CIMMYT

Science and Partnerships to Reduce Poverty and Hunger

Medium-Term Plan of the International Maize and Wheat Improvement Center (CIMMYT) 2005-2007+

July 2004

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CIMMYT® (www.cimmyt.org) is an internationally funded, not-for-profit organization that conducts research and training related to maize and wheat throughout the developing world. Drawing on strong science and effective partnerships, CIMMYT works to create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources. Financial support for CIMMYT's work comes from many sources, including the members of the Consultative Group on International Agricultural Research (CGIAR) (www.cgiar.org), national governments, foundations, development banks, and other public and private agencies.

Correct citation: CIMMYT. 2004. ***Science and Partnerships to Reduce Poverty and Hunger: Medium-Term Plan of the International Maize and Wheat Improvement Center (CIMMYT), 2005-2007.*** Mexico, D.F.: CIMMYT.

Abstract: This publication describes how CIMMYT and its partners are applying science to reduce poverty and hunger through six new research programs established as a result of the Center's recent strategic planning exercise. It outlines the challenges the programs are designed to meet and their activities and expected impacts, with details on financing, staffing, and contributions to the objectives of the Consultative Group on International Agricultural Research (CGIAR).

AGROVOC descriptors: Planning; project management; research projects; research institutions; research support; budgets; finance; international organizations; trends; technical properties
Additional keywords: CIMMYT; CGIAR
AGRIS category codes: A50 Agricultural Research; E14 Development Economics and Policies
Dewey decimal classification: 658.404

Printed in Mexico.

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Part 1: Introduction

Poverty and Livelihoods

Impacts on poverty and the livelihoods of the poor are CIMMYT's starting points for targeting agricultural research and development. To clearly focus its work in this direction, CIMMYT undertook an extensive strategic planning exercise in 2002-03 (see CIMMYT's new strategy, "Seeds of Innovation: Strategy for Helping to Reduce Poverty and Hunger by 2020). By providing agricultural alternatives that empower people to improve their way of life, CIMMYT and its partners can set in motion a chain of events—such as greater access to nutrition, health, information, markets, and wider social participation—that contribute to sustainable development. Confidence in this approach is based on robust evidence that agricultural research and technology help to reduce poverty, especially in Africa and Asia, and are often more effective than interventions in other sectors.

In line with the aim of reducing poverty, in 2004 CIMMYT has restructured its global research agenda and mode of operation. Research management has been strengthened by organizing the Center's work into a matrix of six research programs and five disciplinary groups, as well as through the appointment of a Deputy Director General for Research. The matrix is designed to ensure the close contact of CIMMYT researchers with partners and clients; the disciplinary groups serve among other functions as monitors of scientific excellence. To improve the relevancy of programs and develop enhanced outputs that can be adopted by partners, the Center is deploying several program directors to strategic locations in the developing world. A critical component of this transition will be an open search, to be completed by the end of 2004, for the most skilled talent to lead the newly formed research programs.

Partnerships are one of CIMMYT's key assets, a fact resoundingly echoed by stakeholders in the consultation conducted as part of strategic planning. Reflecting this assessment, the Center will strengthen and expand linkages with a range of partners, including other CGIAR centers, the CGIAR Challenge Programs, various regional and system-wide programs, national agricultural research systems (NARS) in developing countries, non-government organizations, and public and private research institutes.

As mentioned above, in the deliberations leading to its new vision, CIMMYT has not lost sight of its main intervention point for reducing poverty and hunger: the application of quality science. The following sections of this introduction first outline the Center's continuing efforts to harness the best science available in ways directly applicable to the concerns of partners and the resource poor. Next comes a description of the new programs, including the challenges they are designed to address, their expected outputs, and the impacts for which they are to be held accountable. The introduction closes with a statement of how CIMMYT is managing its resources to ensure achievement of the new vision.

Applying Quality Science to Reduce Poverty

People Focused Methods (Social Science / Anthropology / Human Ecology/)
CIMMYT will use a wider spectrum of social science and anthropological methods and tools to understand technical innovation and develop new strategies to address the complex needs of the poor, helping to lift them from poverty and misery. Social science will play an increasingly

important role in research on complex issues regarding users' perspectives, farmers' local knowledge, and the social rules that affect their behavior and well-being. Much information related to these issues is best elicited using qualitative ethnographic and participatory methods. CIMMYT will give increasing attention to ways in which qualitative and quantitative approaches can be combined, and we will systematically study the variation/variability of results and lessons learned from participatory methods applied to common global problems.

Policy Analysis
CIMMYT's programs and partnerships offer a unique vantage point for examining factors that affect the productivity of maize- and wheat-based farming systems in developing countries. Approaches for analyzing these factors, diagnosing constraints to technical change, and prescribing policy interventions to overcome constraints will feature more strongly in the Center's research. Much of the work will be done in close cooperation with NARS and CGIAR partners.

Breeding Approaches with Farmers in Mind
How can the scarce resources of breeding programs in developing countries be used effectively to make an impact in difficult environments? Insights into this question rarely come from graduate training at universities in industrialized countries, but they do come from innovation, experience, and collaboration in the target environments. CIMMYT helps to meet the challenge by bringing together innovative partners of diverse affiliations in the use of new breeding and seed dissemination approaches. Many small-scale farmers still lack access to improved seed or use outdated improved varieties. CIMMYT is committed to research that accelerates the development and deployment of stress tolerant, stable, and well-accepted crop varieties; training in new breeding approaches; and collaboration that increases the effectiveness, impact, and sustainability of breeding approaches in developing countries. As part of this, the Center has developed and helped others to implement alternative maize and wheat breeding approaches that systematically improve varieties' resilience under farmers' conditions, while satisfying other farmer criteria for a "good" variety. Models for participatory breeding and varietal selection have enabled small-scale farmers to influence large-scale breeding priorities and to make informed choices about what variety to grow. Work will continue, drawing added strength from the social science capacity mentioned above.

Where farmers earn an income from their maize and wheat crops and must meet stringent quality standards, CIMMYT can provide varieties with improved micronutrient and protein content, improved quality for specialized food and feed products, and improved storability, among other value-added traits.

Understanding complex genotype x environment interactions. A better understanding of G x E is needed to develop system-based solutions to farmers' problems. The use of international trials, coupled with more sophisticated statistical analyses, remote sensing, crop modeling, GIS, and improvements in CIMMYT field trials, will open the way for much more precise development of varieties and crop management options for specific target environments. CIMMYT's extensive partnerships make it possible to quantify G x E through experiments at agronomically representative sites worldwide.

Geographic Information Systems and Remote Sensing
In collaboration with a private GIS company, the Center has developed, distributed, and provided training to developing country partners on a suite of packages for specific countries and regions. Work in this applied and enabling mode will continue. Meanwhile, the growing availability of spatial data, access applications, and models will significantly influence the ways in which CIMMYT assesses adoption and impacts, makes decisions, targets and promotes technologies, and manages information. Geographic information systems will become seamlessly linked to simulation models to guide the development and diffusion of new technologies on a wider scale. Developments in three other areas are of particular interest: global positioning system (GPS) technology, high-resolution imagery and satellite sensors, and timely (real-time) data provision.

Improving the Efficiency of Field Research
The application of powerful statistical tools can contribute significantly to improving the quality of data obtained from field trials and to reducing their number and size. Technological advances, such as equipment that collects data, handles and packages seed, and automatically recognizes plots and samples, will save labor and time. Sensory tools will increase field selection efficiency and effectiveness by permitting tens of thousands of single plant progenies to be screened in relatively small areas before larger trials are conducted. Physiologists will continue to identify traits that enable significant improvements in the efficiency of early generation selection by saving time, land, and other costs associated with direct estimates of yield.

Biophysical Systems: Research on Soil and Root Health
The intensification of agricultural—particularly in monoculture systems in marginal areas—has often disturbed the soil's ecological and structural balance. One result is that soil-borne agents such as microscopic nematodes and root-rotting fungi begin cutting into crop yields. In combination with drought and micronutrient deficiencies, these pathogens can reduce yields by as much as 60%, and many scientists and farmers are unaware of the problem. Continuing work begun several years ago, CIMMYT will address these “underground problems” through a systems-oriented, interdisciplinary approach. New technologies, particularly from molecular biology, will enhance the understanding of factors affecting soil health, plant productivity, and system sustainability. Wheat cultivars that resist multiple root diseases and tolerate micronutrient imbalances will be the most economic options for farmers and will also use soil moisture more efficiently. Significant genetic variability for several of these traits exists in the wheat gene pool, and CIMMYT has obtained the associated molecular markers through partnerships with advanced research institutes. Genetic engineering, based on a better understanding of gene function, may play a major role in developing resistant varieties.

The underlying effects of crop management on soil health will also receive attention, as researchers determine which practices (diversification, rotations, and/or alternative soil management) are best for healthy soils and plants. Direct seeding without tillage, commonly referred to as "zero-tillage," is being adopted rapidly in South Asia to sow wheat after rice; CIMMYT and partners will study the long-term health of soils under this practice.

Extending the Use of Conservation Agriculture
Conservation agriculture includes the retention of crop residues as mulch, zero-tillage, crop rotations, and in some cases green manure cover crops. Over 70 million hectares are under conservation agriculture around the world, largely in the Americas and Australia, and the practice has spread mainly through farmers. Frequent constraints to its adoption by smallholders, however, include the need for retaining residue (which many small-scale farmers use as animal feed), for special seeding implements (generally of little interest to large-scale manufacturers), for input and credit systems, and for convincing tradition-bound scientists and farmers of its benefits. CIMMYT will continue to interact with conservation agriculture networks and farmers’ associations and use its expertise to catalyze innovation systems in poorer rural populations. Among other things, this will involve (1) facilitating the exchange of information on small equipment and its local adaptation and manufacture; (2) fostering the development of the specialized input supply systems required; and (3) providing relevant component technologies and knowledge through research on genotype x environment interactions, soil and root health, and related topics.

Integrated Natural Resource Management Research
The key word in research on natural resource management is “integration.” Efforts to foster adoption of new resource-conserving technologies need to be integrated with supporting policies. Technology development needs to be integrated with farmer and private-sector participation. Individual incentives to change natural resource management practices need to be integrated with rules governing common property and collective action. Information on near-term technology performance needs to be integrated with information on longer-term consequences. Technical innovations need to be integrated with institutional innovations. An understanding of how natural resource management practices work at the plot or village level needs to be integrated with an

understanding of their outcomes at higher levels of analysis (e.g., the river basin). At the broadest level, the interaction of all partners in the development and dissemination of resource-conserving practices needs to be integrated in the context of an innovation system.

New science will be used to achieve better integration at less cost. New crop and system models will be more capable of simulating the long-term performance and riskiness over time of resource-conserving technologies. Plot-level models will be linked closely with river basin models to determine such things as the consequences of plot-level water savings on basin-level water balances. Information technology will facilitate the sharing of information on what works, where, and why. The new science of innovation systems will help integrate the efforts of different stakeholders to deal more effectively with productivity and sustainability issues through improvements in natural resource management.

Biotechnology Tools to Unlock and Leverage Genetic Potential

One exciting aspect of CIMMYT's new strategy is the cross-linking of disciplines and the building of partnerships with world class organizations, allowing for a comprehensive, integrated approach to crop improvement. This and advances in molecular biology will allow Center researchers to identify, locate, and define the functions of genes of interest, as well as to apply learning across cereal species (see Box 1). A challenge for CIMMYT and its partners—among them, the CGIAR Generation Challenge Program—will be to use this capability to address the needs of small-scale farmers.

Molecular fingerprinting. Important applications of fingerprinting for CIMMYT include improved management of genetic resources in the genebank, identification of useful combinations of inbred lines to make hybrids, more efficient pre-breeding research, detection of allelic variation for further phenotypic screening, and the protection/identification of individual varieties. Newer methods based on single nucleotide differences (SNPs) will provide better discrimination among maize and wheat genetic resources. In addition, the application of functional genomics to genetic resources will provide more detailed analysis of potentially useful genes for breeding. CIMMYT must learn how best to access fingerprinting technologies and develop database systems that allow worldwide sharing of the resulting information.

Marker-assisted selection (MAS). CIMMYT will maintain and build its capabilities in this area, especially in regional programs. Among other things, this will require a high-throughput laboratory for routine analysis of markers, along with information systems that provide results rapidly to researchers. Efforts at CIMMYT or through collaboration with advanced research institutes to develop new marker systems and/or linked markers for additional traits will be undertaken based on CIMMYT’s research priorities and with a view to reducing breeding costs. Advances in comparative genetics will allow linked markers to be used for more than one cereal species. Advances in genomics will allow the simultaneous identification of many traits—and markers—for MAS.

Gene and trait mapping. A prerequisite for MAS is the identification of linked molecular markers. The development of sets of molecular markers that can saturate a genome has provided powerful tools for mapping specific genes and genomic segments responsible for particular phenotypes. The role of mapping is changing, as functional genomics research progresses, but mapping will remain important for some time to validate candidate genes for a given trait and to develop contrasting materials for use in functional genomics approaches. CIMMYT has a number of segregating populations and genetic resources that are useful in mapping studies, whether in-house or through partnerships.

Functional genomics and gene discovery. Genomics, the study of the genome of living organisms, is made possible by the rapid achievements in molecular biology combined with properly phenotyped genetic resources and information science. In addition to innovations from the private sector, advanced research institutes are developing publicly available genomics tools and information to identify genes for a range of traits in many biological systems. Given gene and

genome similarities among all organisms, and especially among cereal crops, much of this research is applicable to maize and wheat. The public sector has recently finished sequencing the rice genome, is sequencing a significant portion of the maize genome (including the recent release by the private sector of significant quantity of maize sequence data), and has initiated discussion on a similar project for wheat.

One of CIMMYT's primary contributions to this work will be to continue supplying key maize and wheat segregating populations and lines. These materials represent extremes in phenotypic expression for important, stress-related traits, such as tolerance to drought and nitrogen-deficient soils or acidic soils, and resistance to fungal diseases and insect pests. Another important contribution will be to continue providing molecular maps with genes and genetic regions (quantitative trait loci, or QTLs) identified for stress tolerance/resistance. By combining the genetic resources and trait knowledge available at CIMMYT with genomic tools and knowledge in the public and private sector, the Center will be able to identify key genes for important traits—information of great use in its own breeding programs and those of partners.

Gene discovery for pre-breeding research. Pre-breeding research seeks to identify genes or gene complexes for traits of value in breeding, and to make the trait available to breeders in a readily usable form (see Box 1). The efficacy of this work can be measured in the expression of valuable traits in locally adapted, finished varieties. Pre-breeding research at CIMMYT will benefit by adopting an applied genetic resources approach that takes advantage of new science and incorporates all genebank operations, including collection, characterization, and regeneration. CIMMYT will interact closely with plant breeders and a range of partners to set priorities and evaluate accomplishments in this area.

Box 1. Taming "Wild" Genetic Diversity

Over millenia, the grasses known as wheat's "wild relatives" have been exposed to cold, drought, heat, waterlogging, and all kinds of diseases and pests. The species alive today have acquired a genetic protection that is almost invincible. Now a brilliant pre-breeding strategy is reclaiming this genetic heritage for bread wheats.

Realizing the wealth of useful traits in wheat's wild relatives, CIMMYT scientist Dr. Abdul Mujeeb Kazi used an elegant and effective strategy to transfer those traits into improved bread wheat, the most commonly used wheat. This painstaking research, which Dr. Kazi has conducted for more than 15 years, involves crossing durum wheat with a wild relative to replicate the original cross that gave rise to bread wheat in nature about 10,000 years ago. The CIMMYT program has been far more successful than other programs in applying this technique, and the "original" wheats it produces have inherited the genetic protection that served their undomesticated parents so well.

The process does not stop there. These original wheats are crossed with high yielding, improved wheats to produce descendants that yield well and possess combinations of traits to withstand tough conditions in varied growing environments. The wheats developed show genetic resistance to six or seven diseases at the same time, plus tolerance to such problems as salinity, waterlogging, and drought. This gives them a huge advantage in most environments where wheat is grown. These materials also have a much broader, and different, genetic diversity than their "normal" counterparts. In farmers' fields this translates into more stable yields. As genetic diversity and its many advantages become increasingly important in modern cropping systems, the value of the work is increasingly evident. Dr. Kazi was named CGIAR Outstanding Scientist in 2003 for these results.

Genetic engineering. Widely publicized is genetic engineering's capability to provide completely new products for farmers (see Box 2). Its use in this regard is most powerful and critical in the case of traits for which there is insufficient genetic diversity within a species. Examples include nutritional traits such as the content of beta-carotenoid, a vitamin A precursor, in wheat, and iron and zinc content in maize. However, the ability to modify specific genes or to introduce an entirely novel gene is also an important tool for studying gene expression and physiological processes.

This approach has been adapted to investigate potential genes for enhancing drought tolerance and disease resistance in bread wheat.

Box 2: Kenya Prepares to Grow Genetically Engineered Maize

Every year, Kenya loses USD 90 million to stem borers that consume 400,000 tons of maize—about 15% of the farmers' annual harvest. The Insect Resistant Maize for Africa (IRMA) project is using biotechnology to develop varieties of maize that are resistant to insects, in particular the stem borer.

The IRMA project is being jointly implemented by the Kenya Agricultural Research Institute (KARI) and CIMMYT, with support from the Syngenta Foundation for Sustainable Agriculture. Recently, the President of Kenya inaugurated a biosafety greenhouse at the KARI National Agricultural Research Laboratory (NARL) in Nairobi. The greenhouse is being used to evaluate Bt maize developed by CIMMYT to determine the level of resistance to insect pests. Seed increase of Bt maize inbred lines and crosses to locally adapted maize germplasm will also be made to develop locally adapted maize types.

The greenhouse has been constructed following all of the necessary biosafety design requirements including features that focus on security, emergency situations, personnel, sanitation, pollen management and material disposal. All these are in accordance with Kenya's regulations and guidelines on biosafety.

Bioinformatics. Structural and functional genomics research and the massive data collections they generate have brought bioinformatics to the forefront of thinking on biotechnology research. Specifically, studies are needed on efficient ways to integrate functional genomics data with structural genomics data in public repositories such as Genbank, and to integrate structural genomics data with the contents of germplasm and breeding databases.

Several advanced research institutes, including the US Department of Agriculture, are developing genetic databases for the major crops, including maize and wheat. CIMMYT need not develop similar systems, but it will need to link to them. A comprehensive and integrated system to manage future genomic data will also be required, whether it is produced by the Center or by its partners. The platform will require links to several crop information and genebank systems, to breeding simulation software, and to the genetic databases mentioned above.

Crop information systems to amplify the power of genetic research. CIMMYT's immense collection of phenotypic information from international crop trials and its stores of maize and wheat genetic resources are arguably its most important assets. This information cannot be used effectively, however, without an information management system that links islands of data collected from dispersed research efforts and provides continuous access to a multitude of researchers around the world. As a global institute with many partners, CIMMYT is uniquely positioned to anchor such an information management system. Accordingly, the Center will make a significant strategic investment in information and communications technology to support a high-capacity, relational database platform, along with rapid data input methods that rely on geo-referencing and electronic data capture technologies. Components of this platform will include a genebank and breeding management system that integrates molecular maps and plant pedigrees, a GIS, bioinformatics systems and linkages, and data management systems relating to G x E. Information in each subsystems will be linked, permitting powerful new insights into the relationships between genes, environment, and the productivity of crops and agricultural systems.

Structuring the Global Research Program

As a framework for applying the science described in the preceding section and other aspects of its work, CIMMYT has defined six new research programs. Programs 1 and 2 are global in scope. The remaining programs have an eco-regional and systems focus, are composed of multidisciplinary teams, and will seek to develop and deliver relevant science products and services that improve the food security and reduce the vulnerability of small-scale farm households and consumers in developing countries. The challenges the programs address, outputs they will provide, and impacts they will achieve are outlined below.

Program 1: Genetic Resources
"Harnessing maize and wheat genetic diversity for humanity" (global, maize and wheat)

Challenges. Genetic resources are CIMMYT's primary asset, and the Center is ethically and legally committed to conserving and facilitating the use of maize and wheat genetic diversity for all humanity, current and future. Essential components to achieve this will include the expanded application of information technology and access to proprietary technology, information, and other resources in the private sector.

Emphasis and outputs. This global program, which contributes to two CGIAR Challenge Programs (Generation; HarvestPlus), encompasses many areas of research: germplasm collection for ***ex situ*** conservation; characterization of genetic resources; applications of genomics; pre-breeding; food safety and toxicology, especially in an overall food quality context; improved and more accessible information on genetic resources; management of intellectual property associated with germplasm; economic assessment of the value of genetic resources; analysis of policies relating to genetic resources and genetic diversity; conservation of wild relatives of maize and wheat; on-farm management of maize and wheat genetic diversity; studies of gene flow under conditions of farmers' management; and the development of alternatives that help traditional communities to continue growing unique genetic resources. The role of bioinformatics will be especially important to link vast amounts of data produced through genomics research to other kinds of information: pedigrees, trial results, and agronomic and socioeconomic data.

Projected impact. Within the term of this MTP, this program will:

- Expand CIMMYT's collection of genetic resources to include more diverse African and Asian maize varieties, wheat cytogenetic stocks, and maize and wheat genetic populations.
- Develop and use a comprehensive data management system to enable global, web-based access to information on genetic resources.
- Assess strategies for on-farm management of genetic diversity, the incentives needed to make them feasible, the effects of gene flow within and between varieties, and the implications for policy analysis and interventions.
- Enhance the molecular and phenotypic characterization of key maize and wheat accessions.
- Identify the genetic bases (genes, alleles and biological pathways) of key traits in maize and wheat through the use of genomic approaches.
- Develop and use the most effective technologies to broaden and deepen the genetic value of wheat and maize germplasm distributed throughout CIMMYT's multiple locations.
- Develop and use improved conventional and molecular pre-breeding techniques for integrating improved traits into maize and wheat varieties.
- Enhance the capacity of CIMMYT partners to manage and use genetic resources in their own crop improvement programs.

Program 2: Impacts Targeting and Assessment

"Strengthening the global maize and wheat innovation network through capacity building, policy development, and the analysis of strategic global issues" (global)

Challenges. To strengthen and increase the impact of the global maize and wheat innovation network formed by CIMMYT and its partners, it is essential to adopt new methods for capacity building, strengthen policy research, and develop center- and system-wide decision tools for improved impact. Such actions must be undertaken in a way that allows comparative analyses that cut across countries and regions. Research with a global focus is needed to understand changes affecting the economic, political, and institutional environments in which CIMMYT operates; identify cross-cutting issues that transcend national and regional boundaries; ensure that the overall portfolio of resources is being used efficiently and effectively; identify key entry points at which policy interventions can improve the likelihood that products and services will reach potential users quickly and effectively; and ensure that when CIMMYT speaks out on issues of importance to the Center and its partners, it does so in a consistent and coherent way.

Emphasis and outputs. This global program, which contributes to the HarvestPlus Challenge Program, will emphasize activities of strategic global importance: building capacity through learning and enhanced knowledge management skills, collaborative research, and mentoring (see Box 3); designing policy interventions and advocating for change; monitoring trends in the world maize and wheat economies; setting overall research priorities; and assessing impact. It will produce new information and methods for research, policy advocacy, and priority setting.

Projected impact. Within the period of this MTP, this program will:

- Establish a strong knowledge management team that can effectively bank and disseminate knowledge to CIMMYT and its partners and translate the acquired knowledge into decision support mechanisms.
- Design policy interventions to strengthen technology delivery systems and remove constraints to the adoption of new technologies.
- Encourage awareness and implementation of policies and contribute to public debate on issues of importance to CIMMYT and its partners.
- Ensure that CIMMYT's research continues to address the priority needs of farmers by monitoring long-term trends in world maize and wheat markets.
- Assist with ongoing priority setting based upon a comprehensive assessment of potential research and development activities worldwide.
- Assess and document impacts of individual CIMMYT projects as well as the global impacts of CIMMYT's work, including the impacts associated with productivity, incomes, livelihoods, and the international dissemination of technologies.

Box 3: Success is in the Hands of People

The key to the success of the green revolution was not so much the dwarf gene technology, but rather a whole package of genes and a capacity building program throughout Asia, primarily of young, keen scientists who could make it happen

- Norman E. Borlaug

As part of its new strategy, CIMMYT will establish strong, collaborative, learning and mentoring service to build human capital among research partners, rural communities, and Center staff. Empowering people to develop, deliver, and use information and products that provide new options for research or for farmers' livelihoods will require the service to:

- Coordinate, support, and innovate capacity building.
- Provide information on learning resources and opportunities within and outside CIMMYT.
- Develop instructional materials that can be adapted to specific local interests and needs.
- Connect people and organizations to foster continued learning.

The spectrum of people who learn through CIMMYT is wide. Our capacity building agenda will be based on a prioritized assessment of needs and demand, done in conjunction with partners and staff in each region,

and matched to expertise and other resources. As much as possible, courses will be demand-driven, interdisciplinary, employ rapidly developing information and communications technology, and count towards advanced degrees. All instructional materials will be available and searchable through the internet and other electronic formats. These materials will be part of CIMMYT's digital knowledge base.

Because learning needs vary greatly, CIMMYT will place greater emphasis on flexible combinations of short courses that can be locally adapted and taught. With other CGIAR centers, CIMMYT will explore and develop distance learning opportunities and other capacity building initiatives, such as the Global Agricultural Open University. Additional partnerships with universities, advanced research institutes, and private organizations in industrialized and developing countries will make it possible to offer a wider range of complementary learning opportunities and share expertise in the development of instructional materials. CIMMYT's strength in these partnerships is its ability to help people apply theoretical knowledge in a real-world setting.

Program 3: African Livelihoods

"Increasing food security in Africa through better technology and improved markets" (sub-Saharan Africa, primarily eastern and southern Africa; emphasis on maize and crop diversification)

Challenges. Of all regions of the developing world, sub-Saharan Africa poses a crucial challenge for sustained improvement of rural livelihoods and agricultural productivity. A combination of uncertain and variable rainfall, poor soils, insect pests, outbreaks of the parasitic weed ***Striga***, and poorly developed markets and rural infrastructure has stalled efforts to improve the productivity and sustainability of agroecosystems. In some countries, conflict, prevailing macroeconomic and agricultural policies, and/or a high incidence of HIV/AIDS have exacerbated these problems. Malnutrition is common among children and women.

Farm households in much of eastern and southern Africa grow mainly maize, the most important staple in most areas, to avoid purchasing it in the hungry season prior to harvest, when prices are high. Maize is frequently grown in rotation or association with groundnut, beans, or other legumes, or with cash crops such as cotton. Livelihood strategies often feature a close integration of livestock and crop management, as well as a reliance on migration and remittances. Farm households need production systems that reduce losses in bad seasons (e.g., under drought); are substantially more productive in good seasons; improve labor productivity to compensate for loss of family labor to migration or HIV/AIDS; exploit in a sustainable manner relatively favorable niches in the landscape; use scarce and expensive inputs efficiently; take advantage of locally available inputs (e.g., leaf litter, cattle manure) to maintain soil fertility; and foster market development to reduce input prices and improve product prices at the farm level.

Emphasis and outputs. This program, which contributes to four CGIAR Challenge Programs (Sub-Saharan Africa; Generation; HarvestPlus; Water and Food), emphasizes improving system resilience and productivity in the face of biophysical and socioeconomic risk. It will develop a range of maize varieties with tolerance to drought and low soil fertility (see Box 4), resistance to insect pests, improved nutritional content, or tolerance to a herbicide seed treatment that controls the parasitic weed, ***Striga*** spp***.*** In the context of local biosafety regulations and informed deliberation by civil society, the program will also explore the release of maize that is genetically engineered to resist stem borers. With partners, it will provide suitable wheat varieties to smallholders in Ethiopia. Participatory selection of varieties will expand, and systems will be established to disseminate improved seed effectively through the private sector and community organizations. The program will support efforts to make good seed reliably available at fair prices to smallholders. Policy and market analyses will be conducted to foster market development and better integrate smallholder cropping systems into national markets. Complementary research on crop and natural resource management will focus on soil fertility management practices for clearly defined land types and farmer categories. Considerable attention will be given to crop-livestock interactions.

Projected impact. Within the period of this MTP, this program will:

- Ensure that at least 15% and, ideally, many more farm families managing maize systems in eastern and southern Africa grow maize that is better at withstanding drought and low soil fertility.
- Develop and promote effective techniques to combat ***Striga***, maize field pests, and maize grain storage pests.
- Develop and promote decision aids that match resource-conserving practices with land types and farmer categories.
- Strengthen collaboration among partners to address development concerns more effectively.
- Foster market development and better integrate smallholder cropping systems into national markets.
- Contribute to the debate on policy and institutional issues affecting the agricultural sub-sector.
- Document impacts of improved practices on incomes, livelihoods, soil and water resources, and the environment.

Box 4: Strengthening Seed Production of Open-pollinated Maize in Southern Africa

In 2003, seed production of drought-tolerant maize varieties was scaled up four-fold in southern Africa compared to the previous year. The new open-pollinated maize varieties (OPVs), with tolerance to drought and low soil nitrogen, were developed through a long-term research collaboration between CIMMYT and NARS partners based on an innovative, farmer-participatory varietal testing scheme involving rural schools, NGOs, and extension agencies. Several donors, including the Swiss Agency for Development and Cooperation, the Rockefeller Foundation, and USAID, have contributed to this effort.

The new OPVs are now being grown on more than 250,000 ha in Angola, Malawi, Mozambique, South Africa, Tanzania, Zambia, and Zimbabwe. This area is expected to increase to 800,000 ha during the next season. On average farmers plant about one hectare to the new OPVs, so it is estimated that they are being grown by about 0.25 million families. The varieties have also shown to be suitable in Kenya, Nepal, and drought-prone areas of India.

Seven seed companies in southern Africa, mostly small and medium-sized, are producing seed of the new OPVs. Some of these companies have come into existence due to the accelerated demand for the new OPVs, so the development of the new varieties has had an important catalytic effect on the local seed industry. This impact is much needed, as both farming families and the seed industry have suffered the affects of repeated droughts and economic downturns.

Program 4: Rainfed Wheat Systems

"Reducing vulnerability by managing risk in rainfed wheat systems" (Eurasia, northern India, South America; comparable ecologies in southern Africa are included in the program on Africa; emphasis on wheat)

Challenges. In these ecologies, crop production focuses on bread and durum wheat, barley, and pulses, although maize is important in some areas and triticale has shown great potential as a food and fodder crop. Often livestock are at least as important as grain production in farm family livelihoods. Widespread land degradation is provoked by over-grazing of pastures, intensive tillage of agricultural land, and the grazing of crop residues. The growing period is short and options for diversification limited. Rainfall is variable, rainfall-use efficiency is low, and drought stress is common. Food security often depends heavily on wheat, which sometimes provides more than half of the calories consumed daily. Micronutrient malnutrition is widespread (see Box 5).

Farmers require production technologies that improve local and regional food security; reduce the risks associated with recurrent drought; combine livestock and crop production; make the most of limited or variable water resources; help reduce land degradation; promote efficient use of scarce

inputs; foster improved input and product markets and related institutions; and contribute to system diversification for more stable production of a wider array of crops.

Emphasis and outputs. This eco-regional program, which contributes to three CGIAR Challenge Programs (Water and Food; HarvestPlus; Generation), emphasizes the development of drought-tolerant, input-responsive, disease-resistant wheat varieties; resource-conserving technologies; crop diversification; and policy analysis and advocacy to foster market development.

Projected impact. Within the period of this MTP, this program will:

- Promote successful adoption of resource-conserving technologies, together with varieties specifically adapted to them (especially wheat with increased drought tolerance, resistance to soil-borne diseases, and better nutritional value).
- Raise water productivity and improve soil fertility by expanding cereal-legume rotations and diversifying cropping systems, including the use of cash crops.
- Improve the nutritional value of wheat.
- Help meet the demand for better livestock feed through triticale and drought- and heat-tolerant maize with enhanced protein quality.

Box 5: This Day our Daily Bread be Biofortified

Zinc deficiency is implicated in health problems throughout the world, especially across a wide band of countries in West Asia and North Africa and the Asian subcontinent where more than half of inhabitants' daily calories come from wheat. In South and West Asia, millions of heavy wheat consumers are also iron deficient. Women and children are particularly prone to zinc and iron malnutrition.

As part of HarvestPlus, the CGIAR's global alliance to breed and disseminate crops for better nutrition, CIMMYT is developing high-yielding wheat varieties whose grain contains 30 to 50% more iron and zinc. Given that wheat varieties developed by CIMMYT and its partners cover 80% of the global spring wheat area, the potential impact is dramatic. The best sources of these micronutrients are grass species that do not cross easily with modern wheats. Researchers have therefore created a "bridge" variety by crossing one such grass (***Aegilops tauschii***) with a high-micronutrient primitive wheat (***Triticum dicoccon***). The resulting varieties combine readily with modern wheat varieties, producing lines whose grain contains more iron and zinc than modern wheat. Partners in India and Pakistan are using this approach to develop high yielding, disease-resistant, biofortified wheat for the region.

In Turkey, home to pioneering research on zinc deficiency and wheat, wheat landraces and cultivars that take up and use zinc more efficiently are being combined with wheat varieties that have resistance to yellow rust and root diseases. Staff in CIMMYT labs and elsewhere are identifying molecular markers for genes that control grain iron and zinc levels, to facilitate their transfer to new varieties. Finally, studies have begun on iron and zinc losses in milling and cooking. This and the center's research on bio-availability will help determine exactly how much it helps to eat biofortified daily bread.

Program 5: Tropical Ecosystems

"Improving livelihoods and conserving natural resources in tropical ecosystems" (Latin America, Southeast Asia, and tropical areas of southern China; emphasis on maize)

Challenges. Poor farm households require production systems that improve their livelihoods; exploit ecologically-friendly principles to control weeds, pests, and diseases; conserve soil and water; and help meet increasing demand for food and feed (especially in Asia). In Latin America, households often grow maize to avoid purchasing it when prices are high and to feed small numbers of livestock. Livelihood strategies may include the production of cash crops (e.g., coffee), remittances from family members or seasonal off-farm work. In Asian systems, maize is grown predominantly for feed (although Asians consume more maize for food than the entire population of Latin America). Throughout the tropics, mounting demand for maize has caused production to encroach on tropical forests and fragile hillsides.

Emphasis and outputs. This eco-regional program, which contributes to the HarvestPlus Challenge Program, emphasizes the integration of high-yielding, stress-tolerant, nutrient-enhanced maize germplasm with resource-conserving technologies. It will develop maize that copes with acidic soils, drought, low soil fertility, diseases, and insects. Many of these varieties will have improved protein quality and some will have higher micronutrient content. They will increased tolerance to harsh conditions and yield well under favorable conditions. Resource-conserving practices to control weeds and erosion, improve water-use efficiency, and improve soil fertility will include direct sowing with reduced or zero tillage, cover crops, crop residue management, mulch management, and alternative and more diverse cropping patterns. Substantial farmer participatory experimentation will contribute to the development of new varieties and help to refine resource-conserving practices and associated equipment. The program will encourage system diversification to avoid continuous maize cultivation, a goal that requires a combination of policy analysis and advocacy, market analysis, and farmer experimentation with alternative crops. The impact of technical change on the livelihoods of resource-poor farmers and the longer-term consequences of resource-conserving practices will be studied.

Projected impact. Within the period of this MTP, this program will:

- Improve the productivity and profitability of maize-based agro-ecosystems in tropical ecologies.
- Promote successful adoption of conservation agriculture, especially zero tillage with mulch soil cover, on more than one million hectares of tropical lowlands and uplands (improving incomes and livelihoods, reducing production costs, and reducing land degradation).
- Promote successful adoption of more stress-tolerant and nutritious maize varieties.
- Promote diversification of cropping systems and substantially reduce the area under continuous maize cultivation, especially in fragile areas.
- Document impacts and consequences for farm family livelihoods and the environment of technical change in maize systems.
- Promote technical options that help improve the availability of livestock feeds to resource-poor farmers

Program 6: Intensive Agroecosystems

"Safeguarding food security through sustainable intensification" (Indo-Gangetic Plains, Mediterranean littoral, Yellow River Basin, northwestern Mexico; emphasis on maize, wheat, and crop diversification)

Challenges. Many of the world's poor live in densely populated rural areas where cropping systems are intensive and complex. Farmers in these areas tend to be more market-oriented and driven by the need to sustain local communities and neighboring cities. Globally, improved food security and livelihoods for poor people depend heavily on these production systems, which are often irrigated. The challenges are to foster the development of farming systems that are more intensive and more sustainable than current systems; assure food-grain security while delivering a more diverse set of higher-value products; use external inputs more efficiently; generate more employment for the landless; supply less expensive food for poor urban consumers; and conserve and improve soil and water resources. Water is a particular concern because of competition for urban, industrial, ecological, and other non-agricultural uses.

Emphasis and outputs. This eco-regional program, which contributes to the Rice-Wheat Consortium for the Indo-Gangetic Plains (see Box 4) and two Challenge Programs (Water and Food; HarvestPlus), emphasizes improvements in system productivity and diversity, which may at times imply a decrease, not an increase, in resources devoted to cereal production. Instead of increasing input use for higher grain yields, the program will improve nutrient- and water-use efficiency, which should ultimately lead to better harvests with fewer inputs.

Research will focus on resource-conserving technologies (zero-tillage for wheat after rice; zero-tilled, rice-based rotations on permanent beds, with rice grown as an aerobic crop followed by wheat, maize, legumes, or other crops; non-traditional rice transplanting practices; and surface seeding of wheat after rice in low-lying, poorly drained soils). Methods will be developed to allow a third crop after wheat and substitute pulses, maize, or potatoes for wheat. Laser-leveling of irrigated fields will be emphasized. Maize and wheat varieties for these systems will be adapted to new resource-conserving practices. They will also yield well, possess durable disease resistance, resist pests, reduce the need for irrigation, tolerate salinity, and have good quality for consumer and industrial use. Quality protein maize varieties may become important for meeting China's growing demand for feed maize. Policy analysis will focus on maximizing the benefits of improved technologies for smallholder farmers and poor consumers.

Projected impact. Within the period of this MTP, the program will:

- Promote successful adoption of resource-conserving technologies and specifically adapted maize and wheat varieties across a significant area in Asia, Africa, and Latin America.
- Promote successful adoption of more holistic cropping systems so that grain supply keeps pace with demand and food remains affordable for the poor.
- Reduce water use in agriculture by more than 20% and substantially decrease fuel use.
- Enhance farmers' access to markets by providing cereal varieties with specific value-added traits (e.g., improved quality for making leavened, steamed, and flat breads; maize with better nutritional characteristics).
- Measure impact of the technologies deployed in terms of poverty alleviation and livelihood improvement.

Box 6: Promoting Zero-tillage for the Indo-Gangetic Plains

The Rice Wheat Consortium (RWC) for the Indo-Gangetic Plains comprises international agricultural research centers, national agricultural research organizations from Bangladesh, India, Nepal, and Pakistan, and advanced research institutes. The RWC has developed and promoted several practices that increase farm-level productivity, conserve natural resources, and limit negative environmental impacts. These resource-conserving technologies have been actively promoted for some 10 years in the Indo-Gangetic Plains, a region where more than 300 million people depend largely on the rice-wheat crop rotation for food and livelihoods.

Zero-tillage was introduced into South Asia nearly 20 years ago, among other things as a way to overcome late planting of wheat after long-duration basmati rice crops. Puddling fields to grow rice essentially destroys the soil structure, which must be laboriously rebuilt through six-to-eight tractor passes using several implements over as long as two weeks, to sow wheat. By the time late-sown wheat matures, summer heat may have set in, adversely affecting yield and grain quality. In zero-tillage, farmers seed the wheat crop directly into rice stubble right after rice harvest.

Experience in other parts of the world show that successful adoption of zero-tillage depends critically on farmer knowledge and the availability of appropriate machinery. Researchers under the RWC organized an extensive program of on-station and on-farm trials, leading to suitable zero-tillage management recommendations. A parallel program of research focused on the design of effective and affordable zero-tillage seeding equipment and the strengthening of local manufacturing capacity.

These efforts, together with active participation by farmers, strong input from manufacturers, and the dramatic benefits of zero-tillage for wheat have accelerated its adoption, particularly in the irrigated Indo-Gangetic Plains. Informal surveys (based on machinery sales) suggest that the area under zero-tillage exceeded 500,000 ha during the 2002-03 wheat season and is expanding quickly. Net benefits in India and Pakistan through higher yields and lower land preparation costs amounted to more than USD150 million in winter 2003 alone. Use of zero-tillage for wheat saves about 50 liters of diesel per hectare. Besides farm-level savings in fuel and labor, zero-tillage help spare the release of huge amounts of CO_2, even at current levels of adoption.

Financial and Managerial Highlights

CIMMYT Funding Overview
Our grant revenue estimates for unrestricted and restricted grants, as detailed in this MTP submission, indicate total revenues of $37.657M for 2004 and $37.461M for 2005 which represent an increase of approximately 6.5% over actual 2003 results. Grant revenue projections for 2006/2007 are predicted to return to 2003 levels as this is currently considered to be a sustainable long term target. These projections are more conservative that those provided in previous years MTP submission and management believes that not only are achievable and realistic, but there is a reasonable probability that actual results will exceed our projections, particularly in the out years of the plan.

The increase in activity during the initial two year period (2004 – 2005) is driven by changes arising from the implementation of our new strategic plan, details of which are outlined below. Obviously the speed and success of implementing our new strategic plan will depend on careful cash flow management, particularly given that CIMMYT is determined to move from reliance on external debt financing to being debt free by the end of 2004. The vagaries of the timing of receipt of investor funding will be a major factor in our ability to achieve this goal – delays in receipt of one or two major investor contributions which normally are received at the end of the financial year, as happened in 2003, will have a severe impact on our operations and cause us to incur unplanned financing costs.

Due to a change in the nature of funding by DfID in 2004 from restricted to unrestricted support, we expect that unrestricted funding will increase to approximately 42% of total funding in 2004. Unfortunately, our percentage of unrestricted funding is expected to decrease to 36% in 2005, and decline further in out years, as investors continue the trend of increasingly targeting their contributions.

Implementing CIMMYT's Strategic Plan
CIMMYT's new strategy envisions CIMMYT as a research center that has gone far beyond a commodity and production focus to become more effective at responding to local needs, improving livelihoods in rural communities, and contributing to poverty alleviation. The new strategy and mission requires CIMMYT to: 1) continue to maintain the skills, infrastructure, opportunities, and management to remain a center of scientific excellence; 2) work as an extremely decentralized organization with an expanded field presence; and 3) forge strategic, highly complementary, and enduring partnerships that use resources more efficiently, achieve results more widely, and encourage the management, sharing, and application of knowledge at all levels.

To align itself with this vision of the future, CIMMYT is currently undertaking decisive action in three crucial areas:

1. Core competencies. CIMMYT must possess the core competencies to implement its strategy and has therefore initiated action to:
    - recruit young researchers with essential new skills;
    - phase out skills that are no longer essential, and implement a succession planning program; and
    - build capacity in locally recruited staff working in key support areas.
2. Relocation. CIMMYT is in the process of relocating key staff to regional locations, consistent with its plan to decentralize its management structure.
3. Infrastructure. CIMMYT is carefully investing in its field, laboratory, and office operations to ensure that they will be both efficient and safe, and will provide the support needed to undertake our mission within the parameters of our new strategic plan.

Working Capital Reserves
CIMMYT's ability to undertake these critical first steps towards implementing the new strategy has been severely constrained by its financial situation. Between 1997 and 2002, CIMMYT maintained an overly ambitious program of activities that eroded the working capital reserve from more than $ 9M to just $ 0.2M (the equivalent of two days of working capital).

In March 2003, the CIMMYT Board approved a plan developed by CIMMYT management to restore the working capital reserve to an appropriate level of 90 days by the end of 2007. To achieve this target CIMMYT has placed very strict controls on expenditure in an environment where funding levels are expected to remain flat. This is a severe constraint at the same point in time when additional costs need to be incurred in order to effectively implement the strategic plan.

During the 2003 year, CIMMYT was able to increase unappropriated unrestricted reserves from a low of approximately $300K (3 days) to a much more acceptable level of approximately $3M (more than 30 days). This rate of increase cannot be sustained during the next two years as expenditures are incurred to implement the strategic plan however management has planned to achieve the Board target through increased contribution to reserves during the 2005 – 2007 years. On average, CIMMYT will need to put aside at more than $2M per year over the 2005-07 period to reach the target of 90 days – this can only be achieved through generating an increased surplus from unrestricted funding income during these years.

Staffing
In response to financial constraints, CIMMYT implemented two significant downsizings in December 2002 and in May 2003 which resulted in a reduction of 21 internationally recruited staff and more than 60 nationally recruited staff positions. The recurrent savings that accrued as a result of these measures amounted to more than $ 2.6M.

It is important to note that national staff numbers have increased during 2004 due to the effect of regularizing the status of many NRS who were employed on long term temporary staff contracts and therefore not recognized in prior years.

In order to ensure that CIMMYT has the core competencies needed to implement its strategy, additional IRS positions will be introduced during the '04 and '05 years. This will result in an increase in the number of IRS however the demographic balance of staff will change significantly due to the focus on recruiting young scientists and Post Doctoral positions. The key positions to be recruited over the '04/'05 years include:

- Social science positions (2). An ***impact assessment specialist*** will develop methods and conduct research to demonstrate how the adoption of improved technologies contributes to CIMMYT's mission of improving livelihoods and alleviating poverty. A ***poverty specialist*** will help ensure that CIMMYT's work has a strong pro-poor orientation and document how the work of CIMMYT and its partners contributes to improving the livelihoods of the rural poor who depend on maize and wheat for food and income.
- Farming systems positions (3) A ***systems agronomist*** for maize- and wheat-based systems in eastern Africa will identify constraints to system productivity in the region and work with national programs on priority issues. Two ***conservation agriculture specialists*** will work on 1) the development and adoption of resource-conserving technologies across rainfed wheat systems and intensive systems, especially in South Asia and China; and 2) regional constraints to improved productivity and sustainability in Central and West Asia and North Africa.
- Seed systems specialists (2). Two ***seed systems specialists*** will work on 1) seed production and dissemination in sub-Saharan Africa, where access to improved seed is a major constraint to increased productivity; and 2) seed systems and technology dissemination in South Asia, where a lack of functional seed production systems is a major impediment to the adoption of improved varieties.

- Postdoctoral fellows (3). Two ***postdoctoral fellows*** will work on 1) nutritional enhancement of maize and 2) expanding the use of genetic resources for traits of interest. One ***postdoctoral fellow*** will develop research on the impacts of farming systems and changing environmental conditions (e.g., shorter growing seasons) on biotic stresses, especially rust and powdery mildew, which are diseases of global importance.
- Bioinformatics specialist (1). One ***bioinformatics specialist*** will provide leadership at CIMMYT for developing and implementing information management systems that integrate molecular information with data from more than 30 years of international maize and wheat performance data, pedigree data, GIS, and other data. New tools to link this information, much of it extremely valuable and unique, will permit powerful new insights into the relationships between genes, environment, and the productivity of crops and agricultural systems.

Staff Relocation
As stated in its strategy, CIMMYT seeks to decentralize and locate management staff throughout the regions rather than in one head office. CIMMYT's Program Directors were formerly all located at its head office, but three Directors will now be based outside of Mexico.

Staff Development
In recent years CIMMYT has invested little in building capacity in its locally recruited staff throughout the world, especially in key support areas such as information technology, human resources, and financial management. Several of these areas were previously staffed by internationally recruited staff however budget constraints, as well as a historical reluctance to recognize the importance of these support functions, caused the Center to appoint locally recruited staff to some of these positions without providing adequate training. A training needs analysis has recently been undertaken and the results of this will be used to develop a consistent training plan for all CIMMYT staff.

Infrastructure
In 1999, CIMMYT resorted to a capital "savings" measure that reduced the capital budget by 50% to free up more funds to meet obligations for its research operations. This temporary measure unfortunately prevailed through 2003 (for 2004, a full capital budget has been allocated). A total of US$ 3.425M was diverted from capital investments to operational expenditures over 1999-2003.

The result has been a severe decline in the maintenance of fixed assets (i.e., buildings, including laboratories) and the inability to replace key laboratory and field equipment. For example, the five experiment stations in Mexico that are the base of CIMMYT's global crop improvement research have very significant field and other assets. Many of these assets should have been replaced long ago. An additional, and worrisome, symptom of insufficient capital investment is increasing concern about occupational health and safety.

CIMMYT's MTP includes a commitment to reinvest an amount equal to its depreciation expense, in order to maintain the value of its fixed asset base.

Part 2: Budget Tables

Table 1a. CIMMYT - Cost Allocation: Financial Requirements by CGIAR Output, 2005.

Center Projects	Germplasm improvement	Germplasm collection	Sustainable production	Policy	Enhancing NARS	Project Totals
1. Genetic Resources	1.35	3.44	0.00	0.62	0.74	6.15
2. Rainfed Wheat Systems	1.51	0.79	3.27	0.00	0.48	6.06
3. Sustaining African Livelihoods	2.87	0.64	2.39	0.80	1.27	7.96
4. Intensive Agro-ecosystems	1.94	1.55	3.34	0.00	0.93	7.76
5. Tropical Ecosystems	2.04	0.92	0.77	0.00	1.38	5.11
6. Targeting Knowledge for Impact	0.00	0.00	0.00	1.35	0.50	1.86
7. Genetic Diversity (Generation) Challenge Program	3.16	6.42	0.48	0.94	2.30	13.30
8. Rice-Wheat Consortium	0.13	0.05	0.48	0.05	0.13	0.83
Output Totals	**13.00**	**13.81**	**10.72**	**3.76**	**7.73**	**49.01**

Table 1b. CIMMYT - Cost Allocation: Financial Requirements by CGIAR Output, 2006.

Center Projects	Germplasm improvement	Germplasm collection	Sustainable production	Policy	Enhancing NARS	Project Totals
1. Genetic Resources	1.28	3.27	0.00	0.58	0.70	5.83
2. Rainfed Wheat Systems	1.41	0.73	3.04	0.00	0.45	5.63
3. Sustaining African Livelihoods	2.83	0.63	2.36	0.79	1.26	7.86
4. Intensive Agro-ecosystems	1.85	1.48	3.17	0.00	0.89	7.38
5. Tropical Ecosystems	1.91	0.86	0.72	0.00	1.29	4.77
6. Targeting Knowledge for Impact	0.00	0.00	0.00	1.14	0.42	1.56
7. Genetic Diversity (Generation) Challenge Program	3.60	7.20	0.60	1.05	2.55	15.00
8. Rice-Wheat Consortium	0.13	0.05	0.48	0.05	0.13	0.83
Output Totals	**13.00**	**14.21**	**10.37**	**3.61**	**7.68**	**48.86**

Table 1c. CIMMYT - Cost Allocation: Financial Requirements by CGIAR Output, 2007.

Center Projects	Germplasm improvement	Germplasm collection	Sustainable production	Policy	Enhancing NARS	Project Totals
1. Genetic Resources	1.28	3.26	0.00	0.58	0.70	5.82
2. Rainfed Wheat Systems	1.40	0.73	3.03	0.00	0.45	5.61
3. Sustaining African Livelihoods	2.82	0.63	2.35	0.78	1.25	7.84
4. Intensive Agro-ecosystems	1.84	1.47	3.17	0.00	0.88	7.36
5. Tropical Ecosystems	1.86	0.84	0.70	0.00	1.25	4.65
6. Targeting Knowledge for Impact	0.00	0.00	0.00	1.13	0.42	1.55
7. Genetic Diversity (Generation) Challenge Program	3.96	7.92	0.66	1.16	2.80	16.50
8. Rice-Wheat Consortium	0.13	0.05	0.48	0.05	0.13	0.83
Output Totals	**13.29**	**14.90**	**10.39**	**3.71**	**7.88**	**50.16**

Table 2. CIMMYT - Cost Allocation: Project & Output Cost Summary.

Project	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
1. Genetic Resources	0.00	6.03	6.15	5.83	5.82
2. Rainfed Wheat Systems	0.00	6.08	6.06	5.63	5.61
3. Sustaining African Livelihoods	0.00	8.20	7.96	7.86	7.84
4. Intensive Agro-ecosystems	0.00	7.75	7.76	7.38	7.36
5. Tropical Ecosystems	0.00	5.13	5.11	4.77	4.65
6. Targeting Knowledge for Impact	0.00	2.73	1.86	1.56	1.55
7. Genetic Diversity (Generation) Challenge Program	0.50	8.39	13.30	15.00	16.50
8. Rice-Wheat Consortium	0.00	0.88	0.83	0.83	0.83
Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**

Summary by CGIAR Output	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
Germplasm Improvement	0.00	11.93	13.00	13.00	13.29
Germplasm Collection	0.50	11.37	13.81	14.21	14.90
Policy	0.00	4.05	3.76	3.61	3.71
Sustainable Production	0.00	10.70	10.72	10.37	10.39
Enhancing NARS	0.00	7.13	7.73	7.68	7.88
Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**

Table 3. CIMMYT - Cost Allocation: Allocation of Project Costs to CGIAR Activities.

Project	Activity		Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
1. Genetic Resources							
	Documentation, Publication, Info, Dissemination		0.00	0.36	0.37	0.35	0.35
	Germplasm Enhancement and Breeding		0.00	1.33	1.35	1.28	1.28
	Improving Policies		0.00	0.60	0.62	0.58	0.58
	Saving Biodiversity		0.00	3.38	3.44	3.27	3.26
	Training & Professional Development		0.00	0.36	0.37	0.35	0.35
		Total	**0.00**	**6.03**	**6.15**	**5.83**	**5.82**
2. Rainfed Wheat Systems							
	Documentation, Publication, Info, Dissemination		0.00	0.24	0.24	0.23	0.22
	Germplasm Enhancement and Breeding		0.00	1.28	1.27	1.18	1.18
	Networks		0.00	0.24	0.24	0.23	0.22
	Organization & Management Counselling		0.00	0.24	0.24	0.23	0.22
	Production Systems Development - Crops		0.00	0.24	0.24	0.23	0.22
	Protecting the Environment		0.00	3.04	3.03	2.82	2.81
	Saving Biodiversity		0.00	0.79	0.79	0.73	0.73
		Total	**0.00**	**6.08**	**6.06**	**5.63**	**5.61**
3. Sustaining African Livelihoods							
	Documentation, Publication, Info, Dissemination		0.00	0.25	0.24	0.24	0.24
	Germplasm Enhancement and Breeding		0.00	2.21	2.15	2.12	2.12
	Improving Policies		0.00	0.82	0.80	0.79	0.78
	Networks		0.00	0.74	0.72	0.71	0.71
	Organization & Management Counselling		0.00	0.41	0.40	0.39	0.39
	Production Systems Development - Crops		0.00	0.98	0.96	0.94	0.94
	Protecting the Environment		0.00	1.48	1.43	1.41	1.41
	Saving Biodiversity		0.00	0.66	0.64	0.63	0.63
	Training & Professional Development		0.00	0.66	0.64	0.63	0.63
		Total	**0.00**	**8.20**	**7.96**	**7.86**	**7.84**
4. Intensive Agro-ecosystems							
	Germplasm Enhancement and Breeding		0.00	1.94	1.94	1.85	1.84
	Networks		0.00	0.62	0.62	0.59	0.59
	Production Systems Development - Crops		0.00	1.71	1.71	1.62	1.62
	Protecting the Environment		0.00	1.63	1.63	1.55	1.55
	Saving Biodiversity		0.00	1.55	1.55	1.48	1.47
	Training & Professional Development		0.00	0.31	0.31	0.30	0.30
		Total	**0.00**	**7.75**	**7.76**	**7.38**	**7.36**
5. Tropical Ecosystems							
	Documentation, Publication, Info, Dissemination		0.00	0.46	0.46	0.43	0.42
	Germplasm Enhancement and Breeding		0.00	2.05	2.04	1.91	1.86
	Networks		0.00	0.00	0.00	0.00	0.00
	Production Systems Development - Crops		0.00	0.26	0.26	0.24	0.23
	Protecting the Environment		0.00	0.51	0.51	0.48	0.47
	Saving Biodiversity		0.00	0.92	0.92	0.86	0.84
	Training & Professional Development		0.00	0.92	0.92	0.86	0.84
		Total	**0.00**	**5.13**	**5.11**	**4.77**	**4.65**

Project	Activity	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
6. Targeting Knowledge for Impact						
	Documentation, Publication, Info, Dissemination	0.00	0.25	0.17	0.14	0.14
	Improving Policies	0.00	1.64	1.11	0.93	0.93
	Networks	0.00	0.35	0.24	0.20	0.20
	Organization & Management Counselling	0.00	0.25	0.17	0.14	0.14
	Training & Professional Development	0.00	0.25	0.17	0.14	0.14
	Total	**0.00**	**2.73**	**1.86**	**1.56**	**1.55**
7. Genetic Diversity (Generation) Challenge Program						
	Networks	0.50	8.39	13.30	15.00	16.50
	Total	**0.50**	**8.39**	**13.30**	**15.00**	**16.50**
8. Rice-Wheat Consortium						
	Documentation, Publication, Info, Dissemination	0.00	0.05	0.05	0.05	0.05
	Germplasm Enhancement and Breeding	0.00	0.13	0.13	0.13	0.13
	Improving Policies	0.00	0.05	0.05	0.05	0.05
	Production Systems Development - Crops	0.00	0.22	0.20	0.20	0.20
	Protecting the Environment	0.00	0.30	0.28	0.28	0.28
	Saving Biodiversity	0.00	0.05	0.05	0.05	0.05
	Training & Professional Development	0.00	0.08	0.08	0.08	0.08
	Total	**0.00**	**0.88**	**0.83**	**0.83**	**0.83**
	Center Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**
	Summary by Undertaking:					
	Saving Biodiversity	0.00	7.35	7.39	7.01	6.98
	Increasing Productivity	0.00	12.35	12.24	11.69	11.62
	Improving Policies	0.00	3.11	2.57	2.35	2.35
	Protecting the Environment	0.00	6.96	6.88	6.54	6.51
	Strengthening NARS	0.50	15.42	19.93	21.26	22.72
	Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**
	Summary by Output:					
	Sustainable Production	0.00	10.70	10.72	10.37	10.39
	Germplasm Improvement	0.00	11.93	13.00	13.00	13.29
	Policy	0.00	4.05	3.76	3.61	3.71
	Germplasm Collection	0.50	11.37	13.81	14.21	14.90
	Enhancing NARS	0.00	7.13	7.73	7.68	7.88
	Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**

Table 4a. CIMMYT - Cost Allocation: Allocation of Resources by CGIAR Undertaking.

Allocation of Resources by CGIAR Activity	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
Increasing Productivity	**0.00**	**12.35**	**12.24**	**11.69**	**11.62**
of which:					
Germplasm Enhancement & Breeding	0.00	8.94	8.88	8.46	8.40
Production System Development & Management	0.00	3.41	3.36	3.23	3.22
Protecting the Environment	**0.00**	**6.96**	**6.88**	**6.54**	**6.51**
Saving Biodiversity	**0.00**	**7.35**	**7.39**	**7.01**	**6.98**
Improving Policies	**0.00**	**3.11**	**2.57**	**2.35**	**2.35**
Strengthening NARS	**0.50**	**15.42**	**19.93**	**21.26**	**22.72**
of which:					
Documentation, Publication, Info, Dissemination	0.00	1.61	1.53	1.43	1.42
Networks	0.50	10.34	15.12	16.73	18.22
Organization & Management Counselling	0.00	0.90	0.81	0.76	0.76
Training & Professional Development	0.00	2.58	2.48	2.35	2.32
Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**

Table 4b. CIMMYT - Cost Allocation: Allocation of Resources by CGIAR Output.

Allocation of Resources by Outputs	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
Germplasm Improvement (Activity: Germplasm Enhancement & Breeding plus Networks as appropriate)	0.00	11.93	13.00	13.00	13.29
Germplasm Collection (Activity: Saving Biodiversity, plus Networks as appropriate)	0.50	11.37	13.81	14.21	14.90
Policy (Activity: Improving policies, plus Networks as appropriate)	0.00	4.05	3.76	3.61	3.71
Sustainable Production (Activity: Production System Dev & Mgmt Protecting the Environment plus Networks as appropriate)	0.00	10.70	10.72	10.37	10.39
Enhancing NARS (Activity: Strengthening NARS - the three sub-activities, plus Networks as appropriate)	0.00	7.13	7.73	7.68	7.88
Total	**0.50**	**45.19**	**49.01**	**48.86**	**50.16**

Table 5a. CIMMYT - Investments: Investment by Production Sector and Commodity.

Production Sectors & Commodities		Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
Germplasm Improvement						
Crops		**0.00**	**9.92**	**9.84**	**12.64**	**10.13**
Maize		0.00	5.01	4.92	6.32	5.06
Wheat		0.00	4.91	4.92	6.32	5.07
	Total	**0.00**	**9.92**	**9.84**	**12.64**	**10.13**
Sustainable Production						
Crops		**0.00**	**10.36**	**10.24**	**9.77**	**9.73**
Maize		0.00	7.72	5.12	4.89	4.87
Wheat		0.00	2.64	5.12	4.88	4.86
	Total	**0.00**	**10.36**	**10.24**	**9.77**	**9.73**
Total Research Agenda						
Crops		**0.00**	**36.81**	**35.70**	**33.86**	**33.66**
Maize		0.00	17.12	17.85	16.93	16.83
Wheat		0.00	19.69	17.85	16.93	16.83
	Center Total	**0.00**	**36.81**	**35.70**	**33.86**	**33.66**

Table 5b. CIMMYT - Investments: Investment by Developing Region.

Region	Actual 2003	Estimate 2004	Proposed 2005	Plan 2006	Plan 2007
Sub-Saharan Africa (SSA)	0.00	13.62	14.28	13.54	13.46
Asia	0.00	10.31	12.50	11.85	11.78
Latin America and Caribbean (LAC)	0.00	9.20	5.36	5.08	5.05
West Asia and North Africa (WANA)	0.00	3.68	3.57	3.39	3.37
Center Total	**0.00**	**36.81**	**35.71**	**33.86**	**33.66**

Table 6. CIMMYT - Financing: Unrestricted and Restricted Grants.

Investor	Actual 2003		Estimate 2004		Proposed 2005
	(Nat'l. currency)	(US$)	(Nat'l. currency)	(US$)	(US$)
Unrestricted Grants					
Australia (AUD)	0.74	0.38	0.70	0.45	0.45
Belgium (BEF)	0.09	0.09	0.09	0.11	0.11
Canada (CAD)	1.81	1.26	2.20	1.72	1.63
China	0.00	0.15	0.00	0.15	0.15
Denmark (DKK)	4.00	0.60	4.00	0.69	0.65
Germany (DEM)	0.25	0.29	0.25	0.29	0.30
India	0.00	0.11	0.00	0.11	0.11
Japan (JPY)	148.05	1.36	133.25	1.27	1.20
Korea	0.00	0.05	0.00	0.05	0.05
Mexico	0.00	0.09	0.00	0.09	0.09
New Zealand	0.00	0.00	0.00	0.05	0.10
Norway (NOK)	1.50	0.21	1.50	0.22	0.21
Peru	0.00	0.02	0.00	0.02	0.02
Philippines	0.00	0.01	0.00	0.01	0.01
Sweden (SEK)	2.80	0.32	2.70	0.38	0.35
Switzerland (CHF)	0.40	0.29	0.40	0.31	0.31
Thailand	0.00	0.01	0.00	0.01	0.01
United Kingdom (GBP)	0.00	0.00	0.86	1.58	1.59
United States	0.00	4.90	0.00	4.50	4.50
World Bank	0.00	2.50	0.00	1.80	1.80
Subtotal	**159.62**	**12.64**	**145.93**	**13.80**	**13.64**

Restricted Grants (US$)	Actual 2003	Estimate 2004	Proposed 2005
ADB	0.57	0.38	0.38
Australia	1.52	1.92	2.22
Austria	0.00	0.05	0.05
Belgium	0.35	0.30	0.30
Bolivia	0.01	0.00	0.00
Canada	0.62	0.85	0.84
CGIAR	0.08	0.00	0.00
Challenge Program - Generation	0.00	0.77	0.77
Challenge Program - Harvest Plus	0.15	0.76	0.64
Challenge Program - Water and Food	0.00	0.10	0.10
China	0.29	0.00	0.00
Colombia	0.11	0.11	0.11
Denmark	0.15	0.00	0.00
EC	2.70	7.51	7.83
FAO	0.05	0.03	0.20
FENALCE	0.04	0.07	0.10
FONTAGRO	0.00	0.04	0.00

Restricted Grants (US$)	Actual 2003	Estimate 2004	Proposed 2005
France	0.84	0.27	0.27
Germany	0.70	1.28	1.08
IFAD	0.15	0.15	0.50
Iran	0.30	0.32	0.26
Japan	0.65	0.94	1.18
Korea	0.10	0.04	0.04
Mexico	0.35	0.02	0.02
Miscellaneous	1.40	0.00	0.00
MONSANTO	0.21	0.00	0.14
Netherlands	0.47	0.43	0.43
New Zealand	0.11	0.00	0.00
Nippon Fdn	0.69	0.74	0.64
Norway	0.03	0.00	0.00
Oklahoma State Univeristy	0.00	0.00	0.14
OPEC	0.03	0.05	0.05
Paraguay	0.02	0.00	0.00
Peru	0.04	0.04	0.04
Pioneer	0.03	0.04	0.00
Rockefeller Foundation	1.99	2.39	2.40
Sasakawa Global 2000	0.06	0.00	0.00
South Africa	0.06	0.05	0.05
Spain	0.26	0.22	0.22
Stanford University	0.15	0.06	0.07
Sweden	0.02	0.12	0.10
Switzerland	0.88	1.03	1.03
Syngenta Foundation	1.10	0.78	0.78
Unidentified	0.00	1.92	1.75
United Kingdom	1.42	0.00	4.60
United States	3.26	2.90	3.05
Uruguay	0.13	0.00	0.00
World Bank	1.12	5.55	4.74
Subtotal	**23.20**	**32.24**	**37.11**
Total Unrestricted and Restricted Grants	**35.83**	**46.04**	**50.75**

Table 7. CIMMYT - Staff Composition: Internationally and Nationally Recruited Staff by Function.

	Actual 2003		Estimate 2004		Proposed 2005		Plan 2006		Plan 2007	
Hired By:	**Center**	**Other**	**Center**	**Other**	**Center**	**Other**	**Center**	**Other**	**Center**	**Other**
Internationally-Recruited Staff (IRS)										
Research and Research Support										
Associate Professionals	5	6	7	3	7	6	7	6	7	6
Post-doctoral Fellows	6	2	7	2	11	2	11	2	11	2
Regular Appointments	56	13	56	12	59	8	53	8	53	8
Subtotal	**67**	**21**	**70**	**17**	**77**	**16**	**71**	**16**	**71**	**16**
Research Management										
Associate Professionals	0	0	0	0	0	0	0	0	0	0
Post-doctoral Fellows	0	0	0	0	0	0	0	0	0	0
Regular Appointments	6	2	8	2	8	2	8	2	8	2
Subtotal	**6**	**2**	**8**	**2**	**8**	**2**	**8**	**2**	**8**	**2**
Training/ Communications										
Associate Professionals	0	0	0	0	0	0	0	0	0	0
Post-doctoral Fellows	0	0	0	0	0	0	0	0	0	0
Regular Appointments	4	0	5	0	5	0	5	0	5	0
Subtotal	**4**	**0**	**5**	**0**	**5**	**0**	**5**	**0**	**5**	**0**
IRS Center Total	**77**	**23**	**83**	**19**	**90**	**18**	**84**	**18**	**84**	**18**
Nationally-Recruited Staff (NRS)										
NRS Center Total	**584**	**0**	**654**	**0**	**654**	**0**	**654**	**0**	**654**	**0**
Total IRS and NRS Staff	**661**	**23**	**737**	**19**	**744**	**18**	**738**	**18**	**738**	**18**

Part 3: CIMMYT's Project Portfolio—Log Frames

Genetic Resources

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions
Goal. Enhance the productivity and nutritional quality of maize and wheat varieties through the targeted use of genetic resources	At least 25% of the new maize and wheat varieties produced by CIMMYT and its partners containing novel gene combinations derived from elite or untapped genetic resources (e.g., landraces and wild relatives)	Ability to access genetic resource information and seeds via the web Database reports New useful germplasm incorporated into breeding programs Scientific articles and reports	Access to global genetic resources Sufficient variation for a trait in available genetic resources Suitable phenotypic screening methodology for target traits/environments A genetic basis of trait phenotypes Ability to negotiate necessary freedom-to-operate for any required intellectual property
Purpose 1. Global custodianship, characterization and management of the genetic resources of maize, wheat and related species	Genetic resource information available for at least 25000 maize and 75000 wheat accessions Global maize and wheat genetic resource network involving at least 75% of the maize and wheat genebanks	Database reports Scientific articles and reports Feedback from partners	Access to global genetic resources Willingness to establish global network
Result 1.1. Enhanced global collection of maize and related species resources, including key genetic materials	By 2007, a 5-10% increase in the number and type of maize and related species accessions available in the gene bank By 2007, a 5% increase in the number of requests for seed	Database reports Genebank seed requests	Access to global genetic resources
Activity 1.1.1. Improve the Latin American, African and Asian maize germplasm collections			
Activity 1.1.2. Access key related species and genetic materials of maize into the collection			
Result 1.2. Inventoried wheat and related species collection, including key genetic and cytogenetic materials	By 2007, a database with data for at least 75000 wheat and related species	Database reports	
Activity 1.2.1. Inventory entire wheat collection checking quantity, viability and data quality	Complete inventory by end of 2006	Database reports	
Activity 1.2.2. Access key genetic and cytogenetic materials of wheat into the collection	A 25% increase in the number of genetic and cytogenetic stocks by 2006	Database reports	
Result 1.3. Characterized maize and wheat genetic resources	At least 25% of the gene bank accessions characterized at the phenotypic and/or molecular levels by end of 2006	Database reports Scientific articles and reports	Suitable phenotypic screening methodology for target traits A genetic basis of traits
Activity 1.3.1. Phenotype maize and wheat accessions for key traits	5-10% of the maize and wheat accessions phenotyped for at least 1 trait each year	Scientific articles and reports Database reports	
Activity 1.3.2. Fingerprint using molecular markers key maize and wheat accessions and related species	5-10% of the maize and wheat accessions fingerprinted each year	Scientific articles and reports Database reports	
Result 1.4. Web-based genebank information, management and distribution system	A global web-accessible maize and wheat genetic resource information system	Ability to access genebank information globally	
Activity 1.4.1. Develop an updated, web-accessible genebank management and information system	Beta-version available by end of 2005 Operational version by 2006	Available software User reports	

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions
Activity 1.4.2. Incorporate existing genebank data into the new system, improving data quantity and quality	Data entered by end of 2005	Database reports	
Result 1.5. Statistical and simulation models for efficient maintenance and use of maize and wheat genetic resources	Computer-based models for regeneration of genebank accessions Strategies for efficient genebank management	Scientific articles and reports Computer software Genebank operating manual	
Activity 1.5.1. Evaluate statistical genetic models for classifying genetic resources, studying phenotypic and genetic diversity, and forming core subsets.	Initial models available by 2005 Testing of models in 2006+	Scientific articles and reports	
Activity 1.5.2. Develop population genetic models for efficient regeneration and collection of genetic resources.	Initial models available by 2005 Testing of models in 2006+	Scientific articles and reports	
Result 1.6. Strategies for on-farm management of genetic resources	Knowledge of geneflow in farmers fields At least 1 strategy to improve conservation of farmer varieties At least 50 farmers participating in the on-farm management of genetic resources	Scientific articles and reports Farmer interviews	Willingness of farmers to participate
Activity 1.6.1. Study the effects of gene flow within and between farmer grown varieties			
Activity 1.6.2. Determine incentives required for *in-situ* conservation of genetic resources			
Purpose 2. Effective approaches identified in genetic resources and transferred to useful maize and wheat germplasm for improving critical traits as prioritized by CIMMYT and its partners	At least 1 genetic solution in maize for improved tolerance to abiotic stresses (drought, low nitrogen and acid soil), biotic stresses (storage insect pests and pathogens) and grain nutritional quality (QPM, vitamin A, iron and zinc) At least 1 genetic solution in wheat for improved tolerance to abiotic stresses (drought, low nitrogen, heat and salt), biotic stresses (fusarium, septoria and powdery mildew diseases) and grain nutritional quality (vitamin A, iron and zinc)	Improved sources identified Novel genetic diversity transferred through pre-breeding into adapted genetic backgrounds Useful diversity being incorporated into breeding programs directly or through use of pre-breeding products Scientific articles and reports	Sufficient variation for a trait in available genetic resources A genetic basis of trait phenotypes Ability to negotiate necessary freedom-to-operate for any required intellectual property
Result 2.1. Maize and wheat consensus maps for tolerance/resistance to abiotic and biotic stresses, and enhanced grain nutrition	Consensus maps for drought tolerance and insect resistance in maize by 2005 Consensus maps for drought tolerance and fusarium resistance in wheat by 2006	Scientific articles and reports	Traits are controlled by key consensus genomic regions
Activity 2.1.1. Develop and analyze maize and wheat genetic populations to identify QTL for tolerances to abiotic and biotic stresses, and grain nutritional quality components	At least 1 mapping population analyzed per year	Scientific articles and reports	
Activity 2.1.2. Assemble consensus maps for maize and wheat and display multiple traits across environments and populations			
Activity 2.1.3. Link genomic regions of interest identified on maize and wheat consensus maps with other species (and vice versa)			

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions
Result 2.2. Identification of genes, alleles and biological pathways involved in tolerance to abiotic and biotic stresses, enhanced grain quality, and asexual reproduction (apomixis)	Genes, alleles and/or pathways identified for improving abiotic stress tolerance by 2005 Genes, alleles and/or pathways identified for improving biotic stress resistance by 2006 Genes, alleles and/or pathways identified for asexual reproduction by 2007+	Scientific articles and reports	Sufficient variation for a trait in available genetic resources Ability to produce apomictic seed in diploid species Ability to negotiate necessary freedom-to-operate for any required intellectual property
Activity 2.2.1. Identify and validate candidate genes and biological pathways involved in tolerances to abiotic, biotic stresses and grain quality in maize and wheat using functional genomics, allele mining and association genetics			
Activity 2.2.2 Identify gene systems for conditioning asexual reproduction (apomixis) in cereals	Nucellar/ovule-specific and inducible promoters identified by 2005 Embryogenesis genes identified by 2006 Cell differentiation genes identified by 2007	Scientific articles and reports	Ability to negotiate necessary freedom-to-operate for any required intellectual property
Activity 2.2.3. Screen candidate genes from cereals and other species in maize and wheat for improved tolerances to abiotic and biotic stresses, and nutritional quality using genetic engineering	Screen 10 genes for abiotic stress tolerance in wheat by 2006 Screen 10 genes for biotic stress tolerance in wheat by 2007 Screen 5 genes for grain nutritional quality in wheat by 2007+	Scientific articles and reports	Ability to negotiate necessary freedom-to-operate for any required intellectual property
Result 2.3. Bioinformatics platform for handling and analyzing genomic data	Bioinformatics platform established and functioning by end of 2005	Scientific articles and reports Bioinformatic tools User feedback	
Activity 2.3.1. Implement central data repository for CIMMYT-derived genomic data	Data repository available by end of 2005		
Activity 2.3.2. Identify and adopt key bioinformatics packages for analyzing genomic data	Packages available in 2005+		
Result 2.4. Useful maize and wheat germplasm with enhanced tolerance to abiotic and biotic stresses and enhanced grain quality	At least 10 maize and wheat lines as sources for improved tolerance and/or nutritional quality produced per year	Scientific articles and reports Germplasm requests	Sufficient variation for a trait in available genetic resources Ability to negotiate necessary freedom-to-operate for any required intellectual property
Activity 2.4.1. Develop novel 'synthetic' or 'bridge' wheats using wild A, B and D genome donors	At least 50 new 'synthetic' or 'bridge' wheats produced	Scientific articles and reports	
Activity 2.4.2. Produce doubled haploid populations of wheat for mapping projects and pre-breeding purposes	At least 10000 doubled haploid individuals per year	Scientific articles and reports	
Activity 2.4.3. Characterize at the phenotypic and molecular levels key maize and/or wheat genetic resources under water-stress, low nitrogen, and/or acid soils conditions and for resistance to fusarium, septoria and powdery mildew to identify novel sources of tolerance	At least 1000 accessions evaluated for key traits each year	Scientific articles and reports	

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions
Activity 2.4.4. Incorporate novel sources of tolerance into useful maize and wheat germplasm using conventional, molecular-marker and/or genetic engineering strategies for further use by breeding programs of CIMMYT and its partners	Drought tolerant maize lines by 2005+ Acid soil and drought tolerant wheat lines by 2006+ Fusarium and septoria resistant wheat lines by 2006+	Scientific articles and reports	
Activity 2.4.5. Screen maize and wheat genetic resources for elevated levels of iron, zinc and pro-vitamin A in the grain	Maize and wheat lines screened by 2005+	Scientific articles and reports	
Activity 2.4.6. Incorporate novel sources of elevated levels of micronutrients into useful maize and wheat germplasm using conventional, molecular-marker and/or genetic engineering strategies for further use by breeding programs of CIMMYT and its partners	Increased iron and zinc wheat lines by 2007+	Scientific articles and reports	
Result 2.5. Improved marker-assisted selection strategies and use by CIMMYT and its partners	At least a 10% increase in the number of MAS assays per year At least 1 new effective MAS strategy proposed by 2006	MAS use reports Scientific articles and reports Improved germplasm	Good knowledge of gene networking and interaction Continued demand for MAS
Activity 2.5.1. Model use of molecular markers in breeding programs to identify optimal application	At least 1 new strategy by 2006		
Activity 2.5.2. Increase the number and efficiency of marker systems for use by CIMMYT and its partners	At least 2 new marker systems adopted per year		
Activity 2.5.3. Establish regional marker laboratories backstopped by a central facility	At least 1 regional marker lab established by 2005 At least 4 regional marker labs established by 2007	MAS use reports	Continued demand for MAS in the regions
Result 2.6. Genetic engineered event of key genes for ultimate deployment to CIMMYT partners	Maize and wheat germplasm containing at least 10 transgenic events each for at least 2 genes by 2007	Scientific articles and reports Improved germplasm	Ability to negotiate necessary freedom-to-operate for any required intellectual property NARS and public interest in transgenic varieties Simple gene solutions for critical traits
Activity 2.6.1. Produce low-copy and selectable marker free events of most effective genes	*Agrobacterium* transformation system for wheat by 2005 Gene excision/recombination system for maize and wheat by 2007	Scientific articles and reports	Ability to negotiate necessary freedom-to-operate for any required intellectual property
Activity 2.6.2. Develop source lines containing these events along with required regulatory information	At least 6 events in extended field trials by 2007	Scientific articles and reports Biosafety applications and approvals	Appropriate biosafety regulations for field trials in target countries
Purpose 3. Capacity in genetic resource management, maintenance and use enhanced globally	At least 50 NARS staff trained per year	Workshop and training reports NARS and farmer feedback	
Result 3.1. Improved capacity for storage and management of genetic resources by CIMMYT's partners	Quality of maize and wheat global genetic resources increased in at least 5 NARS each year	NARS feedback	
Activity 3.1.1. Develop user-friendly, portable genetic resource information system	System available by 2006	Software reports User feedback	

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions
Activity 3.1.2. Conduct workshops and/or host visiting scientists/students on genebank management (*ex-situ* and *in-situ*)	At least 1 workshop held each year At least 2 scientists/students hosted each year	Workshop and training reports	
Activity 3.1.3. Help NARS and CIMMYT partners develop or improve genebank facilities	At least 5 NARS or partners helped each year	NARS feedback	
Result 3.2. Increased use of genomic approaches by CIMMYT and its partners	At least 5 NARS scientists trained in genomic approaches each year	NARS reports Scientific articles and reports	
Activity 3.2.1. Develop user-friendly bioinformatics tools			
Activity 3.2.2. Conduct workshops and/or host visiting scientists/students in the application of genomics (QTL/gene discovery, MAS) in maize and wheat breeding	At least 1 workshop held each year At least 2 scientists/students hosted each year	Workshop and training reports	
Activity 3.2.3. Provide appropriate software tools to CIMMYT partners			

Impacts Targeting and Assessment

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Goal. Increase CIMMYT's impact on helping to improve the livelihoods of poor maize and wheat producers and consumers in the developing world			Current focus on poverty and livelihoods maintained
Purpose 1. CIMMYT's work has a strong anti-poverty orientation	CIMMYT resources allocated in pro poor fashion; CIMMYT outputs useful to the poor and jointly developed when appropriate	Internal and external reviews	Institutional support; adequate staffing with appropriate skills available; financial resources available; new partnerships established; effective collaboration established with current and new partners
Result 1.1. Better understanding of causes and symptoms of poverty and of the livelihood strategies of the poor	Heightened awareness among staff and partners, e.g., through increased access to relevant information	Content analysis of CIMMYT's internal and external communications (e.g., research proposals, documents, speeches, presentations)	
Activity 1.1.1. Monitor current thinking on poverty and livelihoods	Relevant papers reviewed and synthesized; workshops and external events attended; linkages established to centers of excellence	Publications and presentations; analysis of CIMMYT staff performance appraisals (MBOs)	
Activity 1.1.2. Develop and maintain databases containing information on poverty	Data relevant for poverty analysis accessed, archived, and made available	Inventory of CIMMYT databases	
Result 1.2. Better understanding of the role played by maize and wheat in the livelihood strategies of the poor	Heightened awareness among staff and partners, e.g., through increased access to relevant information	Content analysis of CIMMYT's internal and external communications (e.g., research proposals, documents, speeches, presentations)	
Activity 1.2.1. Conduct descriptive and diagnostic studies to clarify the role of maize and wheat in the livelihood strategies of the poor	Studies conducted; papers published; learning workshops organized	Publications and presentations; analysis of CIMMYT staff performance appraisals (MBOs)	

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.2.2. Develop and maintain databases containing information about the maize and wheat sectors	Data relevant for maize and wheat sector analysis accessed, archived, and made available	Inventory of CIMMYT databases	
Result 1.3. Better understanding of the potential of improved maize and wheat technologies to provide pathways out of poverty	Heightened awareness among staff and partners, e.g., through increased access to relevant information	Content analysis of CIMMYT's internal and external communications (e.g., research proposals, documents, speeches, presentations)	
Activity 1.3.1. Conduct targeted case studies to identify impact pathways through which technology interventions affect livelihoods of the poor	Case studies conducted, papers published	Publications and presentations	
Result 1.4. Improved knowledge of poverty and livelihoods used for research priority setting in CIMMYT	Heightened awareness among staff and partners, e.g., through increased access to relevant information	Content analysis of CIMMYT's internal and external communications (e.g., research proposals, documents, speeches, presentations)	
Activity 1.4.1. Communicate methods and findings to colleagues	Collaborative work carried out; papers published; seminars delivered, workshops organized; web-based knowledge management tools developed	Publications and presentations; research collaborations; existence and use of knowledge management tools	
Activity 1.4.2. Participate in CIMMYT priority setting process	More sophisticated priority setting tools developed (e.g., RAT 2.0); data analysis carried out	Existence and use of priority setting tools and analysis results	
*Activity 1.4.3.*Track changes in evolution of CIMMYT's activities	CIMMYT research portfolio patterns and outputs analyzed	Internal and external reviews	
Purpose 2. CIMMYT's work is carried out cost-effectively using "best practices" (optimal mix of tried-and-true methods and cutting edge methods)	CIMMYT is competitive supplier (of technology) in global research marketplace	Competitive grants obtained by CIMMYT	Institutional buy-in and willingness to change; Partners willing to help generate and to apply best practices

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Result 2.1. Best practices identified and utilized	Relevant papers reviewed and synthesized; workshops and external events attended; linkages established to centers of excellence	Publications and presentations; analysis of CIMMYT staff performance appraisals (MBOs)	
Activity 2.1.1. Analyze the cost-effectiveness of current practices	Case studies conducted and published	Publications and presentations	
Activity 2.1.2. Compare cost-effectiveness of current practices to cost-effectiveness of best practices	Case studies conducted and published	Publications and presentations	
Result 2.2. Current practices modified as appropriate	Practices change periodically	Periodic internal and external reviews; appropriate adoption of new practices	
Activity 2.2.1. Communicate information about best practices effectively	Papers published; workshops organized; collaborative research carried out	Publications and presentations; research collaborations	
Activity 2.2.2. Implement best practices	CIMMYT practices considered state of the art, e.g., emulated by others	Periodic internal and external reviews; appropriate adoption of new practices	
Purpose 3. Impact of CIMMYT's work is rigorously documented and effectively communicated	Information on impacts readily available	Publications, presentations, and reports; information utilized by stakeholders	Open-mindedness within CIMMYT and partners; willingness to ask hard questions and admit shortcomings
Result 3.1. Adoption of improved technologies well documented	Information on adoption readily available	Publications, presentations, reports, and databases	
Activity 3.1.1. Conduct technology adoption studies (including baseline studies)	Adoption studies conducted and published	Publications and presentations	
Result 3.2. Impacts attributable to technology adoption well documented	Information on impacts readily available	Publications, presentations, reports, and databases	
Activity 3.2.1. Conduct ex-ante impact assessment studies (including baseline studies)	Ex-ante impact assessment studies conducted and published	Publications and presentations	

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Activity 3.2.2. Conduct ex-post impact assessment studies (including baseline studies)	Ex-post impact assessment studies conducted and published	Publications and presentations	
Result 3.3. Impacts communicated successfully	Communication activities undertaken e.g., scientific publications, press releases and conferences, media events, etc.	Publications and presentations; media events, etc.; target audiences knowledgeable about CIMMYT's impacts	
Activity 3.3.1. Disseminate results to a variety of appropriate audiences	Research papers published, seminars delivered, workshops organized	Publications and presentations, media events, etc.	
Purpose 4. Policy implications inform policy debates and are used by policy makers in decision-making	Heightened awareness among staff, partners, and policymakers	Content analysis of policy dialogue relevant to CIMMYT's mission (e.g., documents, speeches, presentations)	Policy linkages available and effective; willingness to take position; external policy makers trust and appreciate our findings and advice
Result 4.1. Policy implications analyzed	Implications drawn from research results	Publications and presentations, workshops	
Activity 4.1.1. Conduct focused policy studies on topics of relevance to CIMMYT research	Policy studies conducted and then published	Publications and presentations	
Result 4.2. Policy implications communicated	Awareness of target audiences	Publications, press releases, learning workshops, interaction with policy makers	
Activity 4.2.1. Communicate policy implications to relevant audiences	Research papers published; policy briefs published; seminars delivered, workshops organized	Publications and presentations, workshops	
Activity 4.2.2. Advocate in favor of selected policies (as appropriate)	Research papers published; policy briefs published; seminars delivered, workshops organized	Publications and presentations, workshops	

African Livelihoods

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Goal. Enhance food supply, food security, and improve livelihoods of resource-poor smallholder farm families in eastern and southern Africa.	National GDP of agricultural sector; commercial and foreign aid imports of food, especially cereals; numbers of people affected by drought and famine.	Government statistics; statistics of UN, Aid agencies and NGOs.	Governments are committed to the goal; international community finances the agenda; global fair trade practices are implemented; food aid is not used as a means of dumping surplus production from the North
Purpose 1. In close collaboration with partners (NARS, SROs, NGOs, private sector, farmers, etc.), develop and disseminate improved maize varieties production technologies targeted at maize-based systems and related policy recommendation that contribute to higher and more stable farm-level productivity, and improved nutrition of resource-poor smallholder families while protecting and enhancing the natural resource base.	Increased maize production and productivity; increased use of improved varieties including those with special traits (nutritionally rich, herbicide resistant); increased adoption of better cereal-legume and cash crop production systems for soil fertility maintenance and pest management, that conserve natural resources and increase productivity; number of trained researchers from NARSs who contribute to the development of sustainable maize and wheat production systems.	National maize production statistics; seed sales of improved nutritionally rich varieties; PRAs and surveys of extension services and agriculture oriented NGOs on adoption of improved production systems; NARS Annual Reports and staff lists	Food security, livelihoods and increased food supplies are a priority for governments of countries in sub-Saharan Africa; national economies and political stability do not deteriorate substantially.
Result 1.1. Improved Germplasm-related technologies developed *Activity 1.1.1.* Develop stress-tolerant nutritionally enhanced maize varieties by screening germplasm from various origins at key screening and hot spot sites in ESA, and by improving populations and developing inbred lines and hybrids for characteristics particularly important to resource-poor farmers, including: tolerance to drought and low soil fertility; resistance to important pathogens, insect and weed pests; early maturity; and traits conferring improved storability, nutritional value and food safety. *Activity 1.1.2.* Develop adapted maize varieties which are resistant to herbicide seed treatment for *Striga* control. *Activity 1.1.3.* Identify and incorporate traits in maize germplasm (including farmers' varieties) that improve the suitability of varieties for integrated maize-livestock systems and provide other opportunities for alternative use of maize (e.g. oil or starch production). *Activity 1.1.4.* Include farmer input in varietal development through participatory rural appraisals and farmer-participatory variety evaluation such as 'Mother-Baby' trial evaluations, of new varieties and hybrids.	Number of releases of varieties with specified tolerance to biotic and abiotic stress tolerance, and nutritional attributes; sales of fertilizers to smallholder farmers; area under maize systems or numbers of farmers using improved crop and soil management techniques such as conservation agriculture practices; sales of grain of grain legumes associated with maize-legume systems; no. of mother-baby trials.	Reports of national seed release and certification agencies, NARS reports, seed company sales information; surveys of seed companies and stockists; household surveys, interviews of extension service; surveys of stockists, fertilizer wholesalers, government statistics on imports; network progress reports.	NARSs and donors continue to invest in maize research and development activities; risk that human resources in NARS will continue to decline; clients find the seed and NRM technologies attractive; recipients will use economic and policy recommendations.

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.1.5. Develop national and regional facilities for ensuring sustainable development and maintenance of stress tolerant, nutritional enhanced varieties.			
Result 1.2 Improved crop management-related technologies developed *Activity 1.2.1.* Develop and/or evaluate and promote soil fertility management practices to enhance productivity of improved maize varieties, including fertilizer management, and use of green manures and grain legumes in 'best-bet' systems. *Activity 1.2.2.* Develop and facilitate the accelerated adoption of conservation agriculture practices for soil and moisture conservation in maize-based systems through the development and synthesis of information and methodologies based on multi-stakeholder collaboration and farmer experimentation. *Activity 1.2.3.* Develop and promote decision aids that match resource-conserving practices with land types and farmer categories.	Number of best-bet technologies developed and disseminated; no. of best-bet options adopted.	Annual reports of partner organizations; surveys of farmers in target areas.	NARSs and donors continue to invest in crop management research; NARS will continue to decline; clients find the conservation tillage and NRM technologies attractive; recipients will use economic and policy recommendations.
Result 1.3. Improved technologies delivered *Activity 1.3.1.* Conduct maize production demonstrations and field days in farm communities in collaboration with extension staff and other stakeholders *Activity 1.3.2.* Promote adoption and use of improved maize varieties by involving farmers in the varietal development process such as 'Mother-Baby' testing. *Activity 1.3.3.* Evaluate alternative storage practices and methods of storage pest control including the use of botanicals and inert dusts. *Activity 1.3.4.* Promote the use of improved post-harvest technologies among small-scale farmers. *Activity 1.3.5.* Develop and provide promotional materials (brochures, publications, leaflets, videos, news releases) to publicize technology recommendations and demonstrations among farmers and other stakeholders such as extension, NGOs, rural schools and other farmer-support organizations.	Number of farmers aware of improved varieties with particular attributes such as QPM, drought tolerance.	Farmer surveys conducted by CIMMYT and others on no. of technologies tested in a participatory manner; annual reports of partner organizations.	Maize continues to be a commodity considered important for food security and income generation

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.3.6. Continue to improve efficiency of technology transfer activities in particular to outlying areas and where farmers are insufficiently linked to markets.			
Result 1.4. Human resource capacity enhanced *Activity 1.4.1.* In particular given the high staff-turn around in NARS, provide NARS scientists and partners with training to maintain and enhance their skills in development and delivery of improved technologies to resource poor farmers and in the development and implementation of more appropriate policies. *Activity 1.4.2.* Help to maintain and enhance the regional pool of researchers by providing opportunities for graduate training in national, regional, and international universities *Activity 1.4.3.* Train staff from farmer-associated organizations (NGOs, extension, rural schools, churches) in implementing activities that augment farm-level productivity (e.g. seed production) and link farmers to markets. *Activity 1.4.4.* Organize symposia and conferences on issues of regional importance (e.g., NARS role in a more liberalized seed industry, effective control of Striga , post-harvest issues, etc.) and provide opportunities to partners to participate	Number of maize breeders/ scientists active in NARS programs and small seed companies in the region; no. and discipline of scientists participating the regional networks (ECAMAW, SADLF, etc); no. of conferences and training courses organized.	Surveys of partner organizations on no. of their staff pursuing degrees and conducting research and technology transfer activities; informal surveys of trainees on quality of training and training materials.	NARS and donors continue to invest in human resource development; motivated and interested young staff are available for training.
Result 1.5 Social science research and policy interventions *Activity 1.5.1.* Conduct socio-economic and gender analyses to estimate demand for improved maize technologies and agronomic practices to determine constraints to their adoption. *Activity 1.5.2.* Analyze input/output markets to determine their effects on adoption of improved maize technologies. *Activity 1.5.3.* Analyze the institutional framework in which farmers operate, determine its constraints and identify means to overcome constraints to enhance adoption of agronomic practices, improved varieties and inputs. *Activity 1.5.4.* Conduct ex-ante and ex-post assessment of the potential impact of improved maize technologies on farmers' income, rural poverty and nutrition. This includes the impact of nutritionally enhanced maize varieties on vulnerable human populations (women, children) and as livestock feed on farm-level income.	Number of impact and other social studies conducted and published; no. of policy recommendations made and implemented.	List of publications, especially refereed ones; subjective assessment of the contributions by informal surveys of partners.	NARS and donors continue to emphasize on agriculture as an engine to growth and development; maize continues to be an attractive commodity for food security and income generation.

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.5.5. Develop policy recommendations to reduce or remove constraints to increased use of improved varieties, inputs and the adoption of improved agronomic technologies, and assess the impact of different policies. *Activity 1.5.6.* Examine opportunities for value addition or alternative uses of maize to reduce price collapse in times of surplus. *Activity 1.5.7.* Foster the implementation of more effective models for NARS given more liberalized economies and the need for more client-oriented program activities of the public sector. *Activity 1.5.8.* Contribute to the debate on policy and institutional issues affecting the agricultural sub-sector.			
Result 1.6. Partnerships strengthened *Activity 1.6.1.* Develop strong partnerships with NARS, SROs, FARA, and NEPAD to effectively address development concerns especially related to the maize sector. *Activity 1.6.2.* Participate in national, sub-regional, and regional discussions on priority setting in agriculture, policy debates, and align our priorities with those of our partners *Activity 1.6.3.* Encourage linkages between NARS breeding programs and appropriate partners (NGOs, CBOs, small seed companies) for research and dissemination of new technologies and in particular seed production. *Activity 1.6.4.* Enhance the availability of improved seed to farmers by clarifying and advocating a harmonized seed policy to accommodate community-based seed production systems, identifying and empowering small seed companies, and identifying areas where smallholder farmers are not served by the commercial seed sector and where there is potential capacity for seed production and dissemination. *Activity 1.6.5.* Work with regional organizations to harmonize seed laws across the region to increase access to improved germplasm by resource-poor farmers	Volume of seed sales of improved varieties by seed companies and production of seed by CBOs registered with seed certifying agencies; subjective assessment of partner satisfaction with ALP performance in the SSA.	Annual reports of partner organizations acknowledging ALP participation and contributions.	National governments, partner organizations, and donors continue to emphasize on agriculture as an engine to growth and development; maize continues to be an attractive commodity for food security and income generation.

Rainfed Wheat Systems

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Goal. To reduce poverty by increasing the ability of farm households to manage risks to their livelihoods by improving local and regional food, feed and fodder security in rainfed wheat systems (RFWS), and by slowing or halting land degradation. Increase adoption by farmers in target ecoregions of new conservation agriculture (CA) practices, more diverse cropping systems and rotation options, and new value-added wheat varieties, all of these compatible with improved livestock and crop residue management practices and less susceptible to the effects of drought	· Release and adoption of improved bread and durum wheat, triticale, barley and maize cultivars contribute to production increases in rainfed wheat-systems of the developing world. · Increased sustainability of cropping systems through adoption of resource-conserving and durable resistance technologies by farmers. · Increased feed and fodder supplies for livestock and poultry systems · Greater diversity of crops in farmers' fields. · Increased on-farm water productivity. · Strengthened research, development, human resource, and technology transfer capacity. · More efficient allocation of agricultural research resources in developing countries. · Partnerships established to improve RFWS productivity.	Impact assessments of varieties grown by farmers, cultural practices used, economic opportunities and impacts, principles learned, technological failures, R&D capacity, etc., new partnerships developed.	Funding secured and functioning partnerships established. Enhanced ICARDA/CIMMYT collaboration.
Purpose 1. New or improved crop or agronomic components in sustainable wheat-based production systems will be used by partners, and adopted by farmers.	· Increased RFWS productivity and sustainability · Farmers adopt and partners use higher yielding, stress tolerant varieties · Farmers adopt resource conserving, CA practices and have greater systems diversity.	Cultivars released and adopted; Area using CA technologies; Area under new introduced crops.	
Result 1.1. Specific trait genepools developed, characterized and distributed.	· Increase in genetic diversity available to partner breeding programs.		
Activity 1.1.1. Development of gene pools with resistances/tolerances unique to the RFWS for abiotic (nutrient deficiencies including zinc and boron, drought-tolerance, heat, cold) stresses using trait-oriented analytical, physiological tools and molecular approaches.	· Advanced bread and durum wheat lines (200+) and segregating populations (40+) targeted to abiotic stresses limiting production in RFWS assessed by partners. · Drought tolerant germplasm (60+) with enhanced seedling vigor developed/verified. · Zinc efficient germplasm tested by partners	International Wheat Improvement Network (IWIN) germplasm distribution and phenotypic records; HarvestPlus progress reports.	HarvestPlus continuing collaboration.
Activity 1.1.2. Development of bread and durum wheat gene pools with resistances/tolerances for biotic (e.g. cereal rusts, bunts, smuts, root rot and nematodes, Hessian fly, Tan spot, *Septoria* spp., Russian wheat aphid, BYDV and sunn pest) stresses using trait-oriented analytical, physiological tools and molecular approaches.	· Advanced bread and durum wheat lines (300+) and segregating populations (50+) with enhanced durable resistance/tolerance to the major biotic stresses distributed. · Lines with enhanced cereal rust and root pathogen resistance using conventional and MAS (20k+) methods	IWIN germplasm distribution and phenotypic records; ACIAR project reports. NARS data return. MAS assays performed.	Morocco germplasm improvement project funded. NARS strong to contribute to pathology data collection networks.
Activity 1.1.3. Development of gene pools with enhanced nutritional, consumer preference and market-oriented, valued-	· Advanced lines (100+) and segregating populations (40+) targeted to specific end-use quality and	IWIN germplasm distribution; Industrial partners feedback.	NIR screening capabilities improved. NARS quality

Narrative summary	Verifiable indicators	Means of verification	Assumptions
added traits, unique to the cultural identity of our diverse partner communities.	preference requirements used by partners.		testing capacity strengthened.
Activity 1.1.4. Enhanced use of shuttle breeding methodology for both generation advancement and screening at disease and stress hot spots.	· Participation in global and regional wheat improvement networks increases. · Global monitoring and pre-emptive screening against new diseases and new virulences before major epidemics occur. · Sharing of improved, multi-disease resistant germplasm and performance data increases.	IWIN germplasm distribution and phenotypic data return; IWIN data "hits" via the Internet; Global and Regional Disease Monitoring Bulletins; Publications defining relevance of shuttle locations.	Cooperation with ICARDA-led regional disease monitoring and research networks.
Activity 1.1.5. Physiological or morphological enhancements of drought and heat tolerance (e.g., modified canopy architecture, enhanced spike fertility and stay-green capacity) using trait-oriented analytical, physiological tools and molecular approaches.	· Advanced lines (80+) targeted to the major abiotic and biotic stresses limiting production in RFWS. · Novel wheat genetic resources (25+) developed with stress adaptive traits identified.	ACIAR, GRDC and Generation CP progress reports.	
Activity 1.1.6 Development of spring wheat germplasm and establishment of shuttle breeding program for high latitude wheat (N. Kazakhstan, Siberia).	· Photosensitive lines spring bread wheats (100+) tested in northern latitudes with focused end-use quality selected (20+)	ICAR annual progress reports.	Tripartite network linkages between Central Asia, USA and CIMMYT strengthened.
Result 1.2. Genetically diverse wheat varieties and crops are made available to partners.	· Measurable increase in productivity, genetic diversity in farmers' fields.	Variety release data; New partnerships established.	Market-oriented technologies available.
Activity 1.2.1. Improvement of spring and winter bread and durum wheat and triticale using: conventional and molecular approaches; shuttle breeding; global and regional research networks; and participatory approaches with farmers/consumers/processors to evaluate technology preferences and acceptability.	· At least 80 bread and durum wheat lines identified by NARS, NGOs, Private Sector for advanced testing. · At least 30 lines submitted for varietal testing by NARS, NGOs, Private Sector and 10 cultivars registered for release.	Annual national planning meeting reports; Varietal candidate and release records.	International, Regional and National varietal release regulations harmonized.
Activity 1.2.2. Enhanced options for farmers, involving cultivar and alternate crop (including maize and triticale) suitability will be investigated.	· Increased crop diversification considered. · At the minimum, maize, triticale, oats and safflower germplasm tested.	RFWS and partner annual progress reports.	Partners involved to test and induce new legume, oil-seed and forage crops.
Activity 1.2.3. Germplasm and data distributed through the international and regional wheat improvement networks to partners.	· Annual transfer/exchange of international and regional germplasm nurseries (15+) and data published on Internet. · Regional germplasm exchange and testing networks supported	IWIN germplasm distribution and phenotypic records; Central Asia, China, Asian Sub-Continent, TCI-IWWIP, Southern Cone reports.	Phytosanitary, intellectual property rights and germplasm sharing constraints minimized.
Result 1.3. Resource conserving technologies will be developed, tested, and adopted with partners and farmers.	· Networks of partners working to develop and promote conservation agriculture. · Principles affecting tailored adoption of Conservation Agriculture (CA) practices.	CA training course attendance, and alumni impact studies. Case study principles published.	Applied, appropriate agronomic expertise available.
Activity 1.3.1. Develop and adapt improved crop management strategies including CA practices such as zero, reduced and minimum tillage, and input efficiency and water productivity.	· CA implements and practices tested, refined in 12 RFWS affected countries. · Locally produced CA implements (8 countries). · Long-term rotation trials maintained (2).	NARS progress reports; Industrial partner reports; Publications; Traveling seminars.	Government policies foster resource conserving husbandry practices.

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.3.2. Develop a rapid appraisal methodology to assess effective CA implementation, recognizing alternative residue uses, household value (fodder, fuel, thatch, etc.) and communal cultural receptivity.	· Rapid Appraisal Tool(s) developed, verified, and used by partners.	Tools published for peer review and partner use.	ILRI collaboration.
Purpose 2. To characterize agroecological, societal and livelihoods environments faced by partners and farmers in RFWS.	· Better focused, more efficient research and technology development by understanding significant points of intervention. · More effective technology and information transfer among and between partners.	Disciplinary Group, Program and network discussions and recommendations and implementation plans; E-Databases.	
Result 2.1. Rainfed crop and livestock systems will be better characterized, and the information will be used to target and monitor technology development goals.	· Information will be used to target and monitor technology development activities and goals.	Research methodology changes. Partner profiles are affirmed or change.	ILRI/CIMMYT Livestock Mapping Initiative successful.
Activity 2.1.1. Improve the characterization and definition of target production and consumption environments, to direct wheat research objectives and germplasm screening methods/locations better.	· International Adaptation Trial published (4+). · Regional/national IWIN and GIS studies (2+). · Wheat-based production environments re-classified (2+).	Publications. Research methods affected or re-focused.	Strengthened Crop Information databases used.
Activity 2.1.2. Assess yield loss due to nematode and root rot pathogens and develop strategies to reduce damages.	· Document (4) frequency/distribution, biology and economic losses due to root diseases in Turkey, Iran.	Publications. Research strategies initiated.	Constraint awareness enhanced.
Activity 2.1.3. Characterization of field soil quality.	· Rapid method for assessing soil salinity/fertility.	Surveys conducted/published.	
Result 2.2. The risk assessment of potential adoption of new technologies and reoccurring environmental and socio-economic stresses, in the context of livelihood security, understood and quantified.	· Adoption constraints will be better understood and documented (2) with research priorities oriented towards partner/client needs.	Publications. Impact pathways defined.	Livelihoods approaches understood and embraced in the research planning and conduct processes.
Activity 2.2.1. Investigate technology use, constraints to use, factors influencing adoption, implications for income and gender equity, resource conservation, and anticipated future research priorities.	· Farm-level survey (1 country) to collect primary data for household decision-making behavior. · Identify obstacles to adoption of technologies. · Estimate and understand the impacts of technology adoption on livelihoods.	Publications (3). Research methods affected or re-focused.	
Purpose 3. Institutions -- including CIMMYT – and partnerships are strengthened to increase our capacity to contribute to our mission(s).	· Stronger institutions and partnerships, higher quality, more relevant research addressing the needs and constraints of RFWS farmers.	Retention of researchers in research roles; Quantified outputs and impacts.	
Result 3.1. Increased effectiveness of partner and CIMMYT research activities is achieved.	· Farmers' livelihoods improve, production sustainability enhanced, poverty reduced, and incomes increase through RFWS technologies.	Impact assessments.	
Activity 3.1.1. Utilization of new field/lab screening methodologies, and marker assisted selection (MAS) for germplasm enhancement.	· Increased efficiency in field operations through greater mechanization (examples, 5+). · CIMMYT and partners use and disseminate more efficient (3-5) selection methodologies.	New methods defined. Additional MAS markers used. ICIS migration. NIR selection for quality.	CIMMYT adopts and migrates to ICIS database.
Activity 3.1.2. Seed production schemes will be supported.	· Quicker response to private sector/NGO /farmer demand for improved or candidate varieties. · Production and dissemination of high quality breeders seed Afghanistan and Central Asia.	Constraints to wheat/maize seed production report. Quantities of seed produced and distributed.	Market-oriented technologies, and markets available.

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 3.1.3. Promotion of new research methods, crop management practices and varieties through, training, demonstration and participatory on-farm trials.	· Technology development specific to end-user demands and preferences (examples, 15+). · On-farm promotion (70+) of CA technologies and in areas affected by salinity.	Impact assessments. Involvement in training, participation in research, verification and dissemination.	Effective extension and NGO dissemination channels.
Activity 3.1.4. Partnerships developed with organizations and institutions contributing to improved livelihoods for farmers in RFWS.	· Collaboration established or enhanced with traditional and new partners. · New joint projects (3) with partners.	Annual planning meetings. Tapping into new, plentiful sources of funding.	Projects with ICARDA, ILRI, etc.
Result 3.2. Training of NARS will be increased in areas of specific need.	· Enhanced human resource capacity of NARS and partners.	Trained colleagues. Post-training impact assessments.	
Activity 3.2.1. Conduct international and regional training courses, regional conferences and workshops.	· Courses, conferences, workshops, seminars, field days, educational curricula, annual planning/coordination meetings.	Colleagues trained. Curricula published. Post-training impact assessments.	Qualified and willing partners.
Activity 3.2.2. Supervise M.Sc. and Ph.D. university students, and facilitate opportunities for training in ARIs from partner organizations.	· Theses, dissertations completed (15+). · Research on program-relevant topics will increase program/partner effectiveness	Students supervised. Publications (5+).	Institutional mentors available for legacy planning.
Result 3.3. Technology and information dissemination.	· Better informed and participating partners.		
Activity 3.3.1. Program objectives, challenges, partners, linkages, and outputs will be distributed to partners, the general public and policy makers.	· Scientific and general audience publications, press releases, oral presentations, field days, traveling seminars, Internet access and use.	Publications. Numbers of people reached.	Internet access and use. High literacy rates. Multi-lingual publications.
Activity 3.3.2. Dissemination and use of experiences in successful technology development and transfer to partners and CIMMYT scientists to improve relevance of technologies.	· *Ex ante* case study (1) projecting likely future impacts of improved technologies. · Case studies (2) on-farm demonstrations, partner participatory evaluations.	Case studies (3).	

Tropical Ecosystems Program

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Goal. Improve the livelihoods of resource-poor farmers in the tropics by increasing the productivity and profitability of farming systems that include maize (or wheat)	Nutritional, production, and income statistics for target countries attended by TES	Various statistics and reports	Governments' policies congruent with orientation to food security and poverty alleviation
Purpose 1. Farmers' livelihoods and well-being are improved by TES Program's products	Various impact assessments	In-house or contracted consultancy reports, e.g. Center Commissioned External Reviews; publications	Targetted farmers have access to improved technologies; suitable impact assessment methods are available
Result 1.1. Appropriate, improved maize hybrid and OP varieties will be available on a five-year "replacement cycle"	Farmers' and scientists' assessments of performance of new vs. previous and vs. best check varieties	Internet, on-line reports; national, regional and international farmer-participatory and scientist-managed trial reports; reports to donors of special projects	Adequate financial resources are available (e.g. to maintain or strengthen breeding work); effective partnerships can be established for germplasm evaluation
Activity 1.1.1. Breed stress-tolerant (abiotic and biotic), productive maize germplasm suitable for resource-poor farmers in lowland and highland tropical environments	Performance of new vs. previous and vs. best check varieties in researcher- and farmer-managed target environments	Internet, on-line reports; 'Maize-finder' or similar data management system	
Activity 1.1.2. Breed maize germplasm suitable for acid soils	Performance of new vs. previous and vs. best check varieties	Internet, on-line reports; 'Maize-finder' or similar data management system	It is feasible to develop improved acid soil tolerant maize cultivars
Activity 1.1.3. Breed maize germplasm with enhanced nutritional value, especially high-lysine maize (QPM), and increased pro-vitamins A	Performance of new vs. previous and vs. best check varieties	Internet, on-line reports; 'Maize-finder' or similar data management system	
Activity 1.1.4. Introduce elite alleles (e.g. drought tolerance or lodging resistance) to farmer-preferred germplasm	Performance and farmer-acceptance of new germplasm vs original farmers' varieties	Internet, on-line reports; 'Maize-finder' or similar data management system	Farmers are willing to participate
Activity 1.1.5. Conduct farmer-participatory research to assess technology preferences and acceptability	Farmers' maize varietal preferences documented	Internet, on-line reports; Reports of farmer surveys and farmer-participatory trials	Effective partnerships established; farmers willing to participate
Result 1.2. Profitable crop management or farming systems options identified or developed within 5 years for at least 2 major farming systems that include maize in the tropics	Estimates of economic, social and agronomic benefits of recommended technologies	Internet, on-line reports; in-house or contracted consultancy reports; reports to donors of special projects	Strategic partnerships can be enhanced or established to access farming systems expertise; adequate financial resources available

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.2.1. Crop management (including tillage) research for/in various defined agro-ecosystems (e.g. acid soil, weathered hillsides, etc.)	Performance estimates from scientist-managed trials	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	
Activity 1.2.2. Evaluate genotype x management, or genotype x system (e.g. rotations, livestock, etc.) interactions	Performance estimates from scientist-managed trials	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	
Activity 1.2.3. Farmer-participatory research to assess acceptability and profitability of emerging options	Quantitative and qualitative data from farmer-participatory trials	Internet, on-line reports; reports or invited seminars by participating scientists	Effective partnerships established; farmers willing to participate
Result 1.3. Effective methodologies for technology development and dissemination identified or developed; and used	Comparison of breeding, testing and dissemination strategies used in 2004 vs. those used in 2009	Internet, on-line reports; in-house or contracted consultancy reports; reports to donors of special projects; publications	Adequate financial resources are available; effective partnerships and alliances are established
Activity 1.3.1. Develop and test protocols to effectively breed maize germplasm suitable for acid soils	Various breeding efficiency parameters (e.g. heritability of selection parameters, expected gains from selection); economic comparison of selection methods	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	Available lab and field screening technologies to identify maize genotypes tolerant to acid soil.
Activity 1.3.2. Identify or develop criteria to predict and/or assess the impact of tillage and crop management options on system sustainability and profitability	Research results comparing effectiveness and practicality of various methods and parameters to assess impact of tillage and crop management options on system productivity and sustainability	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	
*Activity 1.3.3***.** Develop and/or identify, and test technology options that increase human and livestock health by reducing mycotoxins and pest damage post-harvest	Estimates of health, economic, social and agronomic benefits/gains associated with use of new technologies	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	Strategic partnerships can be enhanced or established to access mycology, health science, and engineering expertise
Activity 1.3.4. Develop and test methods for introgressing favorable alleles to farmer-preferred varieties	Agronomic and socio-economic comparison of at least three experimental models by end of 2009	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	Necessary permissions are granted to work with farmers' germplasm
Activity 1.3.5. Develop and/or test models for technology dissemination, including seed systems, with particular emphasis on reaching resource-poor farmers	Farmer, farmer organizations, NGO, extension service, social scientists' assessments	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Activity 1.3.6. Use various information/data management, analysis and sharing tools (e.g. GIS, spatial data analyses, data management tools, varied media) toward outputs 1.3 and 1.4	Quantitative and qualitative assessment of frequency, creativity and effectiveness of use of available tools	In-house or contracted reviews	Technical expertise is accessible
Result 1.4. Ex-ante, livelihood and prioritization analyses conducted; effects and impact of TES/CIMMYT technologies documented (includes developing means of verification for other activities and outputs)	Reports. Productivity, sustainability, profitability and livelihood impact parameters; statistics on use of improved technologies (e.g. seed)	Internet, on-line reports; in-house or contracted consultancy reports; reports to donors of special projects; publications	Strategic partnerships and resources to access impact assessment and livelihoods expertise; adequate financial resources available
Activity 1.4.1. Define our primary "clients" in at least 5 "target" countries, characterize their livelihoods and relate our products to their livelihoods to define impact pathways	Socio-economic / livelihood analysis reports	Reports; internet, on-line reports; phone calls to, or invited seminars by participating scientists	Technical expertise to guide this work is available; partners in selected countries are willing and interested to collaborate
Activity 1.4.2. Design and conduct field research experiments to compare productivity, sustainability and profitability of recommended vs previous technologies	Research data and analysis	Internet, on-line reports; phone calls to, or invited seminars by participating scientists	Access to appropriate farming systems and economics expertise
Activity 1.4.3. Commission, or design and conduct research projects (including base-line studies) to measure the socio-economic, livelihood and ecological sustainability consequences of adopting recommended technologies	Number and quality of pertinent theses and other publications produced by supervised students or consultants; research data and analysis	Phone calls to, or invited seminars by participating scientists; theses, reports and publications	Access to appropriate socio-economic and livelihoods expertise; effective partnerships established
Purpose 2. Capacity of others to contribute to our goal is enhanced	Number of stakeholders benefiting from various types of technical or academic development opportunities	In-house or contracted consultancy reports, e.g. Center Commissioned External Reviews; publications	Adequate financial resources available; political, "global" interest in serving the resource-poor increases, or at minimum does not decline
Result 2.1. Professional development opportunities provided to at least 100 scientists each year	Number of scientists benefiting from various types of technical or academic development opportunities	Internet, on-line reports; CIMMYT data bases; phone calls or follow-up surveys with beneficiaries	Adequate financial resources available; political, "global" interest in serving the resource-poor increases, or at minimum does not decline
Activity 2.1.1. Convene or facilitate relevant conferences, workshops, training courses, etc.	Number of events and event participants	Internet, on-line reports; CIMMYT data bases; phone calls or follow-up surveys with beneficiaries	Strategic partnerships can be formed to offer events beyond our in-house expertise

Narrative Summary	Verifiable indicators	Means of verification	Assumptions
Activity 2.1.2. Provide, facilitate or mentor professional development opportunities (e.g. thesis research, visiting scientists, etc.)	Number of beneficiaries of various types of professional development opportunities	CIMMYT data bases; reports, theses, publications; phone calls, invited seminars, or follow-up surveys with beneficiaries	Adequate physical facilities to support and/or host beneficiaries
Result 2.2. Active international and inter-institutional partnerships in Latin America and Southeast Asia	Number and productivity of regional and sub-regional collaborative projects, collaborative trials data, joint publications, scientific exchange visits, number and type of technologies shared	Internet, on-line reports and information; in-house or consultancy reports; CIMMYT data bases; publications; reports to donors of special projects	Continued scientific interest and political support for regional collaboration; adequate financial support
Activity 2.2.1. Convene, facilitate, advise and/or participate in global, regional or sub-regional networks or collaborative projects	Number and scope of partners enhancing the productivity of collaborative projects, collaborative trials data, joint publications, scientific exchange visits, number and type of technologies shared	Internet, on-line reports and information; reports; phone or written stakeholder surveys	Adequate partnership-building skills of TES staff; adequate financial support
Activity 2.2.2. Explore and facilitate public – private sector, and other synergistic alliances	Number, diversity and (quantitative and qualitative) contribution of partners to output 2.2	Reports; CIMMYT data bases; phone or written surveys of stakeholders and CIMMYT scientists	Adequate partnership-building skills of TES staff; suitable partners can be identified (with common goals and complementary assets)
Result 2.3. Technical information disseminated through various media	Number, quality and effectiveness of informative messages	In-house or consultancy reports; CIMMYT data bases; internet site(s); publications	Access to communications expertise; effective partnerships established; adequate financial resources
Activity 2.3.1. Disseminate information to farmers, particularly resource-poor farmers	Number of bulletins and multi-lingual reports; percent of farm households aware of technologies developed by CIMMYT or by partnerships involving CIMMYT	CIMMYT data bases; internet, on-line reports and information; phone or written stakeholder surveys	
Activity 2.3.2. Disseminate information to non-scientific, stakeholder community	Number and "reach" of non-technical publications, presentations and formal communications; extent of stakeholder awareness of CIMMYT	CIMMYT data bases; internet, on-line reports and information; phone or written stakeholder surveys	Access to communications expertise
Activity 2.3.3. Disseminate information to scientists	Number and "reach" of scientific publications, presentations and information exchange	CIMMYT data bases; internet, on-line reports and information; publications	Continued or enhanced institutional value of scientific information

Intensive Agroecosystems

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Goal. Reduce poverty and conserve natural resources in densely-populated areas where intensive maize and wheat systems underpin the livelihoods of the poor – by improving incomes for poor farm families, fostering expanded employment for the rural landless, improving food security for rural consumers and conserving water and land resources	Income levels, livelihood indicators, employment rates, malnutrition rates, basin level water use, land quality indicators	Secondary data, targeted surveys, water balance data, GPS studies	
Purpose 1. Employment for the landless poor and higher incomes for farm families through diversification **-** Increase incomes and reduce poverty by expanding employment in rural areas via expanded high-value, labor-intensive crop and livestock activities in maize and wheat systems	Area under food grains vs. diversification crops, wage rates, rural non-farm employment	District level data on land use, surveys of livelihoods of the landless, standard livelihood indicators	labor-intensive activities can be identified that are attractive to farm families
Result 1.1. Freeing resources for diversification - New maize and wheat production technologies that facilitate diversification are developed and adopted. These are practices that free up land, labor, water, and other resources for use by crops other than maize or wheat	In adopting areas, farm resources devoted to cereals declines by 15% over three years in adopting areas	Adoption studies	Grain prices are allowed to fall as cost-reducing grain production practices are used
Activity 1.1.1. Crop improvement to develop input-use efficient, stress-tolerant maize and wheat germplasm that increases factor productivity	Fifty varieties developed and released in three years	Data on variety release	Partners invest in crop improvement
Activity 1.1.2. Participatory research and development of technologies that make it easier to insert high value crops into maize and wheat systems (e.g., zero tillage to reduce turnaround time) or that facilitate poor farmer access to input and product markets (e.g., mechanization)	Three practices and/ or implements developed and adapted in three regions in three years	Technical reports, reports on farmer feed-back	
Result 1.2. Adding diversity to maize and wheat systems - New management technologies that increase diversity in maize and wheat systems are developed and used by partners and communities	In adopting areas, the importance of non-cereals increased by more than 30%	Adoption studies	
Activity 1.2.1. Research and development on introducing into maize and wheat systems high value crops, e.g., legumes and vegetables	Ten high value diversification crops identified and tested in three years	Technical reports, farmer feed-back	Viable diversification crops can be identified
Activity 1.2.2. Research and development on the use of bed and furrow systems that facilitate the establishment and management of a diverse range of crops in intensive agroecosystems	Bed and furrow systems developed and adapted in three regions in three years	Field reports, reports on farmer feed-back	Private sector helps with implement development and sales
Activity 1.2.3. Crop improvement (with germplasm and data distribution) of triticale, maize, and wheat for livestock feed and fodder, and for good performance when used with new rotations	Ten varieties developed and released in three years	Data on variety release	
Result 1.3. Social science and policy support for diversification - Information useful for informing the decision-making process regarding policies and institutions that support and foster increased agroecosystem diversity is produced and shared with policymakers	At least two high level presentations per year with key policymakers	Policy decisions and their documentation	Access to policymakers can be arranged
Activity 1.3.1. Analysis on the consequences of alternative policies and institutional arrangements on agroecosystem diversification	Two case studies of the effect of policy on diversification	Policy briefs and publications	
Activity 1.3.2. Marketing studies to guide diversification activities towards commercially viable alternatives	Two marketing studies conducted in three years	Publications, extension material	
Purpose 2. Food security for poor consumers - Improve food security and reduce vulnerability for poor consumers through production technologies that better tolerate	Incidence of malnutrition, especially during years with crop stress	Monitoring of health status of vulnerable groups, official data	

Narrative summary	Verifiable indicators	Means of verification	Assumptions
biotic and abiotic stress, improved post-harvest storage of food, and supporting policies.		on malnutrition	
Result 2.1. Stress tolerant varieties for food security - Higher yielding maize and wheat varieties, of higher quality, and that are more resistant to abiotic and biotic stresses are developed and used	Level of adoption of stress tolerant maize and wheat varieties	Adoption studies, research work plans	
Activity 2.1.1. Crop improvement in maize and wheat for resistance/ tolerance to *abiotic* stresses (nutrient deficiencies, drought-tolerance, heat), *biotic* stresses (cereal rusts, leaf blights, root diseases) – and for enhanced nutritional, consumer preference and valued-added traits	Twenty varieties developed and released in three years	Data on variety release	Partners continue to invest in crop improvement
Activity 2.1.2. Shuttle breeding on a global scale to screen improved materials in "hot spots" for diseases or other stresses, guided by epidemiological and crop surveillance studies	One summary report submitted describing progress in source germplasm due to shuttle breeding finished by third year	Screening reports	Resources available to support global shuttle breeding
Activity 2.1.3. Physiological or morphological enhancements of drought and heat tolerance (e.g., modified canopy architecture)	Advanced germplasm with enhanced traits	Technical reports	
Result 2.2. Diversified systems for food security - New production technologies for introducing increased diversity in agroecosystems, featuring livestock or crop production activities that generate food or income in hungry seasons, are developed and used	In adopting areas, hunger during the "hungry season" reduced by at least 30%	Land use data, livestock surveys	
Activity 2.2.1. Research and development on maize and wheat system management to provide reliable food during hungry seasons	At least one study on how changes in system mgt affects timing of food availability	Farmer feed-back, crop calendars	
Activity 2.2.2. Research and development on strengthening livestock production in maize and wheat systems through feed and fodder production from maize, wheat or triticale grain or stover/ straw	Information on feed, fodder and crop-livestock integration	Technical reports, reports on farmer feed-back	Poor families own livestock (e.g., ":landless livestock")
Result 2.3. Improved storage for food security - New production technologies that reduce post-harvest storage losses are developed and used by partners and farming communities	In adoption areas, storage losses reduced by 40% in three years	Market studies, storage loss surveys	
Activity 2.3.1. Crop improvement in maize and wheat for reduced storage losses, e.g., through husk cover, seed hardness, etc.	Two varieties developed and released	Data on variety release	
Activity 2.3.2. Research and development on seed and grain storage practices to reduce storage losses	Two storage practices developed and adapted	Technical reports, farmer feed-back	Viable practices can be identified
Result 2.4. Social science and policy support for food security - Information useful for informing the decision-making process, regarding policies and institutions that affect food pricing and availability, is produced and shared with policymakers	Policy changes in directions that enhance food security	Policy decisions and their documentation	Access to policymakers can be arranged
Activity 2.4.1. Policy analysis on the consequences of alternative policies and institutional arrangements food security and vulnerability	Two studies finished on policy and food security	Policy briefs	
Activity 2.4.2. Market and policy analysis on grain trade and drying	One study finished re markets, policy and grain drying	Publications	
Purpose 3. Conserving resources for civil society - Reduce water consumption in agriculture to make more water available for alternative uses (urban, industrial, ecological and environmental). In addition, foster improved soil health and avoid land degradation.	Increased water available for non-agricultural uses, improved soil health	Water balance studies, data on urban water utilization, GPS surveys of soil health	

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Result 3.1. Increased "crop per drop" of water - New technologies for maize and wheat systems that improve water productivity are developed and used	Farm level water productivity, adoption of water efficient practices	Adoption studies	Plot level water productivity also helps at the basin level
Activity 3.1.1. Crop improvement in maize and wheat for varieties that yield well while using less water	Twenty varieties developed and released	Data on variety release	
Activity 3.1.2. Research and development on introducing into maize and wheat systems new crops that are water use efficient	Two new rotations developed and adapted	Farmer feed-back	
Activity 3.1.3. Research and development on crop and system management practices that improve water productivity. These include land leveling, zero tillage, crop residue for mulch, bed systems, etc.	Three practices developed and adapted in three regions in three years	Technical reports, reports on farmer feed-back	
Activity 3.1.4. Whole basin modeling of water balances to assess the effect of plot level techniques on basin level in water productivity	At least one case study on basin-level water balances finished in three years	Model outcomes	Models can be adapted
Result 3.2. Social science and policy support for water use - Information useful regarding water use and water productivity in agriculture is produced and shared with policymakers	Policy changes that favor improved water productivity	Policy decisions and their documentation	Policy change is politically feasible
Activity 3.2.1. Policy analysis on the consequences of alternative policies and institutional arrangements on water productivity	At least two studies on policy and water use finished in three years	Policy briefs	
Activity 3.2.2. Market and policy analysis on factors governing adoption of water use efficient crops and practices	At least two adoption/ policy studies done in three years	Adoption studies	
Result 3.3. Resource conserving technologies (RCTs*)* - New production technologies for maize and wheat systems that foster improved soil health are developed and used	Levels of adoption of RCTs, soil health indicators	Adoption studies, GPS surveys of soil health	
Activity 3.3.1. Research and development on management practices that improve soil health (e.g., reduced tillage, bed systems, crop residue mulch, green manures) or that ameliorate salinity	Four new practices developed and adapted in three regions in three years	Technical reports, reports on farmer feed-back	
Activity 3.3.2. Crop improvement (and related germplasm and data distribution) for maize and wheat varieties that perform well with resource conserving technologies	Twenty varieties developed and released in three years	Data on variety release	
Activity 3.3.3. Farm level monitoring and long-term trials to understand the long-term consequences of the use of new land and water management practices	At least two studies on long-term consequences conduct in three years	Periodic reports on long-term trends	Sustainable funding for long-term research
Activity 3.3.4. Strategic research on biophysical processes associated with resource conserving technologies	At least two studies on biophysical processes finished in three years	Refereed publications	
Purpose 4. Capacity strengthening and targeting - Strengthen the capacity of partners to conduct research for sustainable intensification and diversification of maize and wheat systems, and to use decision support systems to target work towards priority areas	External judgments on quality of work and publications, use of decision support tools	Review reports, bibliographies, documentation of research process	Partners encourage stability of staffing in key positions in their organizations
Result 4.1. Training and HR development - The capacity of partners (NGOs, universities, farmer groups, public and private sector entities) in research and development is strengthened	At least 1000 partner staff benefiting from training over the MTP time period	Training database	
Activity 4.1.1. International, regional and bilateral training courses, conferences, workshops, study tours and traveling seminars	At least 30 training events carried out per year	Training reports	Funding available
*Activity 4.1.2***.** Supervise doctoral and other advanced students	At least one advanced student supervised	University documents	
Result 4.2. Technology targeting and priority setting - The efficiency of collaborative activity with partners is improved by a clear focus on priority areas and activities	Recommendation domains established and used by stakeholders in at least one region	Maps and research reports	Stakeholders "buy in" to priority setting processes

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 4.2.1. Consult with stakeholders on priority areas and activities	At least one stakeholder meeting held per year	Meeting reports	
Activity 4.2.2. Use GIS in site characterization and definition of recommendations and areas of site similarity	Spatial information on technology targeting developed for at least two regions in three years	Maps	Data available
Activity 4.2.3. Develop decision support tools to match technologies to specific sets of agro-climatic and socioeconomic circumstances	Decision support system developed	Materials for users of decision support tools	
Activity 4.2.4. Monitor and evaluate program activities as part of a continuous process to improve program efficiency	At least one monitoring and evaluation activity per year	Monitoring and evaluation reports	

Rice Wheat Consortium for the Indo-Gangetic Plains

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Goal. Improve the productivity and sustainability of cropping systems in those parts of the Indo-Gangetic Plains where land, water and other resources are primarily used for rice-wheat cultivation, while improving the livelihoods of the poor	Factor productivity levels, income levels, livelihood indicators, basin level water use, land quality indicators	Secondary data, targeted surveys, water balance data, GPS studies	
Purpose 1. Developing technologies and policies (all RWC members and partners) - Through collaborative research, develop technologies and policies to improve rice-wheat system productivity and diversity, enhance soil fertility and soil health, reduce the extent of salinity and sodicity, slow or stop groundwater depletion, and resolve problems of pests, diseases and weeds in rice-wheat systems	Technologies and policies developed, adapted, tested, with good initial adoption	District level data on land use, adoption studies, water quality data, diagnostic surveys	Technologies attractive to farmers in the near term can be identified
Result 1.1. Improved water productivity in rice-wheat systems. Technologies for rice-wheat systems that improve water productivity – and stop/ reduce groundwater depletion - are developed and used	Water productivity measures, groundwater levels	Adoption studies, government surveys of groundwater levels	Basin level management practices do not undermine progress made through plot-level practices
Activity 1.1.1. Crop improvement in rice and wheat for varieties that perform well but use less water (CG Centers and NARS)	Suitable varieties developed and released	Data on variety release	
Activity 1.1.2. Research and development on introducing into rice-wheat systems, crops that are water use efficient, e.g. expanding the area of legumes (Partners)	Cultivar choices and new rotations developed and adapted	Technical reports, reports on farmer feed-back	Crops that are economically attractive to farmers in the near term can be identified
Activity 1.1.3. Research and development on crop and system management practices that improve water productivity. These include rice establishment methods (e.g., rice on beds), weed management, seed metering systems, land leveling, zero tillage, crop residue for mulch, bed systems, etc. (Partners)	New practices developed and adapted	Technical reports, reports on farmer feed-back	
Activity 1.1.4. Whole basin modeling of water balances, to ascertain the extent to which plot level improvements result in basin level improvements in water productivity (CG Centers and NARS)	Information on basin-level water balances	Technical reports	
Activity 1.1.5. Monitoring spatial incidence of changes in groundwater levels and quality (NARS)	Trends in groundwater levels/ quality	Technical reports, government statistics	Data is available
Activity 1.1.6. Social science research and policy analysis on the consequences of alternative policies and institutional arrangements for improving water productivity, and the livelihood and equity impacts of changes in water management practices (Partners)	Information on policy and water use, and on impacts of technical change	Policy briefs, impact studies	
Activity 1.1.7. Market and policy analysis on factors governing adoption of water use efficient crops and practices (Partners)	Adoption of water conserving practices	Adoption studies	
Result 1.2. Improved soil health. New technologies for rice-wheat systems that improve soil health and soil fertility are developed and used	Level of adoption of new technologies that improve soil health	Adoption studies	
Activity 1.2.1. Participatory research and development of resource-conserving technologies that improve soil organic matter, fertility, and soil biology, e.g., zero tillage, crop residue management, green manures, fertilizer management practices, weed management, control of root diseases (Partners)	Second generation resource conserving technologies developed and adapted	Technical reports, reports on farmer feed-back	
Activity 1.2.2. Research and development on crop, system and water management practices that ameliorate / facilitate crop production in saline environments, e.g., salt	New practices developed and adapted	Technical reports, reports on farmer feed-back	

Narrative summary	Verifiable indicators	Means of verification	Assumptions
tolerance in crops, use of amendments, conjunctive use of multi-quality irrigation waters, planting systems, rainwater management and salt leaching etc. (Partners)			
Activity 1.2.3. Crop improvement for maize and wheat varieties that perform well in combination with resource conserving technologies (CG Centers and NARS)	Suitable varieties developed and released	Data on variety release	
Activity 1.2.4. Farm level monitoring and long-term trials to understand the long-term consequences and impacts of the use of new land and water management practices on rice-wheat system productivity and sustainability (Partners)	Information on long-term consequences	Monitoring reports, long-term trial reports	Sustainable financial support for long-term measurements
Activity 1.2.5. Strategic research on crop residue management (including development and refinement in planting machinery) and other biophysical processes associated with resource conserving technologies (Universities, CG Centers, partners)	Information on biophysical processes, new implements	Refereed publications, technical reports	
Activity 1.2.6. Interaction among researchers, scientists, farmers, private sector manufacturers and external experts on how to best implement conservation agriculture practices (NARS)	Study tours conducted	Study tour reports	RWC continues to be accepted as suitable for running study tours
Result 1.3. Enhanced diversity in rice-wheat systems. New management technologies that increase diversity in rice-wheat systems are developed and used by partners and communities	Diversity in rice-wheat systems is increased	Adoption studies	
Activity 1.3.1. Research and development on introducing into rice-wheat systems high value crops, e.g., legumes and vegetables (Partners & NARS)	High value crops for different systems identified	Technical reports, reports on farmer feed-back	
Activity 1.3.2. Research and development on the use of bed and furrow systems that facilitate the establishment and management of a diverse range of sole/ intercrops in rice-wheat systems	Bed and furrow systems developed and adapted	Technical reports, reports on farmer feed-back	Suitable implements can be developed or identified
Activity 1.3.3. Social science research and policy analysis on the consequences alternative policies and institutional arrangements on rice-wheat diversification, and the livelihood and equity impacts of diversification (CG centers and NARS)	Information on policies and diversification	Policy briefs	
Activity 1.3.4. Marketing studies to guide diversification activities towards commercially viable alternatives (NARS)	Information on diversification options	Policy briefs and publications	Commercially viable alternatives can be identified
Purpose 2. Accelerating adoption of technologies and policies (all RWC members and partners) Through collaborative development activities, accelerate the adoption of those technologies that lead to improved rice-wheat system productivity and sustainability	Change over time in adoption rates for key technologies and policies	State and district level production statistics, adoption studies	
Result 2.1. Tapping national and local resources. National and local government human and financial resources are tapped to support scaling out of RWC technologies (NARS partners)	Government resources committed	Government and RWC budgets and project documents	Financial windows that can be tapped are available
Activity 2.1.1. Display of successful RWC activities to VIP visitors from national, state, province and local government agencies	Field visits conducted	Field visit reports, photographs	
Activity 2.1.2. Assistance to RWC members in developing and submitting proposals for World Bank and related loan funds through national governments	Proposals submitted and approved	Proposal and project documents	
Activity 2.1.3. Interaction with NGOs and extension agencies whereby these, with their own resources, assist with scaling out of RWC technologies	Resources allocated by NGOs and extension agencies to scaling out RWC technologies	Partner budget/ staff allocation information	Extension agencies are willing to invest own resources
Activity 2.1.4. Participation of development workers, along with farmers, in RWC member research activities	Team membership/ composition	Annual reports, with lists of team members	

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Result 2.2. Technology targeting and priority setting. The efficiency of collaborative activity with partners is improved by a clear focus on priority areas and activities	Recommendation domains established and used	Maps and research reports	
Activity 2.2.1. Consult with members and partners on priority areas and activities, with decisions emerging from the RSC Executive	RTCC and RSC/ Executive meetings	Meeting reports	
Activity 2.2.2. Use GIS and remote sensing tools in site characterization and definition of recommendations and areas of site similarity (NARS and CG Centers)	Spatial information on technology targeting	Technical reports, maps	Spatially referenced data exists
Activity 2.2.3. Develop decision support tools to match alternative technologies to specific rice-wheat system transects in the Indo-Gangetic Plains (CG centers and NARS)	Decision support system developed	Technical reports,	
Result 2.3. Community participation Scaling out of RWC technologies is accelerated by innovative uses and approaches to community participation	Recommendation domains established and used	Maps and research reports	Senior research managers are willing to try community-based approaches
Activity 2.3.1. Build community participation into new project proposals for funding for scaling out of RWC technologies	Participatory methods included in proposals	Project proposal documents	
Activity 2.3.2. Assist member organizations to improve their skills in methods for scaling out involving community participation	Training events	Training reports	
Purpose 3. Governance and knowledge management (Facilitation Unit). Strengthen the capacity of RWC members and partners to address rice-wheat system problems and opportunities	Expert judgments on capacity and research quality	External program reviews, training reports	The FU is financially sustainable
Result 3.1. Knowledge management and human resource development. Information on problems, opportunities, technologies, policies, projects, partners, and financial resources is properly organized and shared	Information accessible in user-friendly form	Databases, web-based information sources functional	
Activity 3.1.1. Study tours that allow farmers, researchers, development workers and other partners to visit and learn from each other's activities and projects	Study tours conducted	Study tour reports	
Activity 3.1.2. Data management systems such as "PRISM" for web-enabled access by members to information on RWC projects and activities	Level of development and use of PRISM	Number of "hits", user feedback surveys	
Activity 3.1.3. Recurring meetings of the Regional Steering Committee and the Regional Technical Coordination Committee to share technical knowledge and take decisions on consortium priorities	Meetings held and decisions taken	Meeting minutes	
Activity 3.1.4. A continuously updated internet web page describing RWC activities and products	Web page available	Web page accessible to users	
Activity 3.1.5. Publishing of research findings through the RWC publications series and Information sheets.	Paper series available	Documents, publications	
Activity 3.1.6. Training events for NARS and partner staff on priority issues for the RWC; capacity building in NARS on GIS and PRISM.	Training events held	Training reports	
Activity 3.1.7. Public awareness activities on behalf of the RWC	Public awareness activities held	Materials available	
Result 3.2. Governance and administration. The affairs of the RWC as an ecoregional program and as a consortium are properly managed	Expert judgments on financial management and administration	External management reviews, external audits	
Activity 3.2.1. Implementation of decisions of the RSC Executive	Whether decisions implemented	Facilitator reports, RSC Executive minutes	
Activity 3.2.2. Prudent management of RWC FU budgets, assets, staff	Financial indicators	External audits	
Activity 3.2.3. Adequate financial and technical reporting to the RSC Executive, Convening Center and other partners	Reports submitted	Reports on file	

Narrative summary	Verifiable indicators	Means of verification	Assumptions
Activity 3.2.4. External management reviews and evaluations commissioned as appropriate	Reviews conducted	Review reports	
Result 3.3. Project development and implementation Financial resources from donors are secured and project activities relevant to the RWC agenda are implemented	Projects submitted, approved and implemented	RWC budgets, Facilitator reports, RSC Executive minutes	
Activity 3.3.1. Development and submission of proposals to donors for funding of FU activities relevant to the RWC agenda	Resources from donors for program activities	RWC budgets	
Activity 3.3.2. Project implementation by the FU in partnership with RWC members and partners, with resources shared with members	Projects implemented	Project reports	
Activity 3.3.3. External program reviews and evaluations commissioned as appropriate, especially regarding livelihood, equity, and natural resource outcomes of projects	Reviews held	Review reports	