of joint products, appropriate to the strength of partners. In both cases, the broad-ranging skills and perspectives of our socio-economic teams are critical.

CIMMYT has also restructured its upstream activities to heighten synergistic effects on our genetic improvement strategies. We are establishing multidisciplinary, trait-based teams that reach deep into biotech research activities and whose priorities are focused by end-users in CIMMYT, NARSs, SMEs, or other entities. Similarly, more generic activities such as information management systems, analysis and decision support tools, and molecular breeding methodology development, are firmly oriented by a single product value chain approach.

Partnering with national programs for product delivery

Partnerships with national programs have constituted the heart of CIMMYT's mechanisms for delivering improved germplasm. The original approaches were developed by Norman Borlaug and his team to disseminate to national programs in India and Pakistan the rust-resistant, high-yielding, semi-dwarf wheat varieties developed in northern Mexico. Continuing linkages with national programs and ongoing capacity building in national programs are achievements of which CIMMYT is proud and intends to maintain. The figure below indicates the strength of these relationships, in the form of collaborative networks that support and feed into knowledge management and underpin CIMMYT's comparative advantage. For example, the many years of data sharing among CIMMYT and national programs has produced collections of long-term, multi-location breeding data of great value in phenotyping, to name one area of research.

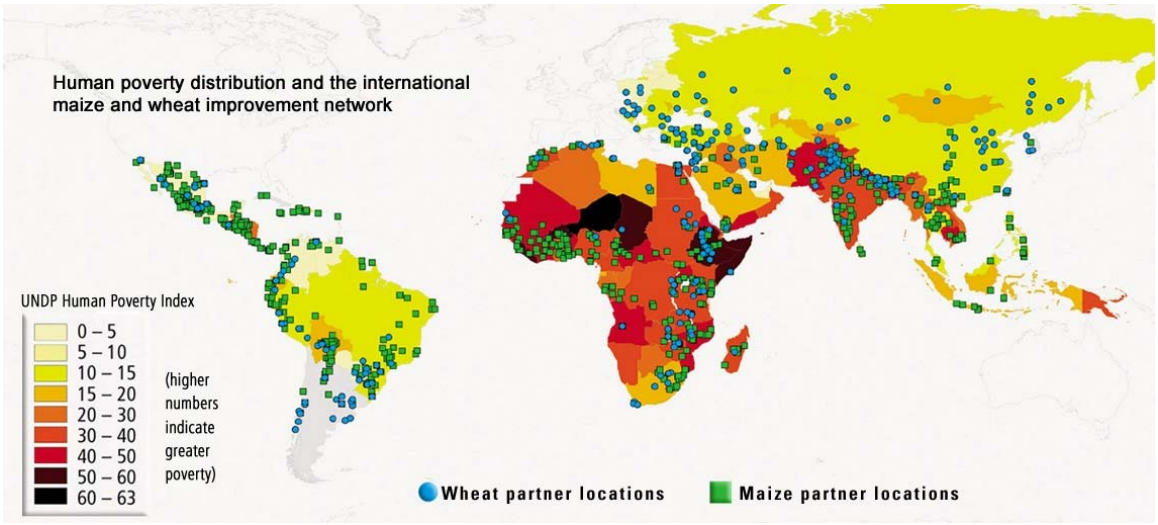


Figure 1. Human poverty distribution and CIMMYT's maize and wheat network.

Cooperation and partnerships with sister centers and regional organizations

CIMMYT is an active and full partner with sister centers of the Future Harvest Alliance. CIMMYT participates in all current Challenge Programs (including hosting the Generation Challenge Program), and a number of inter-center initiatives and system-wide programs. CIMMYT also serves as the convening center for the highly successful Rice-Wheat Consortium for the Indo-Gangetic Plains. While CIMMYT has cooperative research with CIAT, CIP, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, ILRI, IPGRI, IRRI, and IWMI, it also has some deeper relationships that are worthy of special note.

IRRI-CIMMYT: In 2002 the centers opened a dialog regarding a potential research alliance that would enable closer collaboration in areas of common interest. CIMMYT fully endorsed the recommendations of a working group established to study the possibility of an Alliance, including the recommendations on unified governance and management. After extensive discussions, the two Centers have launched an Alliance Program that spells out interaction in three thematic areas: informatics, knowledge management, and intensive cropping systems. Developing and strengthening an alliance with IRRI is an important element of CIMMYT's strategy to enhance our value as a partner for science and development in Asia. CIMMYT and IRRI's complementary scientific skills, complementary capital resources, and complementary networks of partners will be focused to jointly address the three areas described in greater detail below. The work of the Alliance is at the core of our business and as such is integrated into the overall project structure. The informatics work sits within Projects 1 and 2; the cropping systems work is in Project 6 and the knowledge bank work is in Project 11. These three thematic areas were selected by IRRI and CIMMYT to pioneer our alliance. We envisage pursuing opportunities for further synergies between our Centers, once these Projects become fully operational.

Informatics/crop research informatics lab. Advanced bioinformatics tools and access to digitized, cross-disciplinary data sets can enable new discoveries and short cuts to new solutions. IRRI and CIMMYT see a number of areas where a closer relationship will help build sufficient critical mass to address previously unattainable goals, or contribute to establishing a more powerful platform for synergizing progress across cereal species. These opportunities fall into five broad groups:

- Research support and quality assurance. This applies where differentiation of activities within a unified group offers considerable gains in efficiency.
- Institutional research data management. This critical, institute-wide activity has long been on the agendas of both centers, but crop research informatics laboratory (CRIL) now offers sufficient critical mass to facilitate rapid progress.
- Crop information systems for rice, wheat and maize. With both institutions committed to the same informatics platform, there are tremendous opportunities for bringing diverse datasets together.
- Computational biology and bioinformatics. Comparative genomics involving rice, maize, and wheat will drive rapid progress in trait dissection and mining of genetic resources.
- 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. The Integrated Cereal Systems Knowledge Portal (CSKP) is a decentralized, practical "cereal encyclopedia" and dynamic, open knowledge sharing platform, focused on global public goods, notably knowledge with value across many countries. The CSKP will serve researchers and extension professionals supporting the development of food crops in diverse production systems in the developing world. It logically aligns rice/wheat/maize systems information and knowledge (e.g., variety, production, diseases, and pests) extracted from a proposed "world cereal informatics center" with relevant production systems information (e.g., conservation agriculture) in similar formats: manuals, various tools (e.g. rice/wheat/maize doctor, simulators), multimedia presentations, research findings, best practices and ideas, case studies, interactive tests, and facts sheets.

Intensive cropping systems. Intensive, lowland, rice-based agro-ecosystems in Asia are rapidly changing, as farmers adapt to resource limitations such as irrigation water scarcities and to market forces that provide opportunities for increased farm income through diversification to crops such as maize. Traditional, commodity-based research fails to address proactively the emerging environmental and sustainability concerns in these rapidly-evolving agroecosystems. This IRRI-CIMMYT alliance project will apply new approaches and foster partnerships among international centers and NARSs to address these issues. CIMMYT Projects 6 and 11 will be core contributors. Given the well-established activities for rice-wheat systems within the Rice-Wheat Consortium for the Indo-Gangetic Plains, the alliance project will initially focus on rice-maize systems.

ICARDA-CIMMYT joint program. Collaboration with ICARDA is very important to the work of CIMMYT and to NARSs of the Central and West Asia/North Africa (CWANA) region, where ICARDA has its major role. The two centers continue to work together closely on the ground, and great complementarities exist in the skill packages of both. A new, functional agreement between the two centers will be implemented formally in 2006. This agreement allows for clear and effective management of the joint program and offers tremendous scope for operational delivery of products and technologies. CIMMYT will be able to use its shuttle strategy to develop advanced populations, while ICARDA will work on tailoring the resulting materials to regional needs and deploying them in dryland cropping systems. ICARDA's work on water management will fit well with CIMMYT work on conservation agriculture and the introduction of new germplasm with high water productivity. Finally, the relationship should allow both centers to capture synergy benefits in relation to use of regional offices, among others.

Partnerships to regionalize biotechnology research. To support its new, regionalized structure, CIMMYT is committed to establishing the capacity for molecular breeding applications in all major regional breeding programs. This will include creating critical mass teams around current capacity for maize in Kenya (at the BECA) and the Philippines (at IRRI) and for wheat in China (at CAAS), and at least one other location in CWANA. Other opportunities will be pursued in Brazil, Argentina, South Africa, and India. These molecular breeding facilities will be established in collaboration with NARSs and/or regional organizations and will be open to all public and private sector organizations who have a commitment to serve the needs of our clients in given regions. On this basis, it is also envisaged that CIMMYT investments will be augmented by national and/or regional funds.

Partnerships with private sector and advanced research institutes. Bioscience research over the last decade has undergone a major shift, with an increasing portion of research in plant science being proprietary and conducted in the private sector or by advanced research institutes (ARIs). Public-private and public-public sector alliances are critical to ensure that relevant research results are adapted in ways that enable resource-poor farmers to benefit from the newest research findings. The relative strengths of ARIs and the private sector in developing technology and information resources in genomics and biotechnology, and CIMMYT's in germplasm—especially information and expertise relating to the characteristics and improvement of germplasm important to the resource-poor—provide a strong basis and considerable impetus for forming alliances. CIMMYT will enter such alliances provided they (1) significantly enhance our ability to make products available as public goods with particular benefit to the resource-poor, and (2) permit both CIMMYT and the partnering institutions to retain their own identities and credibility, based on their particular missions and constituencies. CIMMYT will make it a core aim to develop over the next 12 months a policy statement that further specifies the conditions under which the Center will engage in such alliances, thereby fostering transparency regarding our choice of partners.

Following market liberalization, public-private sector alliances have also become more critical for the sustainable delivery of appropriate and affordable seed-based technologies

from the public sector to resource-poor farmers and to farmers in low-productivity cropping environments. In many cases, public sector seed delivery mechanisms have effectively disappeared and many donor-led seed dissemination efforts have proven unsustainable. In contrast to collaboration on upstream research, the focus here is on entrepreneurial activities emerging from the grass-root level, such as local, small- and medium-scale entrepreneurs (SMEs) interested in marketing public sector germplasm in lower margin markets that currently lack access to appropriate and affordable seed. In many instances, the interest of SMEs centers on maize. The growth of this sector, if successful, could significantly increase the relevance of CIMMYT's research for resource-poor farmers in particular and for market development in general.

Both a recent center-commissioned external review (CCER) and the 5th External Program and Management Review (EPMR) of CIMMYT recommended that the Center and NARSs partners develop joint strategies for strengthening SMEs through public-private partnerships, as they deliver germplasm to markets most relevant for resource-poor farmers. By facilitating access to CIMMYT maize and wheat germplasm through, for example, more client-focused information, CIMMYT will include SME research staff in training activities, identifying the factors that condition seed sector development into undersupplied regions, and contributing to policy formulation. This will assist SMEs with the ultimate goal of increasing the access of resource-poor farmers to CIMMYT products and strengthening sustainable seed delivery capacities in low income countries. CIMMYT also encourages NARSs partners to take a more proactive role in facilitating and supporting local private seed sector development, among other things implementing more effective germplasm transfer agreements, conducting joint public-private training courses, and supporting the formulation of policies that foster a diverse and competitive seed sector.

An important component of effective interaction with the private sector is clarity on intellectual property (IP) matters. CIMMYT has a policy in this area and posts on its website pertinent information. The rationale of the IP policy is to ensure freedom to operate for CIMMYT and its partners as it relates to information, knowledge, and products.

Why should CIMMYT be seen as partner of choice, and who are the preferred partners? CIMMYT sees an urgent need for the CGIAR to foster a new architecture of innovation that builds true partner synergies and creates greater impact for its stakeholders, at the same time establishing a sustainable, long-term niche for the System. We believe this will greatly benefit our clients and stakeholders. This new paradigm will be characterized by alliances with high reciprocal inter-dependencies between disciplines and sectors, including shared inputs, risks, and rewards that go beyond the linear technology transfer relationships of traditional partnerships. Success in this shift will depend largely on how effectively projects are planned, how well teams are constituted, and how well team members work together. CIMMYT will put a much greater emphasis on collective planning and review involving representatives from all points of value chains within which CIMMYT operates.

Led by this vision, CIMMYT aspires to become the partner of choice in its key areas of work. To ensure this, the Center will build a strong critical mass of interdisciplinary scientists working within solution–oriented, multidisciplinary teams in a systems-oriented approach. At the same time we commit to go beyond simply providing expertise and knowledge, to helping build skills and systems through a systemic integration among those who need, supply, validate, or deploy genetically enhanced, seed-embedded maize and wheat technologies. This will empower our partners to take on many of the activities included as part of our traditional mandate, thereby freeing up CIMMYT to focus a greater portion of its resources on new areas where Center efforts can provide the greatest added value most efficiently. In turn, CIMMYT's chosen partners will be those NARSs, SMEs, and multi-national companies with whom partnerships will result in the greatest synergies.

How we intend to develop and deliver research products

To effectively produce and deliver flagship products, CIMMYT will refine its management structure and move to a project-based approach in budgeting, planning, and defining milestones and outputs. Projects will be the primary management entity; the plan will be implemented through 11 Projects. This approach is wholly compatible with that required by the CGIAR Science Council and will greatly facilitate compatibility between the Business Plan and the MTP processes, including verification of progress based on clearly identifiable milestones.

For effective management of the Projects and their staffing and to ensure integration of work and clarity in delivery, the Projects will be aggregated to higher-level structural management entities, under the leadership of the DDG-Research. There shall be two primary Programs on Maize and Wheat. These Programs will work in close interaction with both the Genetic Resources and Enhancement Unit and the Impacts and Socioeconomics Unit. It is important to emphasize that broad, interdisciplinary groupings are formed at the Project level; this will ensure an integrated approach (see Figure 2 and Annex III). The flagship products (lighter shading) are linked to at least one of CIMMYT's 11 Projects (dark shading). All 11 Projects include one flagship product, which in turn will have direct and indirect beneficial impacts across one or more eco-regions (no shading).

This organizational structure maintains the core thrust of *Seeds of Innovation,* in which CIMMYT's research-for-development efforts follow the continuum formed by two kinds of livelihoods systems: those in which maize and wheat are the staple food of rural households and others in which maize and wheat should generate income, foster economic growth, and alleviate poverty. One can illustrate such points by following the innovation and impact pathways and networks for each flagship product. For example, water-efficient wheat with appropriate quality profiles will be housed in Projects 7 and 9, with a priority given to the drought-prone rainfed systems; however it will have reverse spillover in the intensive agro-ecosystems. This benefit of better water productivity will then free up water resources that farmers can use when diversifying into other crops.

Figure 2. Implementation of the long-term strategy through the business plan.

	Agricultural systems or ecoregion in main target areas			
	Africa	**Tropical world**	**Intensive systems**	**Rainfed wheat systems**
	Eastern and Southern Africa	Tropical America and the Caribbean Southeast Asia	South Asia China, Mexico other irrigated	Central-West Asia and North Africa**** Southern Cone
Project title				
P1 Discovery*	New traits through allele discovery and gene mining			
P2 Tools	Improved methodologies and tools for genetic improvement			
P5 Africa	Stress tolerant maize for			
P3 Stress	food security and crop diversification			
P6 Latin America & Asia **	Biofortified maize and wheat for improved nutrition/health			
P4 Nutrition	Income generation from special trait maize			
P7 Water productivity			Water-efficient wheat	
P9 Biofortification			with appropriate quality profiles	
P8 Pests & diseases			Rust resistant wheat	
P10 Conservation agric.	Resource conservation technologies for cereal systems			
P11 Impacts & targets ***	Capacity building of NARSs and SME breeding programs			

* P1 includes outputs of IRRI-CIMMYT Bioinformatics.
** P6 provides center's resources to IRRI-CIMMYT Alliance (rice-maize) intensive systems in Asia.
*** P11 houses IRRI-CIMMYT Cereal Knowledge Bank.
**** Through joint wheat regional program with ICARDA.

CIMMYT Projects from which flagship products will emerge

The Projects described below will develop and deliver the flagship outputs, as functional units of program activities and operational management units for budgeting and staffing. MTP reporting will also be Project based, thus ensuring that milestones and performance indicators are linked to the flagship products. Work under the IRRI Alliance and the joint program with ICARDA are fully integrated into the Project structure below and do not form separate, stand-alone Projects. The Projects are operational, budget, and reporting entities. Input from various Projects will often be required to develop and promote products.

Project 1: Conservation and characterization of and targeted access to maize and wheat related biodiversity (Flagship products 5 and 6: New traits through allele mining, and Improved methodologies for genetic improvement).

Project 2: Trait enhancement: tools, methodologies, and germplasm (Flagship products 5 and 6: New traits through allele mining, and Improved methodologies for genetic improvement).

Project 3: Stress tolerant maize (Flagship product 1: Stress tolerant maize).

Project 4: Nutritional and specialty traits for maize (Flagship products 4 and 9: Biofortified maize and wheat for improved nutrition and health, and Special trait maize for income generation).

Project 5: African livelihoods (Flagship products 1, 4, and 9: Stress tolerant maize, Biofortified maize and wheat for improved nutrition and health, and Special trait maize for income generation).

Project 6: Maize for Latin America and Asia (Flagship products 1, 4, and 9: Stress tolerant maize, Biofortified maize and wheat for improved nutrition and health, and Special trait maize for income generation).

Project 7: Water productive wheat with appropriate quality profiles (Flagship product 2: Wheat with enhanced water productivity).

Project 8: Enhanced wheat for more durable resistance to diseases and enhanced production potential (Flagship product 3: Rust resistant wheat).

Project 9: Wheat grain enriched for health and profitability (Flagship products 4 and 5: Bio-fortified maize and wheat for improved nutrition and health, and New traits through allele and gene mining of global, crop genetic resources).

Project 10: Conservation agriculture for maize and wheat cropping systems: Safeguarding soils while increasing water productivity and resource use efficiency (Flagship product 8: Resource conservation technologies).

Project 11: Knowledge, targeting, and strategic assessment of maize and wheat farming systems (Flagship product 7: Capacity building).

Financial picture, staffing mix, and targets to deliver the outputs

Finance and administration

Over the last decade, CIMMYT's unrestricted grant funding has fallen from $18.6M in 1995 to $13.3M in 2005; a trend that is fairly consistent across the CGIAR centers. Discounting for inflation at 3% pa implies that the real value of unrestricted funding has declined by about 40%. In addition for CIMMYT, the appreciation of the Mexican peso in recent years and the substantial inflation of local wages and costs in Mexico in dollar terms have significantly affected our operational costs.

In the same period restricted project funding has approximately doubled from $12.9M to $24.1M. More than 20% of the additional funding is for NARSs and ARI partners. The net effect of inflation, parity changes and the additional costs associated with development projects has reduced the real value of CIMMYT's unrestricted funding substantially. This decrease has been expressed in many areas that now need addressing:

- Reductions of professional staffing in core breeding functions that require stable, long-term investment.
- Sub-optimal adoption of modern breeding technologies and data management systems.
- Deferred maintenance and replacement of essential infrastructure, including buildings, greenhouses, mechanization of field station operations, and specialized laboratory equipment.
- Delayed implementation of an appropriate management information system, especially an updated financial system.
- Delayed implementation of a proper system for pricing and costing projects.

Key shifts in investment during plan implementation

One of the key elements of an effective plan is a clear indication of changing investment shifts over the implementation timeframe. CIMMYT is taking fullest advantage of this medium-term planning horizon to make a number of shifts that will better position the Center to deliver its flagship products. The financial plan for 2006-2010 reflects the alignment of flagship products and associated staffing needs, and is presented in the context of 11 new Projects.

Shifts over time to restore/strengthen areas of competence

Relationship of budget and project portfolio. The Business Plan outlines CIMMYT's entire agenda, using its total budget resources. The center already spends heavily in areas of core competence such as genetic resource management and genetic enhancement (Figure 4). In fact, CIMMYT currently spends more in these areas both in relative and real terms than any other CGIAR center. However, as we will see shortly, CIMMYT will enhance its efforts towards bioscience-led, field-based crop improvement programs.

From Table 1 it can be seen that in 2006 CIMMYT will start to adjust its resource allocations by Project to meet the investment needs of the plan. These shifts will be reflected in staffing movements and recruitment and in the relocation of resources from lower to higher priority areas. Over the next five years, as new projects are started and old projects phased out, the flexibility to transfer resources will grow significantly, thus allowing for further staff and program shifts as outlined in the staffing profile charts (Figures 3a and 3b). Commencing in 2006, funds will be allocated to begin addressing the following areas:

- Hiring of staff to further strengthen core competencies (e.g., breeding and associated disciplines). This is reflected by additional resources being made available to Projects 4, 6 and 7.
- Redeployment of some staff to Asia to better tailor products to the growing needs of that region within Project 4.
- Investment in improved communications technology to enhance the ability of CIMMYT to function effectively in a dispersed operating environment.
- Investment in data management to support our work on bioinformatics, crop database management, and GIS.

Financing plan. The plan for 2006-2010 is extrapolated from CIMMYT's 2006 draft budget, which has undergone substantial realignment to reflect the shift from program-based to project-based financial management. Unrestricted income is anticipated to be flat in nominal terms (historically, unrestricted funding has declined on average by 3% pa over the past 10 years). Restricted or project funding is projected to increase by 5% pa from 2007. This is a conservative projection given historical trends. Annual expenditures are projected to rise by an inflationary factor of 5% pa (including staff costs). Flexibility within the budget will be created through the reduction of some activities currently supported with unrestricted funds and a more aggressive move to fund staff costs through project funding. The third mechanism we have for directing resources in support of the Business Plan is through targeted project development and fund raising. Given that about two-thirds of CIMMYT's income is in the form of restricted project funding, there is considerable potential to target donors to increase funding for priority areas of work. CIMMYT has a strong record of attracting project funding (this category of funding has increased on average by almost 9% pa over the past 10 years). Many donors and investors that provide restricted project funding to CIMMYT remain committed with their financial support, year-on-year, even though the nature of the activities supported may vary.

The main feature of the budget projection for 2006-2010 is the gradual move to full recovery of indirect costs. As of 2005, only 33% of CIMMYT's total indirect costs are recovered through restricted and project funding; this is projected to increase to 100% by 2009. A key component of this projection is the ability to track and extract indirect costs in our financial information system. Full cost recovery will provide significant flexibility to implement new initiatives and enhance existing activities. The attached financial plan includes the continued improvement of CIMMYT's reserve. Through the projected addition to reserves of 1.089M in 2006, CIMMYT will meet the minimum CGIAR requirements for short-term and long-term financial stability during that year.

Table 1. Financial projections, 2005-2010.

	Notes	2006	2007	2008	2009	2010
Income						
Grants/Contracts						
Unrestricted	#1	13,390	13,990	13,990	13,990	13,990
Restricted	#2	21,439	22,511	23,636	24,818	26,059
		34,829	36,501	37,626	38,808	40,049
Other Income						
Center Income	#3	1,250	1,300	1,350	1,400	1,450
Total Income		**36,079**	**37,801**	**38,976**	**40,208**	**41,499**
Expenditure						
Project.1 – Discovery		3,720	3,740	3,920	4,130	4,330
Project.2 – Tools		3,610	3,980	4,180	4,400	4,620
Project.3. – Stress		4,420	4,980	5,230	5,500	5,770
Project.4 – Nutrition		2,850	2,990	3,140	3,300	3,460
Project.5 – Africa		3,800	3,980	4,180	4,400	4,620
Project.6 - LAC/Asia		2,610	3,240	3,400	3,580	3,750
Project.7 – WUE		4,510	4,730	4,970	5,230	5,480
Project.8 - Rust/FHB		4,660	5,980	6,800	7,150	8,080
Project.9 – Biofortification		1,430	1,490	1,570	1,650	1,730
Project.10 - RCT's		2,850	2,990	3,660	3,850	4,040
Project.11 – ITA		2,770	2,740	2,880	3,030	3,170
Total Project Expenditure	#4	37,230	40,840	43,930	46,220	49,050
Indirect Cost Recovery	#5	-2,600	-3,600	-5,700	-7,900	-8,300
Total Net Expenditure		**34,630**	**37,240**	**38,230**	**38,320**	**40,750**
Surplus/(Deficit)		**1,449**	**561**	**746**	**1,888**	**749**
Movement in Undesignated Reserves						
Opening Undesignated Reserves		6,861	8,060	8,621	9,367	11,256
Surplus/(Deficit)		1,449	561	746	1,888	749
Net (Increase)/Decrease in Fixed Assets	#6	-250	0	0	0	0
Closing Undesignated Reserves		**8,060**	**8,621**	**9,367**	**11,256**	**12,005**
Indirect Cost Recovery						
Management Expenditure	#7	6,820	7,200	7,520	7,900	8,300
Recovery		2,600	3,600	5,700	7,900	8,300
		38.12%	**50.00%**	**75.80%**	**100.00%**	**100.00%**
Notes						
#1 Assume increase in World Bank funding once reserves are repaired						
#2 Assume 5%/annum increase in restricted funding from '07						
#3 Increased interest income as reserves increase						
#4 Assumes that program expenditure will increase by 5% per annum						
#5 Indirect cost recovery will increase to 100% by 2009						
#7 Indirect costs will increase by 5%/annum						

Relationship of budget and research infrastructure. As a center that is primarily focused on crop improvement through the application of modern plant breeding and enhancement strategies, it is important that CIMMYT have the right distribution and management of its experiment stations.

Since its inception, CIMMYT has used a shuttle-breeding approach for wheat improvement involving two stations in Mexico (Ciudad Obregón and Toluca), in addition to El Batán (CIMMYT-HQ) and quarantined seed multiplication sites. Materials from the shuttle are then tested in regional locations, primarily though direct cooperation with national programs and sister centers. Recent strategic discussions by wheat improvement scientists have endorsed the extraordinary value of this approach, while suggesting some modification to better deal with selection in specific disease hotspots.

In maize improvement, the breeding strategy is somewhat different and more decentralized. Redeployment of additional staff to Asia and the continued strength of maize improvement in various locations in Africa should allow for the consolidation of the research infrastructure needed in Mexico. Likewise, a careful review is needed of experimental locations in Africa and Asia, given the capital and operational costs involved and the fact that several locations are supported with unrestricted funding. It must also be noted, however, that costs associated with closing any experiment station facility are considerable and recurrent savings for reinvestment elsewhere are not recouped for 1-2 years, given local operating environment and national legislation. In 2006, we will commence a systematic review of the need for specific experiment stations.

Staffing. The heart of any research organization is its staff. CIMMYT will rebuild in areas of its core expertise, and will add a number of senior positions over the lifetime of the Plan (Figures 3a and 3b, expressed by IRS staff number changes). Such additions are being achieved by reducing activities in other areas and by continuing to strive for increased efficiencies. It should be understood that, in modern crop improvement, plant breeding is composed not only of breeders *per se*, but a team of complementary disciplines that target product development and delivery.

Figure 3a: IRS distribution by functional area (%).

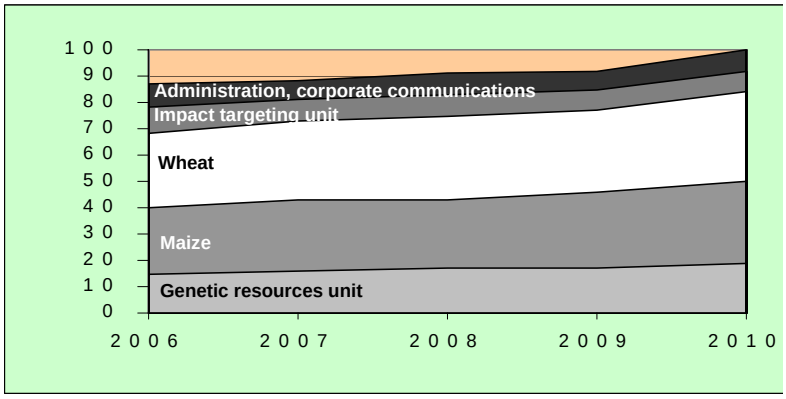
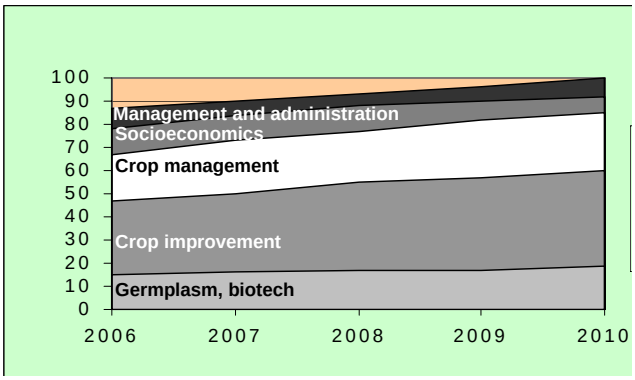


Figure 3b: IRS distribution by key skill (%).



Investments across commodities and by region. CIMMYT has for several years used a resource allocation tool to determine the approximate level of investment needed both geographically and on a commodity basis over time. Current investment by commodity is roughly equal, overall. Despite growth in demand for maize over the next decade, in-house investments between maize and wheat will shift relatively little, in large part because much of the expected demand growth is for livestock feed and will be driven by the private sector. Care must be exercised, however, in the interpretation of these data. Although, at the aggregate level, investment in the two commodities will remain relatively constant, there will be changes in project activities under the two commodities over time.

There will also be shifts in regional allocations over time. While Latin America remains an important partner to CIMMYT, especially as a partner in research, the growth of poverty in Asia and Africa will result in some further shifting of resources to strengthen operations in Asia, especially.

IRRI-CIMMYT investments. As indicated earlier, this relationship is an important one and potentially offers a model for closer program cooperation between Centers. The Alliance program with IRRI is a part of the core agenda of CIMMYT and as such the investments required for this work are embedded in the project budgets. In 2006 some costs will be from unrestricted funding, but as seen by the projected growth of restricted funds, it is expected that many IRRI-CIMMYT activities will be funded through restricted projects. As a part of its commitment to the relationship, CIMMYT has earmarked $300k additional investment for 2006 and will actively seek project funding to increase this investment.

CGIAR outputs. The shifts in investment at the project level envisaged in the Plan will also result in a change in the profile of CGIAR outputs associated with the operations of the center (Figure 4).

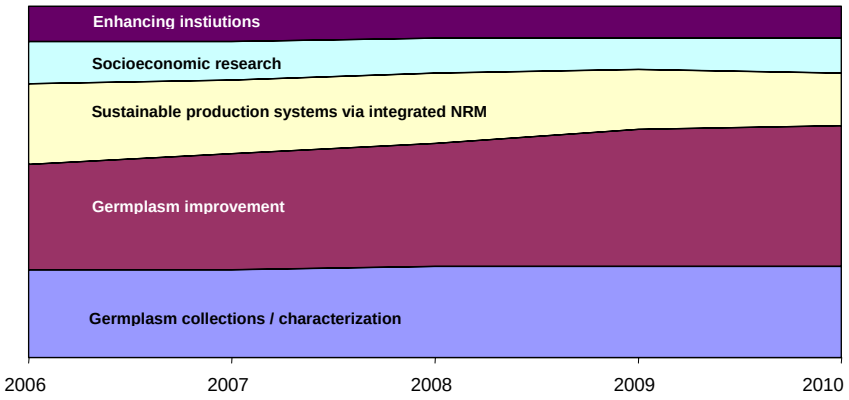


Figure 4: CIMMYT investment by CGIAR output 2006-2010.

Marketing and fundraising

Maintaining funding for CIMMYT's research agenda is a continuous task that involves balancing interactions with investors who provide unrestricted funds and preparing proposals for investors who prefer to contribute through specific projects. There is always a balance that needs to be struck between these forms of support and in avoiding the use of flexible funds in areas where investors are willing to support projects. In 2005 the center developed and began implementing a fundraising strategy. The approach is to develop a series of major initiatives that will support major blocks of work, (an example is the global rust initiative). There is also increased attention to seeking bilateral funds in regional locations and keeping a series of smaller proposals flowing. To date, the Center has been relatively successful in obtaining a high level of project support, with such support being largely in areas of key competence. The strategy of continuing to develop proposals for projects that are clearly aligned with CIMMYT's core competencies will be maintained. To support this strategy, a resource mobilization team will be formed, primarily to identify and market a limited number of large initiatives in support of our Business Plan.

In addition, we have realized that while our loyal, traditional donors have staff who understand our work, there are many at higher, decision-making, policy-setting levels in governments, foundations, and the private sector who do not know us or comprehend the need for our work. To start to redress this, we are implementing a comprehensive communications strategy designed to target messages and knowledge in a creative and effective way to key audiences and organizations.

Risk management strategy
As a part of CIMMYT strategic planning during 2003, one of the six staff task forces conducted a scenario-building exercise. The results will guide CIMMYT as it positions itself and seeks to enhance its relevance and responsiveness in an evolving global setting, minimizing the risk of losing its value in the world.

The CIMMYT Board of Trustees has adopted a "Policy on Risk Management and Internal Control," which provides an institutional framework and proactive action plan to minimize risks and ensure proper risk management. During the period covered by this Business Plan, the following items are considered important risks:

- Major deduction in projected revenue.
- Failure in indirect cost recovery plans.
- Shifting of staff costs from unrestricted to restricted funding.
- Social unrest and difficult operation in some of regional offices.
- Major change in World Bank policy affecting the CGIAR and funding to Centers.
- Staff morale concerns from changes triggered by financial crisis in 2002.
- Social acceptance of biotechnology applications, such as GMOs, for agriculture in developing countries.
- Mexico inflation/labor cost situation, host-country agreement.

CIMMYT management and Board will actively monitor the above risks to ensure the continuous, smooth operation of the Center in a rapidly changing world. Part of such a monitoring system is a process of "red-flagging" areas of substantial risk. These are reviewed twice yearly by the Board.

IPR Policy and the International Treaty on Genetic Resource

CIMMYT has over the years adopted clear and well publicized policy statements regarding its position on both IP and international treaty obligations. The Center will continue to monitor changes in this environment and make amendments as needed, with input and approval from the Board on policy issues. An example of this was the 2005 fall Board meeting endorsing the CGIAR plan to sign agreements relating to the International Treaty on Plant Genetic Resources and empowering the DG to sign the agreement, working proactively with other CG Centers.

In the area of genetically modified crops, CIMMYT will at all times respect the position and laws of the countries in which it performs this type of research and will be open and transparent as to the nature and goals of the work it is performing. There is active debate on this topic in Mexico and transgenes clearly exist in the commercial maize population, despite the current new laws restricting commercial production of genetically modified maize.

Conclusion

This Business Plan charts a clear path and achievable targets for the next five years. We have set our goals high as always, but we know they are realistic. We have built on our core strengths and adapted to new challenges. Our products and outputs will result in impacts, including improved incomes, better livelihoods, and new hope for many of the rural and urban poor who depend on wheat or maize. By making a difference for the world's marginalized, CIMMYT's contribution to the first Millennium Development Goal—the eradication of extreme poverty and hunger—will be real.

Annex 1: Situational Analysis—Challenges for CIMMYT

The 5th EPMR and subsequent analysis by CIMMYT identified many challenges confronting the Center. We believe the Business Plan for 2006-2010 addresses them. They are summarized here as a snapshot of our response to these important issues.

Improving the impact of research information management and the efficiency of genetic enhancement

CIMMYT is committed to applying the most effective new methodologies in a constant process of modernization, driving an increasing pace, scope, and intensity in developing improved germplasm products. This includes globally decentralized selection (shuttles), mechanization and automation of field based operations, and the use of molecular level and related technologies (marker-assisted selection, near infrared screening, single seed descent, doubled haploids, and bioinformatics, to name several). CIMMYT also proposes to maintain a strong engagement and competence in the use of transgenic technologies in its research, although it is increasingly clear that transgenic product development will only become a focus where conducive political environments and diverse private sector delivery partnerships are solidly in place.

Many developed countries and private enterprises are investing heavily in the application of genomics, bioinformatics, and related technologies. It is essential that CIMMYT maintain a credible capability to leverage effective partnerships and to ensure that products of such research are readily translated into potential germplasm benefits as global public goods for resource-poor farmers in developing countries.

CIMMYT will also upgrade its technical data management systems to improve its internal analysis capacity, integrating different data sets from gene bank, laboratory, and field activities and to improve external access by partners and clients. Strengthened investment in the modernization and automation of field based operations, molecular level technologies, and data management has capital budget implications for CIMMYT; these are highlighted in a 5-year financial plan.

Strengthening field-based crop improvement expertise

CIMMYT has strong expertise in laboratory oriented activities that support crop improvement. CIMMYT's core competence over the years, however, has been field-based research, recognizing that a holistic approach to genotype by environment by management interactions is of paramount importance to enhance the relevance and value of strategic products. CIMMYT has recently lost several experienced plant breeders due to retirement, career opportunities with other organizations, and financial constraints, and there is need to reinforce the commitment to field-based plant breeding operations. This will not be easy, given the trend over the past two decades of emphasis on molecular genetics in university research and teaching. CIMMYT is committed to recruiting plant breeders who can work across disciplines and laboratory and field-based crop improvement programs.

Product delivery and partnerships

The *Seeds of Innovation* vision has rightfully given emphasis to a livelihoods approach to address intractable problems of poverty alleviation, in contrast to an approach that simply focuses on increasing maize and wheat production at the expense of other crops and systems. CIMMYT will maintain its focus on maize and wheat research, but we will ensure that these crops are properly integrated in major cropping systems to add value to maize and wheat improvement. For example, maize stover is important in livestock-maize systems in Africa; part of our maize improvement efforts for that continent should be carried out in partnership with organizations, such as ILRI, that possess expertise in livestock nutrition.

The role of CIMMYT extends beyond the development of science-based solutions, covering as well associated technologies, methodologies, services, and processes that make enhanced germplasm practicably accessible and meaningful to resource-poor farmers. These associated functions include knowledge sharing, capacity building, sustainable cropping systems, appropriate research facilities and equipment, seed delivery systems, and an understanding of socio-economic constraints and impacts (market dynamics, commodity effects on livelihoods). CIMMYT's Project structure is described later in more detail. However, of necessity, product development and delivery Projects have been designed for implementation at a regional level, often in partnership with a sister CGIAR center, (NARSs), and SMEs (Figure 1). The combination of dispersed locations, partnerships, and multi-disciplinary tasks imposes significant management complexity and administrative costs on CIMMYT. The tighter definition of Project goals, roles, and responsibilities following the development of this Business Plan will allow for clearer implementation and management.

Finance and administration

Over the last decade CIMMYT's unrestricted grant funding has fallen from $18.6M in 1995 to $13.3M in 2005 (a trend that is fairly consistent across the CGIAR centers). Discounting for inflation at 3% pa implies that the real value of unrestricted funding has declined by about 40%. In addition for CIMMYT the appreciation of the Mexican peso in recent years and the substantial inflation of local wages and costs in Mexico (in dollar terms) have had a particularly significant effect on our operational costs.

In the same period restricted project funding has approximately doubled from $12.9M to $24.1M, of which more than 20% of the additional funding is for NARSs and ARI partners. The net effect of inflation, parity changes, and the additional costs associated with development projects has reduced the real value of CIMMYT's unrestricted funding very substantially. This decrease has been expressed in many areas that now need addressing:

- Reduction of professional staff in core breeding functions that require stable, long-term investment.
- Sub-optimal adoption of modern breeding technologies and data management systems.

- Deferred maintenance and replacement of essential infrastructure including buildings, green houses, mechanization of field station operations, and items of specialized laboratory equipment.
- Delayed implementation of an appropriate management information system, especially an updated financial system.
- Delayed implementation of a proper system for pricing and costing projects.

Development of a global maize breeding strategy
CIMMYT maize research aims to benefit farmers through germplasm improvement and research, particularly resource-poor farmers in Africa, Asia, and Latin America who are not potential clients of private sector providers. In most instances, the targets are stress-prone environments where farmers cannot afford or access inputs such as irrigation, fertilizer, lime or pesticides. Future efforts by CIMMYT towards maize germplasm improvement will include genotype by environment analyses and stakeholder consultations on trait priorities for maize. This approach is expected to highlight significant differences in breeding goals among major maize adaptation zones (lowlands, midaltitude/sub-tropical areas, and highlands) and the role of maize across different regions of the world. As a result, CIMMYT's maize breeding initiatives will be decentralized but coordinated, with scientists located in Africa, Asia, and Latin America focusing on the most important mega-environments worldwide where resource-poor farmers are prevalent. CIMMYT's success in supporting resource-poor farmers will assist them to move to more commercially oriented farming systems.

Governance
In addition to the program and management issues outlined above, CIMMYT is responding to issues of governance raised by the EPMR. The CIMMYT Board of Trustees and management have taken serious steps to address several issues raised by the 5th EPMR and in response to subsequent discussions of the EPMR at the April 2005 Science Council meeting and May 2005 ExCo meeting.

The Board has drafted a proposal for a new governance system for CIMMYT that will ensure that basic functions required by the CGIAR are performed. However, there will be a stronger emphasis on strategy, networking, resource mobilization, oversight of administration, and the financial and fiduciary functions of a Board. To achieve this, the Board will move progressively to acquire the enhanced skills for discharging the above-mentioned functions and roles. The Board will also review implementation of the EPMR recommendations on a quarterly basis through management reports to the Board. The CIMMYT Board and management have agreed on a set of performance indicators that go beyond those for the World Bank and which include early-warning systems to ensure a proactive response to "yellow flags."

The Board has further reduced in size while ensuring possession of the skills mentioned above and suitable diversity in its make-up, by region, gender and partnership. The Board will discharge its fiduciary and oversight responsibilities through more frequent meetings, including at least half by electronic means. The Board views program and scientific quality oversight as extremely important functions, and will form each year ad

hoc teams of eminent scientists to review and provide guidance on specific aspects of CIMMYT's research strategy, programs, outputs, outcomes, and impacts.

A revised governance system was finalized in early November 2005. The Board has taken steps to ensure a clear separation of membership on the Audit and Finance and Administration Committees. The Executive Committee has been re-formulated with the additional role as a governance committee. In addition to these structural issues, the Board has maintained an active role in developing the IRRI-CIMMYT alliance. The two joint Board Committees of the Centers have met twice already.

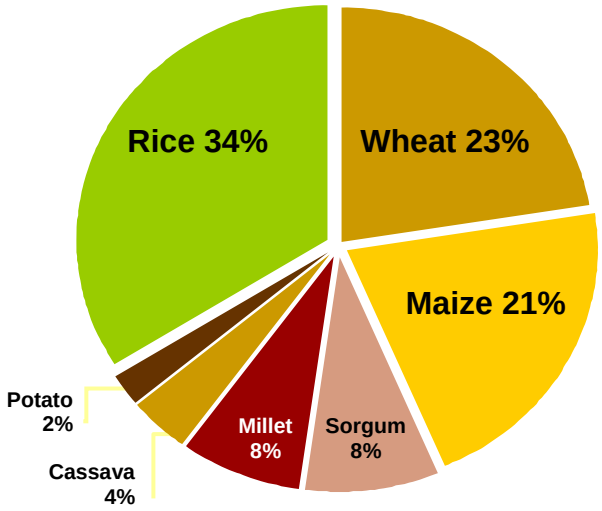
Annex 2: A Strategic Position for CIMMYT

Maize and wheat in the developing world today

In a world with where one person in eight goes to bed hungry, where chronic hunger afflicts 800 million people, maize and wheat (along with rice) underpin the world food supply, providing 44% of the total edible dry matter and 40% of the food crop energy consumed in developing countries. To achieve the main United Nations Millennium Development Goals (MDG) to reduce by half the proportion of the world living in extreme poverty and hunger by 2015, more than 22 million people will have to escape poverty and hunger every year. The greatest numbers of the hungry are concentrated in Africa, where maize is the dominant cereal, and the northern part of South Asia, where wheat is a dominant cereal. In developing regions maize and wheat cover around 200 million ha of crop land, approximately half the 440 million ha presently sown to cereal crops. They are the principal food crops for a majority of the 2.5 billion farming population in developing regions. The two crops are pivotal to improved nutrition, health, incomes, and livelihoods for most of the 4.9 billion people living in developing countries. For example, annual maize consumption per capita in Malawi is 135 kg, and annual wheat consumption per capita in Tunisia is 208 kg. Because maize and wheat are significant crops in so many countries, their improvement is crucial for the economic development of low income countries – and arguably to political stability and global security as well.

Although both maize and wheat are traded internationally, and developing countries have become major importers (wheat accounts for 43% of food imports to developing countries), the reality is that 87% of maize and 81% of wheat consumed in less developed countries is produced and utilized within the same country, if not the same community. In these circumstances, many poor households depend on increased maize or wheat production on their own farms for improved household food security.

Figure 1: World food supply by dry weight (from N. Borlaug, and FAO)

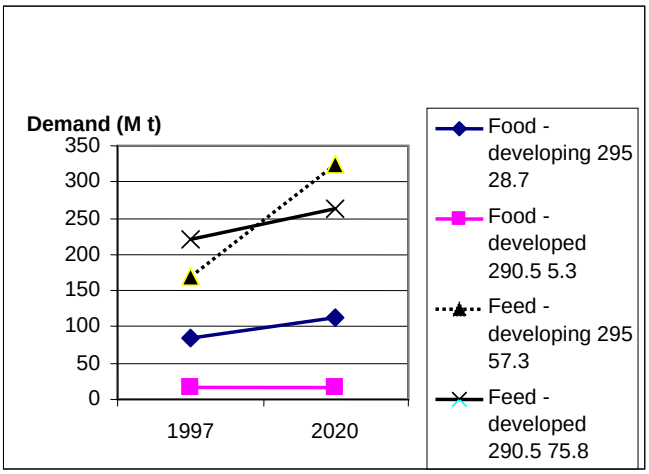


Source: FAOSTAT (2003).

Maize and wheat in the developing world in the future: Challenge and opportunity

The area planted to maize and wheat is projected to grow to 254 million ha by 2030. Moreover, global average will have to increase during the coming 25 years: for wheat from 2.6 t/ha to 3.5 t/ha; and for maize from just under 3 t/ha to 4 t/ha. Such increases in yield, which are essential to maintain global food security, require a continuing supply of improved maize and wheat germplasm.

Figure 2: Demand trends for maize as food or feed.

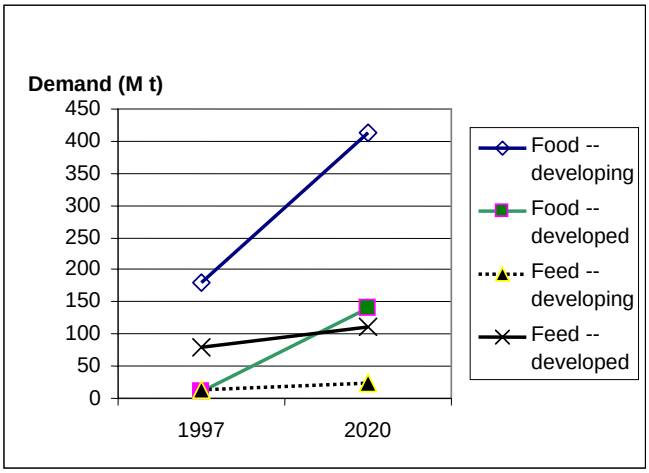


Without maize, the world would have 600 million tons less food and feed each year; and populations in Eastern and Southern Africa, 510 fewer calories per capita per day on a continent where food shortages and famine are common. The projected growth in demand for maize for human consumption in developing countries is 1.3% per annum in the period up to 2020. However, largely because of the widely-proclaimed livestock revolution, demand for feed maize is expected to grow at 2.9% per annum. The required additional

production amounts to no less than 213 million tons, compared with the production of 295 million tons in 1997.

Growth in wheat production in developing countries is expected to be somewhat less than that for maize. In the period leading up to 2020, demand for wheat for human consumption in developing countries is expected to grow at 1.6% per annum, and for feed at 2.6% per annum.

Figure 3: Demand trends for wheat.



An Analytical Framework for CIMMYT research planning

The following analytical framework is based on socio-economic analysis oriented to the improvement of livelihoods and the reduction of poverty, contextualized within diverse research and development innovation networks and impact pathways for maize and wheat production and value chain systems.

During the decades following the Green Revolution, improved cereal germplasm made a major contribution to global food security through increased food production and reduced food prices for urban and rural poor. Most of the additional food was produced in irrigated high-potential areas, often by farmers with reasonable access to resources and markets. There were also some indirect benefits in the form of spillovers, as germplasm targeted to irrigated areas was adopted by farmers in medium-potential rainfed areas. Global food security remains a challenge in coming decades because of the need to feed expanding cities, to meet the increased food staple requirements as the poor escape poverty, and to address the increased demand for animal feed.

More tha half of small farmers who subsist beneath the poverty line depend on the contribution of maize or wheat production to their household food security. There is scope for pro-poor targeting of maize and wheat research to resource-poor farmers in marginal environments to improve their food security and to release resources for diversification to other, higher value crops, to livestock, and to other value-adding on-farm activities. For CIMMYT research to make a difference in the lives of these poor

people, it is essential to consider not only yield, but also risk, vulnerability, and the multiple roles of wheat and maize in complex farming systems with diversified livelihoods, the patterns of which vary within and between different eco-regions. Spillovers from high-potential to medium-potential areas have augmented the large direct benefits to target farm populations. The question is the extent to which substantial "reverse" spillovers might occur, in the sense that germplasm targeted to marginal areas could generate farm benefits for higher- and medium-potential areas. An example is drought tolerant wheat germplasm.

In parts of South Asia and the Middle East, the dominant role of wheat and especially maize on small farms is changing from staple for home consumption to cash crop, not only to feed the "livestock revolution" but also as high-value niche products (baby corn, "friki", wheat's for specialized breads, biofuel, bioplastics, etc). The handling of grain along the value chain also generates significant employment and income in rural areas. Maize and wheat will, therefore, contribute a major share of the increase in rural household cash incomes and the value of agricultural sector output in the coming decades, in some countries more than so-called "high value" crops. Furthermore, increased and more reliable yields of maize and wheat which assure household food security encourage diversification to other income-generating farm and off-farm enterprises. For example, wheat and especially maize will provide most of the feed required by the livestock revolution. Additional benefits will derive from the high feed value of QPM maize, which was developed by CIMMYT to meet human nutritional needs. Thus, maize and wheat improvement offers substantial contributions to global food security, poverty reduction, and rural economy growth.

Beyond the farm gate, the intensification of maize and wheat production on small and large farms generates additional indirect benefits (beyond those arising from the cereal value chains), in that extra farm income stimulates the local non-farm economy, creates new jobs, and reduces poverty, especially among the landless—those often referred to as the "poorest of the poor."

Potential direct and indirect impacts, therefore, need to be taken into account when prioritizing crop improvement research. There is a need to note not only the food security benefits, but also the distribution of benefits among farmers and consumers, the indirect benefits to farmers from diversification, and the benefits to other rural poor through jobs created in the local non-farm economy.

CIMMYT recognizes the diverse livelihood strategies and vulnerabilities of farm women and men that influence their needs for and ability to adopt and benefit from various improved traits and crop management knowledge. In addition, the existence of transaction costs in local seed, produce, and finance markets and institutions are important determinants of farmers' adoption of new cultivars, improved management knowledge, and sustainable utilization of crop genetic resources. Clearly, some of these factors can explain the variation in production functions within agro-ecological zones and can influence the nature of the supply response, which underpins the estimation of economic surplus, to the adoption and management of new cultivars. From an analytical

perspective, farmers and their local institutions can be grouped into relatively homogenous farming or livelihood systems—that is, target domains—with similar constraint and opportunity sets. These target domains provide a systematic basis for assessing adoption and people-level impacts of released cultivars, as well as potential impacts of new traits under consideration. Improved specification of farm household characteristics also helps with one critical challenge facing impact assessment: the identification of a satisfactory counterfactual.

The second major challenge for impact assessment is attribution, which is closely linked to the functioning of the innovation network. Innovation in agriculture is a complex, non-linear social and economic learning process with significant feedback loops. It occurs as a result of cooperation and interaction among farmers, private firms, public officials, and technical specialists in a systems web. An impact pathway describes the dominant chain of events linking research outputs such as germplasm or knowledge to farm household-level impact. The key is to map the chain of events linking research outputs through their uptake by intermediate actors (generating "outcomes") to their eventual adoption by end users (generating "impacts"). Generally, impact pathway analysis provides plausible specification of the dominant links and critical roles of the key actors leading to the adoption and better management of improved germplasm and knowledge on farmers' fields.

Impact assessment and other socio-economic research, particularly where results are spatially explicit, provides a knowledge base to support research decision making in general, and priority setting and targeting in particular. Priority setting depends on the assessment of the expected impacts of the research activity on food security, poverty and the environment, which depend on the magnitude of the potential benefits to the target population and the effectiveness of impact pathways to deliver the research products to ultimate beneficiaries. Normally such estimates of the expected impacts inform a consultative process with major stakeholders.

In the context of farmers' diverse livelihoods and needs and the systematic variation of innovation systems, CIMMYT social scientists generate and disseminate knowledge-based international public goods related to past and potential impacts on farm households, sustainable utilization of crop genetic diversity, and nutritional and economic grain quality traits to support decision making on priorities and targeting. Social scientists support the sharing of maize and wheat scientific knowledge across innovation networks, and further strengthen partners through practical capacity building.

Challenges for maize and wheat improvement in the developing world

The development of genetic enhancement international public goods depends fundamentally on effective custodianship of the global maize and wheat genetic resources. Through the application of advanced methods, which are progressively declining in cost, improved traits and lines (enhanced germplasm) can be identified and developed with high and stable yield, multi-stress resistance (to drought, low soil fertility,

pests, and disease), and quality traits, and which are targeted and accessible to resource-poor farmers, ultimately for the alleviation of hunger and improvement of livelihoods.

Many international policy makers are concerned about the rapid growth of poverty and the prevalence of droughts in Africa, where maize is the main food crop. Major challenges include the availability of drought tolerant improved maize varieties. Insect and disease resistance is also required. Meanwhile, in Asia, maize is expanding rapidly and displacing other crops, largely driven by the burgeoning demand for livestock feed.

The demand for wheat in developing countries will place an enormous strain on scarce land and water resources, as an additional 150 million tons will be required by 2020, over and above the 340 million tons produced in 1997. The challenge in the coming decade will be even greater because, for the last decade, global wheat production has stagnated. Given the strong competition for resources, and especially water—agriculture accounts for some 70% of global fresh water use—improvements in the water productivity of maize and wheat are important agricultural research thrusts which also contribute to drought proofing. Recurrent drought in some regions, especially South Asia and Southern Africa, are a major cause of hunger and poverty

Gains in maize and wheat productivity are continuously threatened by diseases and pests. For example, the emergence of grey leaf spot in Eastern Africa rendered useless a number of popular new maize varieties in Malawi, Tanzania, and Kenya. It is estimated that a virulent new strain (Ug9) of stem rust attacking wheat crops in Kenya and Ethiopia could cause global losses in wheat production worth US$ 2–8 billion yearly, if it is carried on prevailing winds through the Middle East to South Asia. Trade can also be affected by wheat scab and aflatoxins. For this reason research to introduce and maintain resistance to pests and diseases in maize and wheat is a high priority.

Product quality is of growing importance for both maize and wheat. The widespread adoption of QPM maize in Kenya would reduce the feed costs of the broiler industry by approximately 5%. Similarly, QPM maize has been shown to increase the average daily growth rate of pigs in China. More recently, the potential importance of biofortified maize and wheat (beta carotene enriched maize or Zn and Fe enriched wheat) for under-nourished populations is being evaluated.

Both Science Council priorities and MDGs underline the importance of sustainable resource management. The Rice-Wheat Consortium has shown that resource conserving technologies can be adopted widely, if conditions are right and proper efforts made. Experience in successful conservation agriculture needs to be transferred within and across regions and over time the G x E x M interactions explored.

The effectiveness of the CGIAR depends very much on the capacity of partners, and especially NARSs. Evidence shows that the number of wheat scientists per million ha of wheat has increased only slowly since 1990, from 114 to 154 scientists per million ha of wheat. Therefore, a major effort is required in capacity building, especially of NARSs, but also private sector.

Underlying these challenges, the importance of understanding the delivery or impact pathways for the products and knowledge related to maize and wheat improvement is now generally recognized. The knowledge of the ways that these complex networks of public, private and farmer actors function provides guidance to breeders in the priorities for genetic enhancement. Moreover, ex post and ex ante impact assessment and targeting are critical research areas for sustained improvements to research efficiency.

All these are areas where CIMMYT can make the vital difference.

Annex 3: Program and Unit Strategies

Overview of Genetic Resources and Enhancement Strategy

Crop genetic resources are 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 the development and application of bioscience-assisted methodologies and tools for the efficient identification and manipulation of value-added traits and their rapid introgression into elite agronomic backgrounds. In this context, CIMMYT will use all necessary means of finding, introducing, or creating beneficial genetic variation, including new linkages and mutated alleles from cultivated germplasm, novel genomic regions from crop-related germplasm, and unique transgenes from beyond species barriers. In this way, CIMMYT reaffirms its position as a leading provider of international public goods, in the form of genetically enhanced, seed-embedded technologies, for public and private sector breeding programs across our target regions.

Effectively integrating modern bioscience innovations into plant breeding requires a whole range of soft skills which the Genetic Resources and Enhancement Unit (GREU) is committed to providing under the leadership of its maize and wheat molecular breeders. Not least amongst these is driving a new paradigm in crop improvement through harnessing *in silico* methods, most importantly to help integrate and collectively analyze data from across the continuum of genebank to farmers' fields. In so doing, CIMMYT is redefining the notion of a product in the context of the value chains within which we operate. Where NARSs are gaining strength and the private sector are gaining presence, CIMMYT will be focusing its efforts more and more on the development of upstream intermediate products: novel genes from germplasm collections, new bioscience tools and methodologies and trait-enhanced breeding populations. In all these cases, trait-targeted methodologies and trait-specific improved germplasm will become our predominant currencies.

This transition will require CIMMYT and its partners to foster a new architecture of innovation, replacing the conventional linear technology transfer model with a much more systemic and iterative planning and review model involving representatives from across the entire value chain at all stages of project planning, implementation, and product refinement and deployment. This approach will allow CIMMYT to focus on areas of greatest need where we provide greatest added value, while being able to advocate and support other public and private sector players to engage most effectively in the other elements of the product development and delivery.

CIMMYT's operational structure will be formed around relatively small, dynamic, multidisciplinary, trait-based, product-driven teams empowered to operate as task forces within the overall conceptual framework provided by the commodity programs and the product-orientated Projects. It is these soft implementation teams that will provide the holistic perspective across the hard administrative structure of the institute. Moreover, it is these multidisciplinary teams that will reach out for broader orientation from the rest of the respective value chain.

This new model will clearly require CIMMYT to work much more closely with the private sector across its entire portfolio of activities. Inevitably, this will require CIMMYT to develop a new range of skills and capacities, not least to populate the intellectual space between public sector research outputs and agricultural products. This is perhaps the greatest challenge, as it requires a cultural shift in the plant biosciences community where the credibility of product development research remains low and difficult to publish. Equally important, it requires CIMMYT to develop and adopt a predominance of interdisciplinary scientists. For GREU in particular, this will become a defining theme and an increasingly pivotal component of our success.

When successfully established, this model will allow CIMMYT and its partners to address the final frontier of integrating the information continuum from genebank to farmers' field, thereby fostering a new knowledge-led paradigm of design-driven, demand-informed breeding. This will allow us to address a number of fundamental constraints to maximizing the utilization of crop genetic resources and sustaining the historically rapid genetic gains in plant breeding programs—now increasingly required in resource-poor cropping systems:

- Systematically identify important trait-specific gaps in our germplasm collections.
- Optimize rapid and efficient trait-targeted methodologies for identifying beneficial novel genetic variation.
- Develop precise and cost effective methodologies for simultaneously manipulating large numbers of target genes and genomic regions.
- Combine the above through simulation decision support tools to provide easily used, knowledge-based, design-led crop improvement strategies.
- Provide the knowledge and tools to allow plant breeders to profitably manipulate the genetype-by-environment interaction and epistasis that has for so long constrained the obtention of rapid impacts in resource-poor cropping systems.

Global strategies for maize and wheat

Two overall crop strategies are developed, reflecting the unique nature of maize and wheat. These commodity strategies are based on novel genetic variation and new tools and methodologies to effectively manipulate that variation that flow from the Genetic Resource and Enhancement Unit, while our socioeconomics research provides the contextual backdrop for orienting and evaluating all our research and breeding activities, so that products and activities are direct relevant to target beneficiaries.

Overview of CIMMYT's maize strategy

CIMMYT has significant assets available to conduct and deliver key products and technologies to those who depend on maize for food, nutrition, or income. These include the world's largest collection of tropical maize genetic resources; significant and evolving knowledge in developing genetically enhanced tropical maize; excellent

understanding of the complex biophysical and socioeconomic dynamics of maize-based farming systems and institutional delivery pathways relevant to resource-poor farmers and low-income countries; and an extensive network of partners.

The specific goals of the strategy are to conserve and facilitate access to the wealth of diversity and benefits contained in the world's maize genetic resources. This will be accomplished through (1) genetic enhancement projects targeted at highest priority traits and products and (2) research and work with partners to maximize impacts on poverty reduction, resource conservation, and sustainable development from the development and use of genetically enhanced maize and maize-systems related research. Our focus is on:

- Equitable access and effective use of the world's maize genetic resources for increased and sustained world maize production, diverse uses of maize and maize products, and decreased vulnerability of the global and local communities to environmental adversities.
- In low-income countries and regions where maize is an important staple, increased food security and crop diversification, due to sustained productivity increases in maize, and decreased malnutrition and better health of populations at risk.
- New income opportunities for resource-poor, smallholder farmers using maize-based systems.
- Wider use of sustainable crop management practices in maize.
- Stronger national and regional maize research and delivery capacities and more effective links to development partners working with maize-based systems and the maize commodity chain.

Overview of CIMMYT's wheat strategy

All wheat improvement activities (both for germplasm and wheat-based cropping systems) and all associated product deployment activities will be managed under a single commodity program. Research and breeding will be conducted worldwide, through a decentralized hub model where the location in which activities are carried out will be determined by a combination of cost and scientific opportunity criteria. At the heart of this will be an expanded shuttle breeding approach systemically integrating NARSs partners in regions where there are trait hot spots, thereby providing a mechanism for iterative exchange of material and evaluation data through germplasm improvement. This will also allow the effective integration of technologies such as physiology, entomology, pathology, computational sciences, and biotechnology in all components and locations of the product development cycle. Through this process, it is expected that for every target location both CIMMYT and its partners will be able to differentiate their roles to maximize complementarities, efficiency, synergy, and impact.

Innovative breeding approaches will be pursued, particularly to address crop needs under resource conserving practices and those related to nutrition. Work will focus on the targeting of traits, mega-environments, and the use of participatory methods, especially in marginal environments. The portfolio of four Projects in the program will be guided by the following approaches:

- Introduction of new and novel sources of variation through wild species and, potentially, the use of transgenes for intractable traits.

- International shuttle breeding.
- Increased breeding efficiency through marker-aided methods and more targeted use of physiology, genetics, and statistics to improve the design of crosses as well as early generation selection.

We will increase the focus on the needs of end-users by emphasizing regional efforts in participatory research and client-oriented plant breeding.

Overview of CIMMYT's social sciences strategy

The strategy is framed in the context of rapid change and the increasing commercialization of the maize and wheat industries; modest staff resources with a clear comparative advantage at the micro- and meso-levels; the substantial need for social science analysis and services in the delivery of flagship products; the need for improved internal mechanisms for multi-disciplinary research; and the desirability of strengthening external partnerships in social sciences. Further detail on CIMMYT's social sciences strategy as well as the analytical framework which guides social science research, appear in supporting documents (Part B). There are four main pillars or research areas of social science research in CIMMYT:

- First, the conduct of ex ante impact assessment and the creation of knowledge bases within an eco-regional context. Together these form the basis of CIMMYT's priority setting and targeting. CIMMYT and its partners will conduct research on direct and indirect impact and innovation networks that link improved germplasm and knowledge to livelihoods improvement and poverty reduction, as well as the assessments of ex post impacts.
- Second, the better understanding of farmers' sustainable utilization and management of maize and wheat diversity is essential to targeting and crop improvement research. This has particular relevance for maize in Mexico and wheat in the Middle East, notably Turkey, where analyses with partners are on-going.
- Third, the analysis of nutritional and valued-added traits in maize and wheat. Social scientists have been asked to take the lead in the analysis of markets and value chains for new traits in maize and for quality enhancement in wheat. This is in the context of the increasing use of cereal grain for feed that underpins the livestock revolution.
- Fourth, the sharing of science knowledge and the building of capacity are essential building blocks for a responsive agriculture research community. Social science plays an important strategic role in identifying capacity building needs. Furthermore, it is key to the development of the IRRI CIMMYT Cereal Systems Knowledge Bank.

CIMMYT social scientists blend a variety of approaches and analytical tools, including the following: scenario analyses to inform priority setting; zonation of mega-environments and farming systems (target domains) within eco-regions for priority setting and targeting; ex ante and ex post impact assessment, based on, inter alia, economic surplus estimation; meta-analysis of livelihoods and poverty information; mapping direct and indirect impact and innovation pathways/networks; and economic studies of value chain approach. Multi-disciplinary task team work is the norm.

Funding of social sciences depends for the major part on either unrestricted resources or components of research projects from other maize or wheat scientists. In these circumstances, Management provides strong support for social science and ensures that science projects contain adequate social science analysis, in either an ex ante or ex post sense. On average at least one international level professional is foreseen per Project, the exact volume and types of expertise (most of the Projects require social science analytical skills from several individuals) depend on the objectives of the Project.