



S E E D S   O F   I N N O V A T I O N

 **CIMMYT**<sub>MR</sub>

STRATEGY FOR HELPING TO REDUCE POVERTY AND HUNGER BY 2020

CIMMYT® ([www.cimmyt.org](http://www.cimmyt.org)) is an internationally funded, nonprofit, scientific research, training, and development organization. CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the resource-poor in developing countries. Drawing on strong science and effective partnerships, we create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources. CIMMYT is one of 16 food and environmental organizations known as the Future Harvest Centers ([www.futureharvest.org](http://www.futureharvest.org)). Located around the world, the Future Harvest Centers conduct research in partnership with farmers, scientists, and policymakers to help alleviate poverty and increase food security while protecting natural resources. The centers are supported by the Consultative Group on International Agricultural Research (CGIAR) ([www.cgiar.org](http://www.cgiar.org)), whose members include nearly 60 countries, private foundations, and regional and international organizations. Financial support for CIMMYT's research agenda also comes from many other sources, including foundations, development banks, and public and private agencies.

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**Abstract:** This publication describes how CIMMYT will reposition itself to meet the needs for agricultural knowledge and technology in developing countries over the next 10-15 years. It highlights major changes that will enable CIMMYT to become a more effective partner in research and other activities that further the Millennium Development Goals for reducing poverty and hunger.

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# P r e f a c e

In the past decade, CIMMYT has adapted its research agenda and structure to meet emerging needs in international agricultural research and development, but the Center had no mandate to undertake more than incremental changes. In 2002, CIMMYT's Board of Trustees decided to conduct a thorough, wide-ranging evaluation of the Center's mission and, if necessary, undertake a structural transformation to achieve its strategic goals.

This strategy summarizes the outcomes of that process. It presents fundamental changes in the way that CIMMYT will work. The Center has a new mission that emphasizes the role of knowledge in linking and empowering people to overcome poverty and environmental degradation. It has a new structure to bridge the disciplinary divides that occur within most research centers. The strategy focuses CIMMYT's research more sharply on reducing people's vulnerability to poverty by looking at the entire context in which poor households operate and not exclusively at maize or wheat. It highlights a renewed commitment to advocacy and capacity building. It examines strategic opportunities for particular partnerships and networks to meet the needs of poor people and ensure the impact of all partners' efforts to promote sustainable human development. Finally, it reflects a commitment to further collaboration and change within the CGIAR System.

This strategy was developed through a highly participatory process that invited dialogue on sensitive issues and fundamental assumptions, sought feedback from numerous stakeholders, and laid the groundwork for collaborative priority setting and continued organizational learning. Internal task forces explored issues related to global and scientific trends, partnering, structure, management, and fundraising. An external stakeholder consultation, facilitated by the Meridian Institute, gathered feedback from more than 170 individuals representing major constituencies, including the public sector (primarily in developing countries), CGIAR Centers, advanced research institutes, the private sector, non-governmental and civil society organizations, farmers' groups, and development agencies. Stakeholders, including CIMMYT staff, identified likely changes in the context in which CIMMYT operates and specified the Center's strengths, weaknesses, and opportunities for change. Finally, CIMMYT developed several alternative scenarios to catalyze creative thinking about how the future might unfold and assess CIMMYT's strategy in light of unexpected global developments.

This information was exchanged and debated virtually as well as through two major meetings of CIMMYT's staff and trustees. The discussions provided consensus on broad strategic directions for the Center. Several drafts of CIMMYT's strategy were widely circulated, internally and externally, for comment and refinement.

We are confident that the present document reflects what was learned and agreed upon during this intensive process, which has already initiated considerable change within CIMMYT. We appreciate the time and dedication that all participants invested in strategic planning, given that everyone sustained major commitments to research and other activities at the same time. Many wrote sections of the plan and provided insights that improved it. Their contributions made a tremendous difference to the integrity of the final document. We do not provide individual acknowledgements: the list would be long and it would also be incomplete, because we wish to respect the confidentiality of numerous colleagues who shared their views with us.

This strategy does not set forth a formal research and financing plan that will be followed rigorously in the coming years. Prior to more extensive consultation with our partners, it would be presumptuous to determine the details of our research agenda or make assumptions about the resources available to finance that agenda. What we present here is a vision of what we wish to accomplish and how we wish to do so. We recognize that a number of difficult choices lie ahead. Research resources are finite. In concert with our partners, we must be extremely selective in setting priorities among the activities we wish to undertake. In the year to come, we will work with these colleagues to devise research plans and implement organizational practices to support the strategies described here. This continued collaboration will provide a welcome opportunity to further define, assess, and learn from the course we are charting.

  
**Dr. Alexander F. McCalla**  
Chairman of the Board

  
**Dr. Masa Iwanaga**  
Director General

# Executive Summary

**1. Purpose of the strategy.** In developing this strategy, CIMMYT sought to examine the continuing relevance of its mission, define how to position itself to meet the needs for agricultural knowledge and technology over the next 10-15 years, and determine the most appropriate organizational structure and operating modalities.

**2. Analytical foundations.** Considerable analytical work supported the development of this strategy. On CIMMYT's behalf, the Meridian Institute surveyed more than 170 of CIMMYT's external stakeholders from all regions of the world and from diverse constituencies, including the public sector (primarily in developing countries), CGIAR Centers, advanced research institutes, the private sector, non-governmental and civil society organizations, farmers' groups, and development agencies. Stakeholders analyzed CIMMYT's future challenges and its current strengths and weaknesses with respect to those challenges. In addition, CIMMYT prepared a detailed assessment of global trends projected to influence its work, convened task forces to study scientific, organizational, and financial challenges, held seminars on applications of new science, and developed alternative scenarios to assess CIMMYT's strategy in light of unexpected global developments. At two major meetings, staff and trustees used much of this information to come to consensus on the strategic directions that CIMMYT should take. Based on this consensus, additional work was undertaken to develop a model for allocating research resources and to examine alternatives for structuring research at CIMMYT. The outcomes of these analyses and consultations are encapsulated in CIMMYT's new mission and strategy.

**3. Mission.** CIMMYT revised its mission statement to acknowledge the people who are central to its mission: the poor, for whom maize and wheat research offers a path out of poverty and environmental degradation. The revised statement also emphasizes the importance of partnerships for sharing knowledge, catalyzing innovation, and making an impact:

*CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the poor in developing countries. Drawing on strong science and effective partnerships, we create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources.*

**4. Elements of the strategy.** To achieve its mission, CIMMYT will rely on four sources or "seeds" of innovation:

- A focus on people and livelihoods.
- A new innovation agenda that emphasizes global and eco-regional priorities.
- Responsive partnerships and networks for innovation and impact.
- A commitment to sharing and using knowledge for innovation across scientific, institutional, and national boundaries.

**5. A focus on people and livelihoods.** CIMMYT will take a holistic approach in its research, focusing on cropping systems in which maize and wheat are important to people's livelihoods and have potential for helping to alleviate poverty. We recognize that research alone will not solve all of the problems that prevent people from realizing a better future for themselves or their children, but we are committed to ensuring that the research of CIMMYT and its partners is as successful as possible at contributing to better livelihoods.

As a conceptual framework to organize our research, we propose using the continuum formed by two kinds of livelihood systems: systems in which maize and wheat provide food and nutritional security to rural households, and those in which maize and wheat generate income, foster economic growth, and alleviate poverty.

We recognize that the two systems are not mutually exclusive and that a mix of research strategies and partnerships is needed to respond to the particular challenges presented in different settings. We also recognize that households producing maize or wheat for subsistence may gain a significant income from other crops, or they may receive remittances from family members employed off of the farm. Conversely, many households that sell some or all of their maize or wheat production never earn enough to meet their basic needs. The goal of our research is essentially to empower people to choose: to remain in maize and wheat production and make it more profitable; to incorporate more stable maize and wheat production into other, increasingly important livelihood strategies; or to diversify out of maize and wheat entirely if this makes the most socioeconomic sense.

**6. Research agenda and structure.** CIMMYT will organize its work under a matrix formed by several broad, thematic programs interacting with groups that have similar disciplinary research interests. The thematic programs will catalyze interdisciplinary research done in collaboration with a wide range of partners. The programs will maintain a clear focus on livelihoods and production systems. The disciplinary groups will ensure continuing scientific and professional excellence.

CIMMYT's major research programs will have either a global or an eco-regional emphasis. Two global research programs will focus on genetic resources and on global and strategic research. They will reinforce research in four eco-regional research programs: Sustaining African livelihoods; rainfed systems; tropical ecosystems; and irrigated, high-potential maize and wheat systems. The geographic coverage of each program, its major challenges, and its research emphasis, outputs, and expected impacts are outlined in Chapter 3.

Each program will be carried out in collaboration with a diversity of partners, including advanced research institutes, national agricultural research and extension systems, non-governmental organizations, farmers' associations, private companies, and other CGIAR Centers. The precise details of each research program, including activities, priorities, and indicators of impact, will be determined in consultation with these stakeholders. In many cases, CIMMYT already has strong working relationships with the partners who are essential to achieving a program's goals; in other cases, relationships will be established where there are complementarities and shared goals.

**7. Projected impact.** Within 10 years, CIMMYT and its partners will deliver:

- An expanded, more useful, and far more accessible collection of maize and wheat genetic resources.
- Policies to strengthen technology delivery and remove constraints to adoption.
- A strong learning and mentoring service.
- Reduced vulnerability of poor households to drought, infertile soils, diseases, insects, and other stresses, through the use of new varieties and improved crop management.
- Improved nutrition through the availability of maize and wheat varieties with superior nutritional quality.
- Improved access to markets through varieties with value-added traits.

- Expanded crop rotations and greater crop diversification (including alternatives to maize or wheat cultivation) to improve productivity, profitability, and environmental sustainability.
- Resource-conserving technologies, together with varieties specifically adapted to them.
- Substantial reductions in the use of water, fuel, and other inputs in agriculture.
- Decision aids to help farmers use resource-conserving practices.
- On-farm management of genetic diversity.
- More tools and methods for public agricultural research, including a global, interactive portal to knowledge on maize and wheat livelihood systems in the developing world.

**8. Principles for responsive partnering.** CIMMYT works with a wide international network of partners in developing and industrialized countries. More than ever, these partnerships are necessary for research to yield the advances that poor people so desperately need, and for the poor to benefit from them. This strategy cannot be implemented without such partnerships. CIMMYT's intention is to be a true partner in innovation, providing products, services, information, and technical expertise. Principles for partnering include:

- Engage in strategic partnerships for specific purposes.
- Engage in collective priority setting and shared implementation.
- Emphasize equality in sharing resources, contributions, accountability, and credit.
- Wherever possible, work in a network mode that brings together multiple partners to solve complex problems, with each partner contributing from its particular area of expertise.
- Strengthen the capacity of partners so others can take on new roles and create additional synergies; devolve activities wherever possible.

**9. Relations with specific partners.** With respect to specific groups of partners, CIMMYT will:

- Strengthen work with national agricultural research and extension systems, CIMMYT's primary partners, in broad alliances of diverse partners.
- Actively harmonize and integrate CIMMYT's efforts with those of other CGIAR Centers, which have the complementary expertise needed for widespread impact.

- Continue to build relationships with private foundations, which often provide resources to assess and incorporate important new approaches to research and capacity building.
- Expand relationships with non-governmental and civil society organizations, especially in seed production and delivery systems, seed relief, and health initiatives.
- Establish more strategic and productive relationships with the private sector and advanced research institutes to strengthen research capacity and extend research results to areas with less attractive markets.
- Maintain strong links with other international development agencies and global and regional development fora, especially with a view to advocating policies and institutions that favor sustainable development.

**10. Adding value to partnerships and networks through knowledge management.** Networks and partnerships become much more effective when careful attention is given to how people create, manage, and share knowledge. Through its partnerships, CIMMYT will attend to the whole cycle of knowledge management:

- Diagnose needs: Listen to farmers and other partners.
- Provide access to essential knowledge for research.
- Develop new technologies with partners.
- Share new technologies widely with other users.
- Carefully monitor adaptation and use of technologies, to learn for future efforts.
- Understand that knowledge is created and used through a complex system of multiple interacting players and forces.

CIMMYT will further an organizational culture to stimulate the acquisition, sharing, and evaluation of knowledge.

**11. Science-based advocacy.** A wide range of stakeholders advised CIMMYT to give greater attention to its role as an advocate to ensure that research truly fosters sustainable development. Building on a stronger capacity for policy analysis, we will participate more fully in the public debate on issues of importance to us, our partners, and our stakeholders, with the goal of influencing the process through which those issues are

addressed and resolved. Advocacy will be informed by accurate, science-based information and analysis. We will advocate only when we and our partners can offer substantive, competent input; when there is a good chance that by doing so we can increase the range of choices available to our partners and to the poor; and when advocacy is needed to turn research into impact.

**12. Measuring impact.** Impact studies will extend well beyond current analyses to measure multiple effects of the work of multiple partners on food security, livelihoods, incomes, and the environment. We will maintain rigorous guidelines for impact assessment and incorporate them into every research initiative. We will continue to invest in developing methods when needed. By institutionalizing impact assessment in this way, CIMMYT will generate the objective feedback needed for effective self-assessment and accountability, expand the knowledge base for impact assessment, promote a strong impact assessment culture throughout the Center, and strengthen its ability to become a true learning organization.

**13. Implementing the strategy through planning and priority setting with stakeholders.** A critical and immediate step for implementing this strategy will be to hold planning and priority setting meetings with stakeholders. Many difficult choices remain ahead: the proposed research agenda is broad, and in concert with our partners, we will have to be extremely selective in setting priorities and creating specific work plans. Information from the planning meetings will also be essential for CIMMYT to:

- Identify which partners well-positioned to undertake specific activities more efficiently or effectively than CIMMYT.
- Determine CIMMYT's overall research priorities and resource allocations.
- Identify areas where new skills or a different disciplinary balance are needed.
- Identify which new activities and resources are required.

In developing the overall plan of work, CIMMYT will pay particular attention to opportunities for harmonizing its efforts with those of other CGIAR Centers. The research agenda will be implemented by a new management

team, working in the program/disciplinary matrix, and equipped with “enabling strategies” for key activities (e.g., funding, partnerships, advocacy, intellectual property, communications, human resources management, capacity building, and so forth).

**14. Recreating CIMMYT as an integrated network of research locations.** Changes in how CIMMYT works across research locations are vital to implementing this strategy. CIMMYT seeks to function as an integrated network of worldwide research locations, each with considerable autonomy (research leadership will not be centralized at one location). Staff will be grouped at any given location to create the appropriate critical mass of scientific, development, and administrative skills to better achieve our goals. In regular consultation with stakeholders, these teams will act as catalysts for innovation and information sharing—locally, in the region, and throughout the world.

**15. Shifting activities across locations.** To be flexible to serve those who need CIMMYT most, the size and placement of CIMMYT’s various research locations will be dynamic. When it is efficient to do so, we will shift activities across locations (for example, some of our more advanced research initiatives will be housed in laboratories in industrialized countries). Activities that were once centralized may be distributed across locations to be made more effective, such as the development of locally adapted varieties. Other activities, such as the ex situ conservation of genetic resources and pre-breeding, will remain centralized to be efficient and effective. A given location will engage in downstream and upstream research to varying degrees, depending on local needs and circumstances, but most upstream research will be conducted through links to partner institutions.

**16. Promoting organizational change.** Clearly, to transform itself into the kind of organization envisioned in this strategy, CIMMYT must be committed to working in new ways. We must emphasize such practices as participatory priority setting and planning, strategic human resource management, critical interdisciplinary dialogue, partnering for technology dissemination, and

analysis of impact from a systems and livelihoods perspective. To support our new ways of working, we will train staff, modify management practices, and improve management information systems as well as information and communications technology.

**17. Assessing progress in implementing the strategy.** CIMMYT will conduct an overall external evaluation of progress in early 2006 (allowing a two-year interval for implementation). The evaluation will gather external and internal stakeholders’ perceptions to assess progress towards the following goals:

- An increased focus on poverty reduction and natural resource conservation in our research, framed in the context of sustainable livelihoods.
- The use of more consultative approaches and strategic partnerships to develop and execute the research agenda, including the use of new approaches to knowledge sharing.
- A more effective alignment of financial and human resources in support of our research agenda.

**18. Anticipating and adapting to change.** Many of the assumptions supporting this strategy are likely to change over time. To prepare for a future of constant and unpredictable change, CIMMYT will practice the principles of continual organizational learning. We will need a strong understanding of how a learning and knowledge culture is directly tied to our mission, inspires superior performance, and is the source of our strength as an organization. To make these concepts a reality, we will improve skills that foster collaboration and learning across disciplines, cultures, and organizational boundaries. Finally, to be a true learning organization, CIMMYT must be self-critical, be willing to acknowledge and learn from its shortcomings, and be self-correcting. This plan already represents a significant paradigm shift, in moving away from a crop and technology focus to a people-centered livelihoods focus, and from a linear understanding of technology dissemination to a non-linear understanding of how farmers innovate and systems change. Open and wide-ranging dialogue with our allies and critics will ensure that CIMMYT continues to tackle difficult questions in creative ways.

# CIMMYT's Mission



CIMMYT ACTS AS A CATALYST AND LEADER IN A GLOBAL MAIZE AND WHEAT INNOVATION NETWORK THAT SERVES THE POOR IN DEVELOPING COUNTRIES.

DRAWING ON STRONG SCIENCE AND EFFECTIVE PARTNERSHIPS, WE CREATE, SHARE, AND USE KNOWLEDGE AND TECHNOLOGY TO INCREASE FOOD SECURITY, IMPROVE THE PRODUCTIVITY AND PROFITABILITY OF FARMING SYSTEMS, AND SUSTAIN NATURAL RESOURCES.

# Taking up the challenge for the future: A new mission for CIMMYT



## **In this chapter:**

The context and analytical foundations for CIMMYT's strategy are outlined.

A new mission places people at the heart of CIMMYT's strategy.

CIMMYT will rely on four sources or "seeds" of innovation to achieve the new mission:

- *A focus on people and livelihoods.*
- *A new innovation agenda that emphasizes global and eco-regional priorities.*
- *Responsive partnerships and networks for innovation and impact.*
- *A commitment to sharing and using knowledge for innovation across scientific, institutional, and national boundaries.*

I SEE CHILDREN IN THE CLASSROOM WHO ARE MALNOURISHED, AND HERE WE ARE TRYING TO PUMP SOMETHING INTO THEIR HEADS! YOU DON'T TEACH A CHILD WHO IS STARVING.  
—PAUL OKONGO, KENYA, TEACHER, FARMER, FOUNDER OF TECHNOLOGY ADOPTION THROUGH RESEARCH ORGANIZATIONS, AND CIMMYT PARTNER

### ■ The context for CIMMYT's strategy

In developing this strategy, CIMMYT sought to examine the continuing relevance of its mission, define how to position itself to meet the needs for agricultural knowledge and technology over the next 10-15 years, and determine the most appropriate organizational structure and operating modalities.

The first task in this process was to undertake a thorough, highly consultative assessment of the global challenges and opportunities facing CIMMYT and its partners in agricultural research and development (Box 1.1). Our assessment of the dramatic changes that await us in the next 10-15 years underpins all of our choices about strategic directions.

### ■ Understanding the shifting landscape in which we work

When CIMMYT came into being in 1966, the structure of DNA had been known for only 13 years. Agricultural research on staple food crops was largely conducted by the public sector in industrialized countries, and international development was the domain of a handful of institutions. Although famine posed a serious human and political threat in Asia, the notion of establishing an international research consortium to cope with the food crisis had not gained momentum. The "global

village" was a newborn vision, not a reality. Most of the world's people still lived and died in traditional villages, submerged in local concerns. Breeders in CIMMYT's predecessor organization had redesigned the wheat plant for a quantum leap in yield, but the world was largely unaware of the potential impact of this research (Box 1.2., p. 4). The Green Revolution had yet to occur.

Today's "globalizing village" still confronts poverty, hunger, malnutrition, ill health, and conflict, but many things have changed, including the pace of change itself.

- **The world's understanding of the nature of poverty and global inequality has deepened.** The links between economic policy (specifically agricultural subsidies) in industrialized countries and rural poverty in developing countries are increasingly clear. Perceptions of the food crisis have changed as well. Factors such as civil conflict, disease (HIV/AIDS in particular), and gender inequality combine with biophysical threats such as climate change and natural resource degradation to imperil the well-being of the rural poor. The global supply of food may be adequate, but hundreds of millions of people remain hungry because they lack purchasing power and access to food. Poor access to markets for crop inputs and sales limits farmers' opportunities as much as poor access to technology. Productivity increases in maize- and wheat-based farming systems are not enough to raise most farm families out of poverty. New income-generating activities, both on and off of the farm, must enter into their livelihood strategies.
- **The understanding of how agricultural development occurs has become more sophisticated.** The linear, top-down model of technology transfer has been superseded by an appreciation that farmers selectively incorporate new ideas and tools into their practices to meet multiple objectives. Whether the "improved" technology is conservation agriculture or family planning, the participation of end-users in the design, adaptation, and use of technology is recognized as essential to making an impact.

# Analytical foundations for CIMMYT's strategy

Many of CIMMYT's partners, stakeholders, staff, and Board members were consulted over the past year to clarify potential challenges and opportunities for the Center. We began by interviewing or surveying more than 170 external stakeholders from diverse constituencies (national agricultural research services, CGIAR Centers, advanced research institutes, the private sector, donor agencies, and farmers' groups) and all regions of the world. Respondents discussed CIMMYT's future challenges and the Center's strengths and weaknesses in addressing these challenges (CIMMYT 2004c). We prepared a detailed analysis of global trends projected to influence our work (CIMMYT 2004b). We convened task forces to discuss scientific, organizational, and financial challenges and held seminars on applications of new science. A congruency analysis (Appendix 1) provided information to initiate discussion on allocating resources by crop and region.

After reviewing several respected scenario-building efforts, we also engaged in scenario building. By describing plausible but sharply contrasting futures, scenarios help institutions question assumptions about the future and respond effectively when major changes occur. Although we do not claim to be experts at building scenarios, we believe that they can help us to create an organization that will be more resilient and adept at responding to rapid and unpredictable change.

The four scenarios developed by CIMMYT were defined by the matrix arising from four forces that could fundamentally alter global development to 2020: trends towards lesser or greater equity and sustainability, and an emphasis on global ("one world") principles versus an emphasis on regional and local diversity. Figure 1.1 depicts the matrix and the four scenarios that emerged:

- A world of INTERCROPPING, with global governance systems and greater equity and sustainability.
- A world of GARDENS, with regional diversity and greater equity and sustainability.
- A MONOCULTURE world, with global governance systems and less equity and sustainability.
- A SLASH&BURN world, with regional fragmentation and less equity and sustainability.

We assumed that five driving forces would have similar effects across these scenarios and be difficult to alter through human intervention in the next 20 years: climate change, the quantity

and quality of the natural resource base, demographics (including migration and health), baseline trends in food supply and demand, and global trends in basic science and technology. Other driving forces were likely to have different effects under each scenario, however: governance and institutions; economic development; agricultural, food, and trade policies; development and environmental policies; human capital; intellectual property agreements; and priorities for agricultural research and development. Information gathered from the analysis of global trends contributed significantly to our understanding of how these driving forces might play out under each scenario.

Once the outlines of the scenarios were clear, we explored the potential implications of each scenario for CIMMYT by asking several questions: Who and where are our stakeholders/partners in this scenario? What products and services do they require? Under these circumstances, what balance of activities is most appropriate for CIMMYT? What are the best mechanisms for developing and delivering our products and services? What changes can we expect in global trends, partners and networks, science, and funding prospects? What are the implications for how CIMMYT is structured? The scenarios and our conclusions are detailed in CIMMYT (2004a).

The scenario-building effort supported the development of this strategy by encouraging us to consider new ways of working and a new structure to accommodate unexpected change. If scenario building is to lead to true scenario planning at CIMMYT, however, we must use and re-evaluate the information from the scenarios when we periodically re-assess the strategic directions described here.

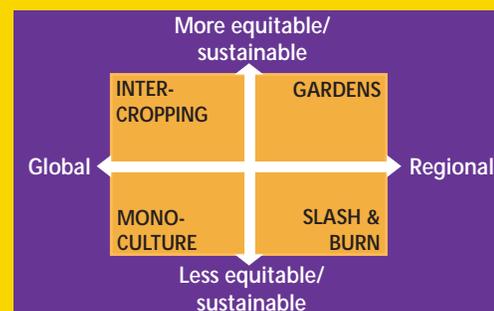


Figure 1.1. Four scenarios of global development.

# The case for CIMMYT and international agricultural research

CIMMYT grew out of a pilot program in Mexico in 1943, sponsored by the Government of Mexico and the Rockefeller Foundation. The world had seen what expertise in plant breeding had accomplished for the USA in the wake of widespread crop failure, hunger, and poverty during the Great Depression. Could similar expertise benefit Mexico and other nations?

The pilot program developed into an innovative, sustained collaboration with Mexican and international researchers. It established international networks to test experimental varieties. One of its researchers, Norman Borlaug, developed shorter wheat varieties that put more energy into grain production and responded better to fertilizer than older varieties. By the late 1950s, Mexico was self-sufficient in wheat production. Mexico's success inspired the program's researchers to become fierce and effective advocates for the Mexican innovation model in other countries. In 1966, having survived one poor harvest but facing another, India took the extraordinary step of importing 18,000 tons of wheat seed from Mexico. The first evidence of success was the Indian wheat harvest of 16.5 million tons in 1968, compared with 11.3 million tons in 1967. Pakistan also began importing Mexican wheats. These two countries doubled wheat production between 1966 and 1971 (Hanson et al. 1982). The Green Revolution—which had by now extended to rice—had begun.

The social and economic achievements of the Green Revolution were recognized worldwide when the Nobel Peace Prize was awarded to Norman Borlaug in 1970. The following

year, a small cadre of development organizations, national sponsors, and private foundations organized the Consultative Group on International Agricultural Research (CGIAR) to spread the impact of research to more crops and nations.

It is widely acknowledged that this visionary investment made a tremendous difference in developing countries. In the absence of the CGIAR Centers, crop yields in developing countries would have been 19.5-23.5% lower; prices for food crops would have been 35-66% higher; imports would be 27-30% higher; calorie intake would have been 13.3-14.4% lower; and 32-42 million more children would have been malnourished (Evenson and Gollin 2003). We can only imagine the social costs of such a scenario. Lower food prices have extended the benefits of agricultural research widely, to poor consumers in urban areas and landless people in rural areas (and even to the industrialized world).

The achievements of CIMMYT's maize and wheat improvement networks have been central to the CGIAR's impact (Heisey et al. 2002, 2003; Morris 2002; Morris et al. 2003). Improved maize and wheat varieties and cropping practices have enabled poor farm households to withstand the effects of unpredictable weather, poor soils, diseases, pests, and other debilitating stresses that threaten crops and livelihoods. The continued work of CIMMYT within the CGIAR will contribute to achieving the United Nations Millennium Development Goals to halve poverty and hunger by 2015. The strategies described here place CIMMYT at the service of these ambitious goals.

**WHAT IS NEEDED ARE VENTURESOME SCIENTISTS WHO CAN WORK ACROSS DISCIPLINES TO PRODUCE APPROPRIATE TECHNOLOGIES AND WHO HAVE THE COURAGE TO MAKE THEIR CASE WITH POLITICAL LEADERS TO BRING THESE ADVANCES TO FRUITION.—NORMAN BORLAUG**

- **Several major environmental and social trends have implications for the future of agriculture.**

Natural resource degradation has increased. A particular concern is the increased scarcity and reduced quality of water for agriculture, occasioned by climate change as well as growing competition for water from other sectors. Rural emigration and the growth of cities also have consequences for the future of agriculture and the kinds of technology needed in farming communities. Urban demand for food will grow significantly, while the availability of good agricultural land and rural labor will probably decline. In many parts of the world, HIV/AIDS will cut deeply into the rural labor force. In this context, how can agricultural technologies—specifically, improved maize and wheat varieties and crop and natural resource management practices—contribute to reducing poverty and hunger? Farmers will require varieties that use inputs such as water, soil nutrients, and labor more effectively, that perform well in low-input environments, and that resist pests and diseases, which may proliferate with climate change and agricultural intensification. Future breeding efforts will need to focus not only on traits that improve productivity but on traits that enhance nutritional quality (especially micronutrient and amino acid content) and processing quality, which will make maize and wheat competitive in local, national, and international markets.

Improved varieties alone are unlikely to lead to significant productivity increases in maize- and wheat-based farming systems, however. Natural resource degradation is widespread in most regions, and current farming practices are not sustainable. Farmers will require help in developing and adopting management practices that permit much greater water-use efficiency and allow sustainable intensification of cropping systems where the natural resource base permits. New technologies will need to be more efficient in the use of physical inputs and labor, more profitable, and more adaptable to complex livelihood systems that include livestock, other agricultural enterprises, and employment off of the farm.

- **The gene revolution has superseded the Green Revolution as the great (but controversial) hope for solving intractable agricultural problems.** In 10 years' time—CIMMYT's medium-term planning horizon—sequencing of the cereal genomes will increase the prospects for overcoming barriers to breeding maize and wheat with better nutritional quality, yield, and

IDEAS WORLDWIDE ARE CHANGING WITH REGARD TO THE ROLE OF INTERNATIONAL AGRICULTURAL RESEARCH CENTERS, AND MANY STAKEHOLDERS REFLECTED THAT “REAL CHANGE” IS NECESSARY FOR CIMMYT TO SURVIVE AND CONTINUE ITS HISTORY AS A HIGHLY SUCCESSFUL ORGANIZATION.—SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT

resistance to stresses. The challenge for CIMMYT and some of its partners in national agricultural research programs will be to remain influential players in this research domain to ensure that poor farmers have access to the benefits of breakthrough technologies. CIMMYT and its partners have an obligation to pay close attention to the social acceptance of technologies such as transgenics (which may vary depending on the transgenic trait in question, not to mention who “controls” the material or technology), as well as to the crafting of biosafety regulations that protect both biodiversity and end-users.

- **The information revolution has as much potential as the gene revolution to change the research, policy, and farm landscape.** Vast quantities of data will become available for analysis, from the molecular to the planetary level (e.g., soil mapping through satellite imagery). Equally important will be new tools to interpret and combine these data, leading for example to a better understanding of the effects of a particular combination of plant variety, biophysical conditions, and farmer management practices. Advances in communications technology hold unknown potential for making knowledge available.

- **The international development community has grown and diversified.** It now encompasses a multitude of organizations, from modest village cooperatives to global networks of non-governmental and civil society organizations (NGOs and CSOs) and large development banks. Programs such as the United Nations Millennium Development initiative are consolidating global commitment to sustainable human development, while promoting a more coordinated approach to achieving this goal. The agenda for agricultural research and development has broadened as well, in recognition of the links between food, poverty, conflict, environmental issues, biodiversity, gender, empowerment, and social equity. CIMMYT and its public-sector partners will need to strengthen ties to a host of new actors, not only in the food sector, but in health, the environment, and in economic development.
- **The roster of players in the field of agricultural research has changed.** The promise of biotechnology and the shield of intellectual property protection have led to a boom in private-sector research oriented towards commercial production. At the same time, support for public agricultural research has declined in real terms in developing countries and in international agricultural research centers. The “rules of the game” are also being rewritten, dominated by the changing role of intellectual property protection and its unknown implications for public-sector research and poor farmers’ access to new technologies. Opportunities for stronger, more complementary cooperation between the private and public sectors are emerging, and the impetus for greater collaboration and efficiency within the public sector itself, including the CGIAR Centers, is growing as well. The agreement to share access to “golden rice” technology is a model for future public- and private-sector partnerships. The International Treaty on Plant Genetic Resources for Food and Agriculture, and the recent announcement by a consortium of US universities, foundations, and non-profit research institutions that they will adopt measures to ensure that publicly funded research products remain in the public domain, are two additional examples of changing rules. More are sure to come.

The report summarizing feedback from CIMMYT’s external stakeholders (CIMMYT 2004c) ended with the following conclusions, drawn by the Meridian Institute team that facilitated the consultation:

*Ideas worldwide are changing with regard to the role of international agricultural research centers, and many stakeholders reflected that “real change” is necessary for CIMMYT to survive and continue its history as a highly successful organization. They would like to see CIMMYT take this opportunity to move beyond discussion of new strategies and take the actions necessary to remain relevant and successful in a changing world.*

CIMMYT took this message to heart in assessing new ways to fulfill its mandate with respect to two of the world’s most important crops, in a time of growing and unpredictable change.

### ■ **Maize and wheat in the developing world**

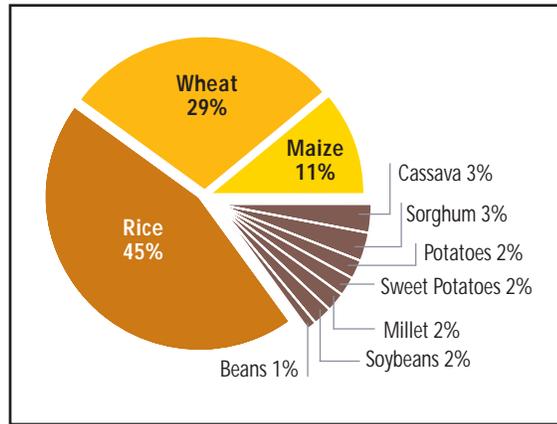
Maize and wheat account for a large share of the calories consumed in developing countries (Figure 1.2) and occupy just over 190 million hectares (FAO 2003). These two crops are pivotal to nutrition, health, income, environmental sustainability, and overall development of low-income countries. Aside from their value for sustainable development, both crops possess a deep cultural significance and are preferred foods for many of the world’s people.

The international maize and wheat improvement network formed by CIMMYT and its partners spans the developing world, including areas where poverty is severe and where maize and wheat account for half of the calories consumed every day in poor households (Map 1.1). This network, built on decades of germplasm exchange, is a strong foundation for innovation that links local, regional, and global perspectives.

Maize has an extensive geographical reach, growing from sea level to elevations exceeding 3,000 meters; from the equator to above 50° north and south (well beyond the tropics and subtropics); and in cold, hot,

rainy, and dry areas (Dowswell et al. 1996). Wheat is found “from within the Arctic Circle to higher elevations near the equator,” from sea level to elevations of 4,000 meters in Peru and Bolivia, and in most areas where it can receive from 250 to 1,750 mm of water (Curtis 2002; P. Wall, pers. comm.).

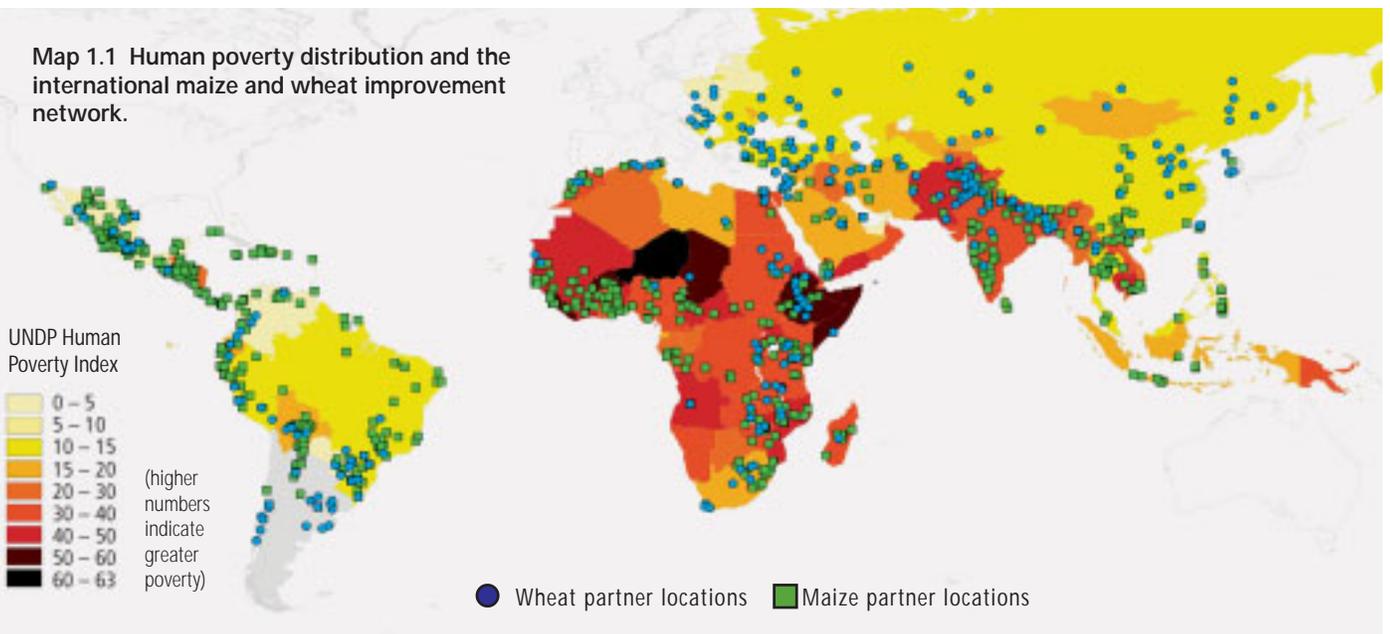
Table 1.1 presents statistics on maize and wheat production, consumption, and trade. A major trend that is not highlighted in Table 1.1 is the rapidly growing demand for maize as livestock feed worldwide, especially in Asia. China will become a major maize importer because of its rapidly growing livestock industry. Niche markets are likely to emerge for certain types of specialty maize (including maize with suitable industrial characteristics and maize with improved nutritional quality) if appropriate varieties become available and the necessary market structures develop. These markets



**Figure 1.2. Daily per capita caloric intake of the 10 most important food crops in developing countries, 1999-2001.**

Source: FAO (2003).

**Map 1.1 Human poverty distribution and the international maize and wheat improvement network.**



**Note:** Based on the high correlation of UNDP’s Human Development Index (HDI) (UNDP 2000) with its Poverty Index ( $r^2 = 0.98$ ), missing human poverty values for some countries were calculated using the HDI value, available for most countries, in the following regression equation [ $HPI=82.036-(90.925*HDI)$ ].

could be important for small-scale farmers, who could produce a differentiated product that would not compete with the cheaper maize produced by the largest producers.

**Table 1.1. Maize and wheat facts.**

	Maize	Wheat
Number of developing countries growing the crop	118	71
Leading producers in developing world (million metric tons)	China: 117.3 Brazil: 33.6 Mexico: 18.3	China: 108.1 India: 70.4 Turkey: 19.5
Highest per capita consumption for food (kilograms per capita per year)	Lesotho: 145 Malawi: 135	Tunisia: 208 kg Algeria: 198 kg
Percentage traded worldwide	13	19
Leading exporters (million metric tons)	USA: 46.3 Argentina: 10.6	USA: 26.9 Canada: 17.8
Percentage of food imports into developing countries	28	43
Percentage of food aid to developing countries	na	6

Source: FAO (2003).  
Note: na = not available.

### ■ CIMMYT’s enduring strengths

Consultations with our stakeholders confirmed that CIMMYT occupies a special niche among the many institutions and actors in global agricultural research and development. Our strengths will continue to be the cornerstone of our work (Box 1.3., p. 10):

- As steward of the world’s largest collections of maize and wheat genetic resources, we have a unique responsibility for conserving those resources and increasing their usefulness to people and the environment.
- The knowledge, expertise, and effectiveness that we bring to international plant breeding—and our

improved maize and wheat varieties themselves—will play an important role in helping people to survive the vagaries of an increasingly unpredictable physical and economic environment.

- Our experience and understanding of the complex dynamics of agricultural systems will guide the development of technologies that include appropriate mixes of improved maize and wheat varieties, environmental and crop management practices, and socioeconomic and policy recommendations, all adapted to particular eco-regions and human systems.
- Our extensive network of partners, which transcends borders and sectors, will continue to provide a forum for setting priorities, collaborating on research that leads to impact, building capacity, gaining feedback from stakeholders and beneficiaries, and multiplying the impact of our work and that of our partners.

### ■ CIMMYT’s core values

What values and qualities will motivate CIMMYT as it pursues its mission?

One quality that is particularly important in CIMMYT’s work is *stewardship*—the responsible care and use of the world’s natural resources, including genetic diversity, water, and soils.

Because CIMMYT and its partners conduct research whose results are intended to be useful in people’s lives, one of our primary values is *pragmatism*, which we define as a practical, realistic, and collaborative approach to setting priorities and achieving the challenging goals described in this strategy.

Because CIMMYT values the ability to work with others to achieve results, *partnership* and *participation* are among our core values. Science depends on effective collaboration, and our vision for the future can be achieved only through successful partnerships, characterized by *knowledge*, *learning*, *communication*, and *respect* for the skills, contributions, and diversity of others.

Because CIMMYT and its partners value the ability to *achieve results* and provide enduring solutions to poor people's problems in the shortest possible time, CIMMYT also values *innovation, quality, flexibility, and urgency* in its research.

CIMMYT is also highly motivated by a sense of *accountability* to the people who support our research, to our partners, to our peers in the sciences, and most of all to the people who can benefit from the products of our research, now and in the future.

### ■ Conclusion: A new mission

CIMMYT's current mission is to alleviate poverty by increasing the profitability, productivity, and sustainability of maize and wheat systems in developing countries. This mission statement is accurate but fails to acknowledge the people who are central to CIMMYT's mission: the poor, for whom maize and wheat research offers a path out of poverty and environmental degradation. The current statement also underplays the importance of CIMMYT's many partners, who are vital for sharing knowledge, catalyzing innovation, and making an impact. We propose a new mission statement that articulates this point more forcefully:

*CIMMYT acts as a catalyst and leader in a global maize and wheat innovation network that serves the poor in developing countries. Drawing on strong science and effective partnerships, we create, share, and use knowledge and technology to increase food security, improve the productivity and profitability of farming systems, and sustain natural resources.*

CIMMYT's strategy for accomplishing this mission rests on four sources or "seeds" of innovation:

- **The heart of the strategy:** A focus on sustainable livelihoods for the world's resource-poor maize and wheat producers and consumers—putting the needs of people first.

STAKEHOLDERS BELIEVED THAT CIMMYT'S RECOGNIZED SUCCESS IN COMBATING HUNGER...AFFORDS IT A GREAT DEAL OF LEVERAGE IN FORMING PARTNERSHIPS, RECRUITING NEW TALENT, AND...SETTING THE TONE FOR AGRICULTURAL RESEARCH AND DEVELOPMENT.  
—SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT

- **The mind of the strategy:** An innovation agenda that emphasizes interdisciplinary research to address global and eco-regional priorities.
- **The muscle of the strategy:** A broad and growing set of partnerships and networks that will enable us to stay attuned and responsive to the needs of poor people and ensure the impact of all partners' efforts to promote sustainable human development.
- **The spirit of the strategy:** Careful attention to the full cycle of innovation and the sharing and use of knowledge across scientific, institutional, and national boundaries.

The chapters that follow elaborate on each of these "seeds of innovation." Although each one is described separately, in practice all four will be woven together and brought to life through CIMMYT's new organizational structure. As the following chapters will demonstrate, in putting the livelihoods of poor people first, CIMMYT will change its approach to research for development. The next chapter explains how this "people first" perspective informs our strategy.

# Building on strengths and fostering emerging competencies for the “new CIMMYT”

This publication describes many changes, large and small, that will help CIMMYT to achieve its mission. It is often the nature of strategies to focus on change, sometimes creating the perception that nothing in the past is worth preserving. That is not the spirit in which this strategy was conceived. Our intention is to build on our strengths and foster emerging competencies to further our mission.

## **CIMMYT will build on the following strengths:**

- Our humanitarian mission to serve the poor in developing countries.
- A global mandate and global experience in maize and wheat research.
- Stewardship over the largest collections of maize and wheat genetic resources.
- Excellence in science, the use of cutting-edge crop improvement methods, a problem-focused, results-oriented approach, and delivery of intermediate and advanced products.
- Systems-oriented, sustainable crop and resource management research.
- Pragmatic and empirical training to create a close-knit family of alumni and colleagues.
- A global network of partnerships, especially with public agricultural research institutes.

Building on our strengths does not mean that we will continue to do exactly the same things in exactly the same way. We expect that the relative importance of these strengths will change over time. They will also grow to support new aspects of our work and benefit from new approaches (for example, in setting priorities). The number of players involved will expand, and they will have different relationships to one another. These changes will necessitate further changes not only in what we do, but especially in how we do it.

## **CIMMYT will foster emerging competencies in the following areas:**

- *Focus on people.* We will give greater attention to improving livelihoods in communities in which maize and wheat underpin the socio-economic fabric. We will measure our success not only by the excellence of the technologies we develop, but also in terms of the impact of those technologies on the livelihoods of the poor.

- *Methods for addressing increasing complexity in the systems where we work.* We will improve our ability to address increasingly complex problems associated with maize and wheat production systems. We will give greater attention to interactions between agriculture, diet, nutrition, and health; off-farm sources of income; access to markets; and the relationship between agriculture and the environment.
- *Expanded circle of partnerships.* We will forge links with new partners who share our mission of developing science-based solutions to agricultural problems. We will develop alliances with new partners in civil society and the private sector, especially those who excel in new areas of research or in reaching the poor.
- *Knowledge management.* We will strengthen our capacity to facilitate global flows of information and knowledge, which will become increasingly important for enhancing the usefulness of the germplasm, crop and resource management practices, and research methods developed with our partners.
- *Advocacy.* In its early days, CIMMYT engaged in advocacy to further the impact of research. Effective science, advocacy, and partnerships made the Green Revolution possible. We will return to (and foster) this area of our work to advocate change with respect to strategically important issues related to maize and wheat.

By adapting our current strengths to the increasingly complex and challenging environment in which research and development take place, we will continue to learn, gain new insights, assess new solutions, and respond more quickly to emerging demands and challenges.

PEOPLE WHO HAVE BEEN TO CIMMYT GENERALLY HAVE ONE THING IN COMMON: THEIR DEDICATION AND WILLINGNESS TO DO WHATEVER IT TAKES TO GET THE JOB DONE.—JORGE COLONEL, ECUADOR, INIAP AGRICULTURALIST AND CIMMYT PARTNER

## Putting people at the heart of our strategy



### **In this chapter:**

A better understanding of the dynamics and dimensions of poverty is central to CIMMYT's strategy.

CIMMYT will take a holistic approach in its research, focusing on cropping systems in which maize and wheat are important to people's livelihoods and have potential for helping to alleviate poverty.

The goal of the research that CIMMYT undertakes with its partners is essentially to empower people to choose: to remain in maize and wheat production and make it more profitable; to incorporate more stable maize and wheat production into other, increasingly important livelihood strategies; or to diversify out of maize and wheat entirely if this makes the most socio-economic sense.



## Poverty and the environment

Developing nations face potentially overwhelming problems of natural resource degradation that threaten the livelihoods of people who already command few resources. The poor understandably focus on near-term survival, especially in risky, marginal environments. Even if they do learn about new seed or cropping practices, the poor often invest only in technologies that generate benefits rapidly, which is not the case with many resource-conserving technologies. When wages and incomes are low, people may adopt some resource-conserving practices (e.g., terracing for wet rice cultivation, or tied ridges for harvesting rainwater), but the technologies must be extremely profitable to be of interest. People who do not own the land they farm—which is often the case for women—may be particularly reluctant to invest in any practice that yields no immediate benefit.

CIMMYT must be committed to developing and promoting resource-conserving agricultural practices, given that farmers' management of their maize and wheat crops, which occupy about 190 million hectares in developing countries (FAO 2003), will greatly influence the overall health of the natural resources that sustain agriculture.

### ■ Poverty and livelihoods

Current views of poverty and livelihoods are CIMMYT's starting point for considering how agricultural interventions might be better targeted to sustain rural livelihoods (see World Bank 2001; Carney 2002; Kanbur 2002; Solesbury 2003; UNDP 2003). 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. Our confidence 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 (Fan and Rao 2003; Hazell and Haddad 2001; Pardey and Beintema 2001; Thirtle et al. 2001).

### ■ Where and who are the poor?

Based on the United Nations Development Programme (UNDP) poverty index, the largest areas of poverty are found in sub-Saharan Africa and South and East Asia (Map 1.1, p. 7). This finding is in agreement with another widely used indicator of poverty, the World Bank's calculation of numbers of people living on less than US\$ 1 per day (World Bank 2000). Seventy percent of the world's poorest people live in rural areas and depend on agriculture (UNDP 2003); agriculture is the primary activity of 64% of the population in sub-Saharan Africa and 55% in South Asia (IFAD 2001). Nelson et al. (1997) estimate that 634 million rural poor live in areas considered marginal for agriculture (Box 2.1). As many as 70% of the rural poor are women (United Nations figures, cited in DFID 1998; see also Box 2.2).

What about the urban poor, whose well-being depends on the availability of low-cost, nutritious food? By 2025, 40% of the world population living on less than US\$ 1 per day will live in urban areas (IFAD 2001). Governments in many developing countries will be challenged to devise strategies that can supply inexpensive food to urban dwellers in the short term without harming the potential for agriculture to contribute to national development over the longer term. CIMMYT and its partners have a crucial role to play in helping to address this challenge (Rosegrant et al. 2001).

## Poverty, gender, and agriculture

Wherever and whoever they are, the poor depend heavily on cereal crops, including maize and wheat, for income and nutrition (Box 2.3, p 14). Urban or rural, they all have a stake in the future of these crops.

### ■ A holistic approach to understanding livelihood systems

As a conceptual framework to organize our research, we propose using the continuum formed by two kinds of livelihood systems: systems in which maize and wheat provide food and nutritional security to rural households, and those in which maize and wheat generate income, foster economic growth, and alleviate poverty.

For the sake of brevity, we refer to these as “subsistence” and “income-generating” systems, but their goals are broader than these somewhat restrictive terms indicate. Generally speaking, as one moves along the continuum from more subsistence-oriented households to more income-oriented households, livelihood strategies become more market-oriented, activities generate more cash income, and households become less vulnerable to poverty. Households located at different points along the continuum represent different sets of needs, which call for different interventions, often from different sets of partners.

The two systems are not mutually exclusive. A great many households grow maize or wheat partly for home consumption and partly for sale. For most households in the middle of the continuum, the relative emphasis given to each objective varies from year to year, depending on decisions taken within the household and factors emanating from outside (including the vagaries of weather, input and commodity prices, and the availability of storage facilities and market infrastructure.)

Although households in subsistence systems tend to be less wealthy than those in income-generating systems, the mix of subsistence and income-generating activities pursued by a given household is not a reliable guide to the level of poverty

CIMMYT will give greater attention to gender, especially in support of women, in all aspects of its work. War, migration, and HIV/AIDS have all taken their toll on numbers of men in rural areas. Women are responsible for 80% of domestic food production in Africa, 60% in Asia and the Pacific, and 40% in Latin America (FAO 2003). More than 550 million women, or 60% of the world's rural population, live in poverty in rural areas. The number of poor rural women rose 50% between the mid-1970s and mid-1990s, compared with a 30% increase for men (United Nations data reported in IFPRI 1995). Women generally have fewer assets than men (e.g., clear ownership of land) and find it more difficult to obtain information, inputs, and credit. Women are much more likely to bear responsibility for child rearing, household food production, and nutrition, at a time when the limited agricultural support services in developing countries focus increasingly on commercial farmers or maintain barriers to women's participation.

of its members. Households that produce maize or wheat for subsistence may gain a significant income from other crops, or they may receive remittances from family members employed off of the farm. Conversely, many households that sell some or all of their maize or wheat production never earn enough to meet their basic needs. The goal of the research that CIMMYT undertakes with its partners is to empower people to choose: to remain in maize and wheat production and make it more profitable; to incorporate more stable maize and wheat production into other, increasingly important livelihood strategies (e.g., livestock production, cash cropping, or non-agricultural enterprises); or to diversify out of maize and wheat entirely if this makes the most socio-economic sense.

Below we summarize the predominant research needs of farm households in the two types of systems. Although the discussion that follows focuses on maize and wheat, the systems in which these crops are grown often involve multiple crops produced in complex rotations, and this agricultural diversity is reflected in the range of economic and environmental issues that these systems present.

## Poverty, hunger, and malnutrition

Malnourished people die by degrees, caught in a vicious circle initiated by poverty. Lacking resources to produce or purchase enough food, they are forced to subsist on inadequate diets, which deprive them of the energy and stamina needed to perform farm or other work. Children—often the last to “reach the table”—succumb before their parents. Underfed people are more prone to health problems, which further reduces the effort they can invest in producing food or otherwise earning a living.

CIMMYT will continue to address malnutrition through the food production system: by developing farming systems that provide more nutritious food or higher incomes to purchase it. The potential to improve human nutrition through plant breeding appears large. It is estimated that the prevalence of anemia would be reduced by 10%—averting more than 100 million cases of iron deficiency each year—if iron-biofortified crops were consumed by 25% of the population in developing countries (CIAT and IFPRI 2002). This area of research will advance considerably through CIMMYT’s participation in HarvestPlus, the CGIAR Challenge Program to breed crops for better nutrition.



### ■ Systems in which maize and wheat underpin food and nutritional security in rural households

Improvements to subsistence-oriented maize and wheat production systems directly increase the food and nutritional security of poor rural households. They can also play an important role in reducing the time needed for cropping operations, which allows members of rural households to pursue alternative sources of income. Most subsistence farmers need technologies that satisfy multiple requirements—increasing productivity, reducing production variability, and improving crop nutritional content. Food and nutritional security are an urgent challenge for households headed by children, women, and elderly people, as family members succumb to the ravages of HIV/AIDS or desperate parents leave in search of income opportunities elsewhere.

Improved crop management technologies based on principles of conservation agriculture can save labor, raise productivity, increase yield stability, maintain or even improve soil fertility, reduce the cost of purchased inputs, and diversify production systems. Labor-saving technologies are often particularly important in some contexts, as they reduce the time needed for cropping operations and allow household members to pursue employment off of the farm, attend school, cope with illness, or attend to other needs. As a result, a greater number of rural households can diversify their income-generating activities and move towards profitable and sustainable small-scale commercial production. Many subsistence-oriented households also need improved maize and wheat varieties that are genetically diverse and can produce high, stable yields under low levels of management and in the face of severe abiotic and biotic stresses. Important traits include tolerance of water stresses (drought and waterlogging), tolerance of soil nutrient imbalances (low fertility, acidity, salinity, and sodicity), and resistance to local diseases and pests, including storage pests. Better nutritional content in maize and wheat is also important for households that consume what they produce (Box 2.4, p. 16). Improved storage systems will help reduce losses after harvest.

Improved production technologies cannot deliver benefits if they are never adopted. Appropriately targeted policy research can generate revealing insights into farmers’ technology needs, as well as a comprehensive understanding of the strengths and weaknesses of technology dissemination systems. Both types of knowledge are essential to design policy interventions capable of overcoming the constraints faced by subsistence farmers.

## ■ Systems in which maize and wheat generate income, foster economic growth, and alleviate poverty

Improvements to income-generating maize and wheat production systems help poor farm households to pay for such things as education and health care and to accumulate assets that buffer the impact of external shocks such as drought, flooding, or the sickness or loss of family members. Such improvements contribute to national (rural and urban) food and nutritional security, macro-economic growth, and overall poverty reduction. CIMMYT focuses on small-scale commercial farmers, who have few resources and experience great difficulty participating effectively in markets. They often suffer from a competitive disadvantage and have limited access to new technology. CIMMYT also works directly with medium- and large-scale farmers when such work helps to achieve the objectives of alleviating poverty, conserving natural resources, and improving the sustainability of agriculture, but most often we reach those farmers only indirectly.

Most income-generating agriculture requires technologies that promote highly productive, profitable production. Resource-conserving crop management technologies, such as zero and minimum tillage and bed planting, can contribute greatly to the long-term productivity, profitability, and sustainability of many intensively cultivated commercial maize and wheat production systems. Income security is improved when improved maize and wheat varieties yield well and meet the increasingly stringent quality standards demanded by industrial users. Aside from showing good resistance to diseases and pests and tolerance of abiotic stresses, these varieties must respond to increased levels of management. To diminish vulnerability to climate change and new stresses, it is essential to develop and disseminate genetically diverse varieties within and between regions.

The mere existence of improved technology does not lead automatically to benefits at the farm level. Farmers also require an efficient and reliable marketing system that allows them to purchase inputs and sell outputs at fair and remunerative prices. When such a marketing system is lacking, policy interventions may be necessary to create economic incentives for commercial farmers to invest in improved technology. Appropriately targeted policy research can generate the information to devise such interventions.

MALNUTRITION  
IS...IMPLICATED IN  
MORE THAN HALF OF  
THE 11 MILLION  
DEATHS OF CHILDREN  
UNDER FIVE IN  
DEVELOPING  
COUNTRIES.—UNICEF

## ■ Conclusion: Framing new research programs, partnerships, and ways of sharing knowledge

This summary has outlined the diverse roles that maize and wheat production play in the livelihoods of the poor throughout the developing world. This diversity has implications for how research is organized to address poverty and food security (rural and urban), hunger, and natural resource conservation. It also has implications for the kinds of partnerships, networks, and knowledge sharing that are required to meet farmers' needs.

We recognize that research alone will not solve all of the problems that prevent people from realizing a better future for themselves or their children, but we are committed to ensuring that the research of CIMMYT and its partners is as successful as possible at contributing to better livelihoods. To address this challenge, CIMMYT will organize its research to:

- Become more successful in addressing both dimensions of the livelihoods framework: food insecurity and income insecurity.
- Learn from commonalities in the biophysical and socioeconomic context in which maize and wheat are produced.
- Capture technology spillovers, so that innovations developed for use with one crop or in one region can be put to use with other crops or in other regions (for example, spillovers from marginal to favored areas and *vice versa*, and across research programs and regions).

The next chapter describes more specifically how CIMMYT proposes to organize its research to accomplish these tasks.

## Which poor people will CIMMYT work for?



Poverty is not a uniform condition. No organization can help all poor people in exactly the same way or to the same extent. To make effective use of its resources, CIMMYT must carefully target its efforts.

CIMMYT will focus on regions in which maize and wheat, together or separately, are important to people's livelihoods and have potential for helping to alleviate poverty and sustain the environment, especially sub-Saharan Africa and Asia. Our work will respond to the challenges faced by small-scale, resource-poor farmers, whose needs are typically overlooked by the private sector or other technology providers. We will work with people who are poor but nevertheless have access to sufficient assets to benefit from our work or to help others benefit. From a practical standpoint, it is important to recall that most rural communities, even those classified as "poor," include a range of wealth classes. "Wealthier" individuals often determine who has access to community members, so in practice it is not always possible to work exclusively with the poorest community members. (In fact, the poorest of the poor in rural areas are frequently landless laborers; at best, CIMMYT can help them only indirectly through the development of improved agricultural systems.) We will consider the full context in which poor households operate and not focus exclusively on the maize and wheat component of livelihoods. CIMMYT does not seek to be a "technology assembly line," but rather to work with its partners in developing a spectrum of options for local circumstances.

**CIMMYT WILL CONSIDER THE FULL CONTEXT IN WHICH HOUSEHOLDS OPERATE AND NOT FOCUS EXCLUSIVELY ON THE MAIZE AND WHEAT COMPONENT OF LIVELIHOODS.**

# Towards a new agenda for innovation



## In this chapter:

CIMMYT will organize its work under a matrix formed by several broad, thematic programs interacting with groups that have similar disciplinary research interests.

The thematic programs will catalyze interdisciplinary research done in collaboration with a wide range of partners, and they will maintain a clear focus on livelihoods and production systems. The disciplinary groups will ensure continuing scientific and professional excellence.

Two global programs will focus on:

- *Genetic resources*
- *Global and strategic research*

They will be reinforced by research in four eco-regional programs:

- *African livelihoods*
- *Rainfed systems*
- *Tropical ecosystems*
- *Irrigated, high-potential maize and wheat systems*

The details of the research agenda, including priorities, will be determined in consultation with stakeholders.

## ■ Structuring CIMMYT’s global research program

How does CIMMYT propose to structure its global research program to meet local needs for alternative livelihood strategies? We will organize our work into a matrix formed by six broad thematic programs, which will interact with various groups representing expertise in specific disciplines (Figure 3.1). The thematic programs will catalyze interdisciplinary research done in collaboration with a wide range of partners, and they will maintain a clear focus on livelihoods and production systems rather than on commodities and disciplines. The focus on livelihoods should help to identify more potential complementarities in research with partners. The disciplinary groups will ensure continuing scientific and professional excellence. The strategic decision to implement research in this manner reflects CIMMYT’s commitment to being as integrative as possible in its research, considering the different natural, economic, and cultural factors that determine where and how maize and wheat are grown.

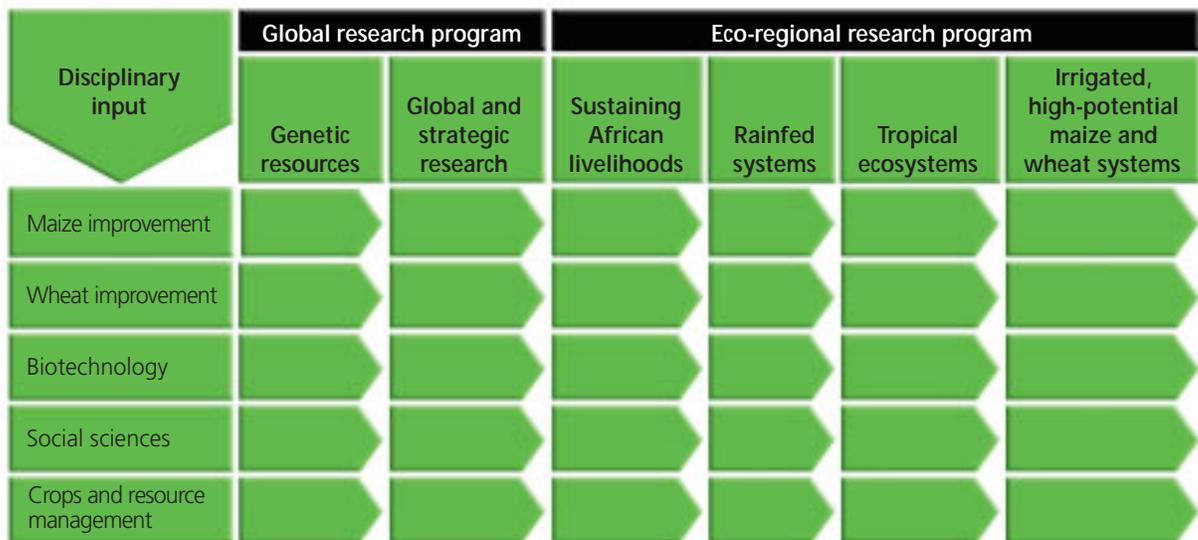
## ■ The agenda is a work in progress

As indicated in the title of this chapter, these proposed programs are the basis for working out a conclusive, prioritized research agenda in consultation with stakeholders. Through this consultation, the details of each program will be articulated in light of local needs.

The proposed programs consist of two global programs designed to reinforce the impact of four eco-regional programs. *The order in which the programs are presented in this chapter is not intended to reflect their relative importance.* One reason for adopting this new structure was to focus CIMMYT’s research on a small number of endeavors of roughly equal importance.

The global programs focus on genetic resources and on global and strategic research. The brief titles of the eco-regional programs indicate the diversity represented in this research agenda: sustaining African livelihoods; rainfed systems; tropical ecosystems; and irrigated, high-potential maize and wheat systems. The eco-regional

**Figure 3.1. CIMMYT’s research structure.** Six broad, thematic programs, focusing on global and eco-regional issues, will catalyze interdisciplinary research done in collaboration with a range of partners. The programs will interact with groups representing expertise in specific disciplines, whose role is to ensure continuing scientific excellence.



approach enables us to concentrate resources on high-priority regions such as Africa and to foster better collaboration with networks, CGIAR Centers, and other initiatives that work exclusively in specific regions.

The precise nature of these programs is likely to change and evolve, depending on the outcome of the dialogue with stakeholders. As we and our partners gain experience with this way of working, we will periodically review CIMMYT's research portfolio and the definition of the research programs.

### ■ Roles of the programs and disciplinary research groups

As noted, each program will draw on multiple disciplines to address a particular set of global or eco-regional issues. Several disciplinary groups will reflect the Center's core competencies in maize improvement, wheat improvement, biotechnology, social sciences, and crop and resource management. Such groups are essential for maintaining a critical mass of staff with particular skills, permitting accurate assessments of strengths and weaknesses, encouraging individuals to excel and innovate in their particular disciplines, serving as contacts for specific requests from outside CIMMYT, and ensuring the quality of science at CIMMYT by making it possible to attract and retain excellent staff. Scientists are expected to work to a high standard within the interdisciplinary teams created by the programs, but CIMMYT recognizes that scientists also require opportunities to conduct additional research that contributes to their particular discipline as well as to the Center's mission. CIMMYT will provide resources and other support for cross-program interactions.

### ■ Programs and partnerships

The next chapter discusses partnerships in detail, but here it is important to emphasize that each program will be carried out in collaboration with a diversity of partners, including advanced research institutes, national agricultural research and extension systems, NGOs, farmers' associations, private companies, and other CGIAR Centers. In many cases, CIMMYT already has strong working relationships with the partners who are

CONCLUSIVE,  
PRIORITIZED AGENDAS  
FOR THE NEW RESEARCH  
PROGRAMS WILL BE  
DEVELOPED IN  
CONSULTATION WITH  
STAKEHOLDERS. DETAILS  
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BE ARTICULATED IN LIGHT  
OF LOCAL NEEDS.

essential to achieving a program's goals; in other cases, relationships will be established where there are complementarities and shared goals.

CIMMYT will provide *some* products and services to each program directly—most notably, improved varieties, which will remain a strong research focus. For other activities, such as cropping systems or socioeconomic research, we will conduct research and also facilitate and lend support to networks of partners who have complementary expertise in these areas. When others have superior capabilities or facilities, we will outsource tasks to other institutions or place staff within those institutions (e.g., to conduct aspects of biotechnology research). Details of such arrangements will be concluded on a program and activity basis with partners.

### ■ Program 1: Genetic resources

*"Harnessing maize and wheat genetic diversity for humanity"*

**Challenges.** Genetic resources are CIMMYT's primary asset, and the Center is ethically and legally committed to conserving and facilitating the use of crop genetic diversity of maize and wheat for humanity, including future generations. Essential components for facilitating access to and use of genetic resources will be 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 (Genetic Resources; HarvestPlus), encompasses many areas of research: germplasm collection for ex situ conservation; characterization of genebank entries; pre-breeding; applications of genomics; improved and more accessible information on stored 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 data: pedigrees, trial results, and agronomic and socioeconomic data.

**Projected impact.** Within 10 years, this program will:

- Complete the regeneration of accessions.
- Complete the molecular characterization of key maize and wheat accessions.
- Expand CIMMYT's collection of genetic resources to include more African and Asian maize varieties, cytogenetic stocks, and genetic populations.
- Store and distribute DNA samples extracted from the most appropriate genetic resources for use with genetic studies (structural and functional genomics).
- 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.
- Further develop and use pre-breeding techniques (conventional and molecular) for maize and wheat.
- Identify the genetic bases of key traits in maize and wheat.
- Develop and use a comprehensive data management system to enable global, web-based access to information on genetic resources.

## ■ Program 2: Global and strategic research

**“Strengthening the global maize and wheat innovation network through capacity building, policy development, and the analysis of strategic global issues”**

**Challenges.** To strengthen and increase the usefulness 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 undertake 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, collaborative research, and mentoring; 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 10 years, this program will:

- Establish a strong learning and mentoring service that develops courses and training modules; facilitates distance learning and the earning of advanced degrees; offers formal training directly; and establishes a network of local training partners in a large number of countries where CIMMYT works.

- 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 the public debate over 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 international diffusion of technologies.

### ■ Program 3: Sustaining 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 the greatest 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 mainly grow 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 cash crops such as cotton or tobacco. 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; sustainably exploit 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; Genetic Resources; 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, resistance to insect pests, improved nutritional content, or tolerance to a herbicide seed treatment that eradicates *Striga*. 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 modified 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 10 years, this program will:

- Ensure that 20% of 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.

#### ■ Program 4: Rainfed systems

**“Reducing vulnerability by managing risk in rainfed systems”** (Eurasia, Central 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). 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.

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 two CGIAR Challenge Programs (Water and Food; HarvestPlus), 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 10 years, 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.
- Improve the nutritional value of wheat.
- Help meet the demand for better livestock feed through drought- and heat-tolerant maize with enhanced protein quality.

#### ■ 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 ecological principles to control weeds, pests, and diseases; conserve soil and water; and help meet increasing demand for food (in Latin America) and feed (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), manufacture of handicrafts, seasonal

off-farm work, or remittances from family members. More recently, they have come to dominate smallholder rainfed agriculture in Southeast Asia. In these 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, waterlogging, diseases, and insects. These varieties will have improved protein quality and higher micronutrient content. They will survive under 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 without 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 longer-term consequences and scale consequences of resource-conserving practices will be monitored. Impacts of technical change on the livelihoods of the poor will be studied closely.

**Projected impact.** Within 10 years, 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.
- Diversify 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.

### ■ Program 6: Irrigated, high-potential maize and wheat systems

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

**Challenges.** A large number 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 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 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.

CIMMYT NEEDS A GREATER REGIONAL PRESENCE TO IDENTIFY, DEVELOP, AND MAINTAIN EFFECTIVE PARTNERSHIPS. CIMMYT CANNOT AFFORD TO BE ISOLATED FROM THE REGIONS WHERE IT IS MOST NEEDED.

—SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT.

Research will focus on resource-conserving technologies (zero tillage of 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 10 years, 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).

### ■ **Conclusion: Focusing on major issues in new ways**

Rather than addressing research issues through purely commodity and disciplinary perspectives, CIMMYT will address them through the lens of eco-regions, cropping systems, and the needs of poor producers. The programs proposed above are designed to encourage the synergies we value among colleagues, disciplines, and partners, including other CGIAR Centers; serve as the platform for setting research priorities and focusing on the major concerns of our stakeholders; highlight complementary efficiencies in our work; and provide a framework for altering our research agenda in a transparent way as needs and strategies change. For an indication of some of the scientific approaches that will be important for this research agenda, see Box 3.1, which is recapitulated in greater detail in Appendix 2.

Obviously the ambitious agenda presented in this chapter cannot be undertaken by CIMMYT alone. CIMMYT does not generate impact by itself. More than ever, partnerships are necessary for research to yield the advances that poor people so desperately need, and for the poor to benefit from them. Chapter 4 provides perspectives on various partnerships that will be needed to achieve CIMMYT's mission. It also discusses how networks and partnerships become much more effective when careful attention is given to how people create, manage, and share knowledge.

## Science of strategic interest to CIMMYT

CIMMYT is committed to evaluating the scientific, humanitarian, and efficiency merits of new science, including applications of biotechnology. It is the nature of many scientific discoveries to be controversial and to require choices that have not been made before. With respect to biotechnology, CIMMYT's position is that we must explore this prolific new area of research, especially to provide informed guidance about its potential risks and benefits. Biotechnology is not—and certainly will not remain—the only area of new science to present challenges to CIMMYT and its stakeholders in the years to come. Our common responsibility is to confront and explore those challenges to the best of our ability and ensure that potentially useful knowledge and technology are employed to benefit the people who need them most.

Space does not permit us to list every proven or novel method and tool that is important to CIMMYT's research, but we would like to give readers some idea of the spectrum of approaches and innovations that have the potential to improve the efficiency and impact of our work. The following list is admittedly quite incomplete, and the approaches mentioned here do not necessarily have priority over others in use at CIMMYT. We mention them because they will complement and extend CIMMYT's expertise and efficiency, especially its core proficiency in plant breeding. In several cases, these tools will not be developed or used directly by CIMMYT.

**Social science methods.** CIMMYT will use a wider spectrum of social science methods and tools to understand technical innovation and develop new strategies for addressing the needs of the poor. Social science methods and perspectives 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.

**Policy analysis.** CIMMYT offers 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 CIMMYT's research.

**Conservation agriculture for small-scale farmers.** CIMMYT will continue to interact with conservation agriculture networks and farmers' associations and use its expertise to catalyze innovation systems in poorer rural populations. In this approach, research does not necessarily provide technology; it acts as an integrator to solve problems emerging within the new system.

For example, CIMMYT can facilitate the exchange of information on small equipment and its local adaptation. CIMMYT can help improve the provision of specialized inputs for conservation agriculture. Through research on genotype-environment interactions and soil and root health, CIMMYT can also provide component technologies and knowledge relevant to conservation agriculture systems.

**Integrated natural resource management research.** New crop and system models will be used to simulate long-term performance (and riskiness over time) of resource-conserving technologies. Information technology will facilitate the sharing of information on "what works, where, and why." Geographic information systems (GIS) will become seamlessly linked to simulation models to guide the development and diffusion of new technologies on a wider scale.

**Genotype-environment (GxE) interactions.** CIMMYT's extensive partnerships make it possible to quantify GxE interactions by conducting experiments at agronomically representative sites worldwide. Among other things, this information provides a better understanding of how to overcome yield barriers. In addition, with data on the performance of individual varieties in representative on-farm sites over a range of agro-ecologies, GIS can provide valuable predictive information on the locations where a given variety is most suited and which resistance traits it should carry to ensure high, stable production. With this information, we can identify locations where pressure from stresses is extremely high and predict shifts in pest and disease incidence associated with climate change. The identification of these hot spots will facilitate the search for resistance genes.

**Geographic information systems (GIS) and remote sensing.** Ever-increasing availability of spatial data is going to have an enormous influence on CIMMYT for adoption and impact assessment; decision-making; improving research



IT IS THE NATURE OF MANY SCIENTIFIC DISCOVERIES TO BE CONTROVERSIAL AND TO REQUIRE CHOICES THAT HAVE NOT BEEN MADE BEFORE. OUR COMMON RESPONSIBILITY IS TO ENSURE THAT KNOWLEDGE AND TECHNOLOGY ARE USED TO BENEFIT THE PEOPLE WHO NEED THEM MOST.

efficiency; communication and diffusion; information management; and technology targeting. Developments in three major areas are of particular interest: global positioning system (GPS) technology, high-resolution imagery and satellite sensors, and timely (real-time) data provision.

***New plant breeding and seed dissemination approaches.***

CIMMYT has an important role to play in developing and advocating practical, farmer-oriented approaches to plant breeding and seed dissemination to meet the needs of poor farmers in developing countries (e.g., approaches for national programs to develop stress-tolerant varieties expressly for poor farmers' conditions; supra-national, multi-stakeholder arrangements for developing, releasing, and providing improved varieties to small-scale farmers).

***Gene discovery for pre-breeding research.*** CIMMYT's pre-breeding research will be made more effective by merging the operations of CIMMYT's genebank—including the collection, characterization, and regeneration of genetic resources—with all of its pre-breeding research into an applied genetic resources approach that takes much greater advantage of new science, such as fingerprinting.

***Molecular fingerprinting.*** This technology is useful for improving the management of CIMMYT's genetic resources, identifying useful combinations of inbred lines, conducting more efficient pre-breeding research, detecting allelic variation for further phenotypic screening, and protecting/identifying individual varieties.

***Gene and trait mapping.*** Mapping will remain important for several years to come as a method for understanding the genetic basis of plant phenotype (i.e., the location and number of regions in the genome that are responsible for the expression of a given trait). This information is the basis for marker-assisted selection, can be used to validate candidate genes for a given trait, and can be used to develop contrasting materials for use in functional genomics approaches.

***Marker-assisted selection (MAS).*** CIMMYT will maintain and build its capabilities in this area to reduce costly field analyses (including plant phenotyping), screen germplasm early in the growth cycle, screen for traits that would not otherwise be detectable in a given location, and select for several traits at once. Efforts to develop new marker systems and/or linked markers for additional traits, especially to reduce breeding costs, will be undertaken based on CIMMYT's research priorities. Advances in comparative genetics will increase the efficiency of the identification of linked markers, as they will allow linked markers identified in one crop to be used in others as well. Furthermore, advances in genomics will allow the simultaneous identification of many traits (and markers) for MAS.

***Functional genomics and gene discovery.*** CIMMYT will advance genomics research by continuing to provide key maize and wheat segregating populations and lines that represent extremes in phenotypic expression of important stress-related traits. Another important contribution will be to continue providing molecular maps with genes and genetic regions identified for tolerance/resistance to these stresses. By combining the genetic resources and trait knowledge available at CIMMYT with genomic tools and knowledge in the public and private sector, we will be able to identify key genes responsible for important traits, use this information in its breeding programs, and provide it to partners.

***Transformation technology.*** The ability to modify specific genes in a genome or to introduce an entirely novel gene will continue to improve our knowledge of gene expression and physiological processes (e.g., to investigate potential genes for enhancing drought tolerance and disease resistance in bread wheat). This technology can also provide completely new products for farmers. Its use is most critical in developing varieties with traits that exhibit an insufficient range of genetic diversity within the species (e.g., some nutritional quality traits in maize and wheat).

***Bioinformatics.*** Given the large investment USDA is making to develop genetic databases for the major crops, including maize and wheat, CIMMYT need not develop similar systems, but it will need to link to them. CIMMYT's investment in systems to handle genomic data is even more limited. A comprehensive and integrated system will be needed to manage future genomic data, whether produced at CIMMYT or by its partners. The platform will require links to a number of crop information systems, genebank systems, simulation models for plant breeding, and the genetic databases mentioned above.

***Crop information systems.*** As a global institute with many partners, CIMMYT is uniquely positioned to anchor an international information management system that encompasses a genebank management system (including molecular maps and plant pedigrees), GIS, bioinformatics, and data management systems related to GxE interactions. By linking information in these subsystems, we can gain powerful insights into the relationships between genes, environment, and the productivity of crops and agricultural systems. To do so, CIMMYT will make a significant strategic investment in information and communications technology (how much of this will be done directly or through outsourcing remains to be determined).

# Global partnerships and knowledge sharing: The foundation for innovation and impact



## In this chapter:

CIMMYT's intention is to be a true partner in innovation, providing products, services, information, and technical expertise. Principles for partnering include:

- *Engage in strategic partnerships for specific purposes.*
- *Engage in collective priority setting and shared implementation.*
- *Emphasize equality in sharing resources, contributions, accountability, and credit.*
- *Wherever possible, work in a network mode that brings together multiple partners to solve complex problems, with each partner contributing from its particular area of expertise.*
- *Strengthen the capacity of partners so others can take on new roles and create additional synergies; devolve activities wherever possible.*

With respect to specific groups of partners, CIMMYT will:

- *Strengthen work with national agricultural research and extension systems in broad alliances of diverse partners.*
- *Actively harmonize and integrate CIMMYT's efforts with those of other CGIAR Centers.*

- *Continue to build relationships with private foundations, which often provide resources to assess and incorporate important new approaches to research and capacity building.*
- *Expand relationships with non-governmental and civil society organizations, especially in seed production and delivery systems, seed relief, and health initiatives.*
- *Establish more strategic and productive relationships with the private sector and advanced research institutes.*
- *Maintain strong links with international development agencies and global and regional development fora.*

Where appropriate, CIMMYT will play a stronger role as an advocate for alleviating poverty and hunger and promoting sustainable development through improved policies and technologies. This role supports all partners, resource-poor farmers and consumers above all.

To add value to its participation in partnerships and networks, CIMMYT will attend to the whole cycle of knowledge management. It will further an organizational culture to stimulate the acquisition, sharing, and evaluation of knowledge.

STAKEHOLDERS...VIEW CIMMYT AS PLAYING AN ESSENTIAL COORDINATING ROLE IN A RICH NETWORK...THAT TRANSCENDS GEOPOLITICAL BOUNDARIES, GIVES AGRICULTURALISTS IN LESS DEVELOPED COUNTRIES ACCESS TO COLLEAGUES IN MORE DEVELOPED COUNTRIES, AND IS UNUSUALLY VERTICAL IN ITS MEMBERSHIP, RANGING FROM FARMERS TO MINISTERS OF AGRICULTURE. STAKEHOLDERS OBSERVED THAT FEW ORGANIZATIONS IN AGRICULTURAL RESEARCH COULD CLAIM AN EQUALLY EXTENSIVE NETWORK.—SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT

### ■ Building on a strong network of partnerships

The consultations and analyses that led to the development of this strategy identified CIMMYT's extensive networks and partnerships as one of its greatest scientific and operational strengths. To achieve its global mission, CIMMYT will build on its partnerships in three ways. First, as counseled by our stakeholders, we will regularly engage partners in a more consultative, locally nuanced process for developing our global research agenda. Second, we will reinforce our research presence in Asia and Africa to address problems of poverty more directly where they are most extensive and severe. Third, we will build on the strength of these partnerships to expand the global public knowledge base for innovation in maize and wheat research.

This first part of this chapter examines the ways in which CIMMYT seeks to work with particular groups of partners—renewing our partnerships with the public sector, seeking more productive partnerships with the private sector and advanced research institutes, encouraging complementarities with other CGIAR Centers and NGOs, fostering innovation with private foundations, and partnering to engage in advocacy on specific issues. In all of these relationships, our intention is to be a true partner in innovation, providing products, services, information, and technical expertise. Our partnerships will emphasize equality in sharing resources, contributions, accountability, and credit. There has been some discussion of the transactions costs involved in extensive partnerships, but it is our belief that the approach described in this chapter will enable partnerships to become more efficient for all involved.

The primary resource shared and created by these partnerships is knowledge. Unlike a particular technology, which may be relatively short-lived, knowledge is a continually changing, renewable resource for science. The second part of this chapter explains a defining feature of CIMMYT's mission and strategy: the commitment to be an effective catalyst in a global knowledge sharing and innovation network.

## Public-sector partnerships prevent epidemics in wheat

### ■ Renewing public-sector partnerships

For an organization such as CIMMYT, whose existence is founded on developing public goods for developing countries, national research and extension programs and agricultural universities are natural allies. Many elements of this strategy, such as a greater regional presence in Asia and Africa, are intended to help CIMMYT become a more valuable and effective partner for the public sector in developing countries.

Based on consultation with many representatives of national research and extension programs, we envision that these long-standing allies will join us in forming broader strategic alliances for managing knowledge and innovation, as described later in this chapter. We also believe that there is great potential to work with these partners to become more effective advocates for policy interventions to alleviate hunger and poverty, as mentioned below.

Our extensive collaborative relationships with public organizations in developing countries, as well as with regional consortia of national research organizations, have stood the test of time—in many cases enduring national conflicts and natural disasters. The economic and efficiency advantages of the international maize and wheat research systems formed by CIMMYT and its public-sector partners in developing countries, as well as the considerable benefits generated by these systems, have been extensively documented (see Box 1.2, p. 4).

In light of the growing competition for resources to conduct public agricultural research and extension, however, some observers have questioned the sustainability of these primary research partnerships for CIMMYT. Money is not the only issue. The private sector's large investment in agricultural research, combined with its tendency to seek intellectual property rights over key processes and products, have raised barriers to innovation by the public sector. In some countries, the number of talented research staff working in the public sector has been depleted by emigration, opportunities in the private sector, HIV/AIDS, and civil disorder. Increased funding alone will not compensate for these losses.

International public-sector partnerships can be the best assurance that some potentially costly problems never reach farmers' fields. For example, a virulent race of yellow rust that arose in East Africa in 1986 migrated to North Africa, crossing West Asia and South Asia to reach Nepal around 1997. On the way, the new race caused epidemics and severe production losses in wheat in Ethiopia, Turkey, Iran, Afghanistan, and Pakistan. The multi-million dollar losses could have been reduced or avoided through concerted disease monitoring and control.

Today, a global network links CIMMYT, ICARDA, and national research organizations in Asia, Africa, and Latin America to report new rust races as soon as they appear and alert unaffected countries to potential epidemics. Scientists and decision-makers in each country use this information to decide whether susceptible wheats should be replaced with new resistant varieties, including some with durable resistance from CIMMYT. Countries in one region may ask CIMMYT to facilitate the testing of their experimental varieties in another region where a disease already has a head start, simply to ensure that they already have good resistance to a disease that may cross their own borders within a few years. This early warning network is a good example of how international public research partnerships produce a global public good—in this case, the prevention of costly epidemics. No single nation can accomplish this task, given that disease pathogens do not operate within national boundaries, and private companies do not address this kind of need at the global level.



# CIMMYT and other CGIAR Centers

Rather than providing an exhaustive list of the many ways that CIMMYT has collaborated with other CGIAR Centers over the years, we offer a few representative examples. Our work with other Centers has ranged from ambitious disaster relief initiatives, to long-term collaboration in research and training, to more mundane concerns such as the development of similar policies and procedures. Some of these efforts have been quite successful, others less so, but we are committed to learning from our experience to support the development of a more integrated, efficient CGIAR.

CIMMYT and several other Centers have formal arrangements for hosting each others' staff, with provision for local support and collaborative research. Collaboration with IPGRI is an essential feature of CIMMYT's work, especially with respect to clarifying and executing international legal responsibilities for conserving and sharing genetic resources. For decades, CIMMYT has worked alongside IITA in maize improvement for Africa and alongside ICARDA in wheat improvement for the Caucasus region, West and Central Asia, and North Africa (CWANA region). CIMMYT and other Centers collaborate in several Ecoregional and System-wide Programs. CIMMYT is currently the convening Center for the Rice-Wheat Consortium for the Indo-Gangetic Plains, in which IRRI, IWMI, ICRISAT, and CIP also have well-defined and highly visible roles. CIMMYT is active in the System-wide initiatives on Integrated Pest Management, on Participatory Research and Gender Analysis, and on Genetic Resources for Agriculture, and partners with the African Highlands Initiative and the Consorcio para el Desarrollo de la Ecorregión Andina (CONDESAN). CIMMYT, IRRI, and IPGRI lead the Challenge Program on Genetic Resources, and CIMMYT will actively participate in the other three programs established to date: Water and Food, HarvestPlus, and Sub-Saharan Africa.

Aside from these formal arrangements, numerous effective and informal partnerships between CIMMYT and other CGIAR Centers are based simply on mutual interest and a desire to get the job done.

Despite these trends, the public sector accomplishes many things that other organizations do not. Publicly funded research and development organizations often have national coverage, direct access to farming communities and local research facilities, a wealth of local knowledge not available elsewhere, and formal governmental support. They continue to play valuable public service roles, such as supporting the conservation and international exchange of genetic resources or monitoring for emerging disease epidemics (Box 4.1). Finally, the public sector in some countries has recently strengthened its commitment to advanced scientific endeavors, including biotechnology and other new research areas, in the service of agriculture.

For these reasons, and because of the proven effectiveness of our partnerships with the public sector, we envision that public research and extension organizations will remain primary partners in the years to come.

## ■ Partnering to support a renewed CGIAR

CIMMYT's history and evolution are virtually inseparable from that of the CGIAR. The Green Revolution in wheat and rice provided much of the impetus for the CGIAR's founding in 1971 (Box 1.2, p. 4). The CGIAR has been a powerful medium for channeling support and setting priorities for international agricultural research. CIMMYT values the determination within the CGIAR to forge the work of the Centers into a more efficient whole to take a coordinated approach to problems of hunger and poverty. This changing vision for the Centers has heavily influenced our strategy, which is intended to offer more opportunities for collaboration and effective change within the CGIAR. The agenda for international agricultural research is expanding, and collaboration is essential to ensure that resources are used intelligently.

CIMMYT and other Centers have partnered in many ways over the years (Box 4.2). The recently initiated Challenge Programs represent opportunities to engage multiple Centers and external partners in research on complex issues of wide significance. Perhaps equally important, the Challenge Programs will generate valuable lessons for how research might be organized and funded throughout the CGIAR. We foresee that similar institutional arrangements, though not on such a large scale, will be essential for success in the years to come (two examples of such arrangements are the Rice-Wheat Consortium for the Indo-Gangetic Plains and the proposed Soil Fertility Consortium for Southern Africa).

As mentioned in Chapter 3, a strong motive for organizing our research agenda into eco-regional programs is to foster greater interaction and integration with other CGIAR Centers. We will seek the expertise and collaboration of other Centers—and offer our support—wherever complementarities exist. Specifically, we will seek to work more closely with IITA, the World Agroforestry Center, CIAT, and ICARDA on eco-regional activities in Africa, Latin America, and Central and West Asia and North Africa, and with ICRISAT in both Africa and South Asia where our mandates overlap in water-stressed regions. Given the importance of maize-livestock systems in Africa, we will also seek to partner more closely with ILRI (for example, in developing dual-purpose maize varieties, or analyzing crop-livestock interactions related to conservation agriculture). Especially in Africa, we see many opportunities to collaborate with other CGIAR Centers in activities such as understanding livelihood systems, conducting participatory research, improving seed systems, strengthening policies and markets, and on a more operational level by sharing infrastructure and data analysis resources. Advances in genomics and overlapping cropping systems in South Asia make stronger collaboration with IRRI advantageous for both Centers. Our relationship with IFPRI will no doubt deepen as CIMMYT commits additional energy to policy and advocacy work. Synergies with all CGIAR Centers on capacity building, knowledge and information management, and intellectual property issues are essential.

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KARKI, NEPAL,  
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GROUP LEADER,  
AND CIMMYT  
PARTNER

#### ■ NGOs, farmer groups, and community and self-help groups

The spectrum of NGOs and CSOs, including community and self-help groups, relief organizations, and farmer advocacy groups, extends from small, locally organized groups to large international concerns. We have relatively longstanding relationships with some large NGOs, such as Sasakawa-Global 2000 and World Vision, and seek to form others. One of CIMMYT's most enduring research relationships is with the Patronato of Sonora, a council of producers in northwestern Mexico that has provided fundamental support to CIMMYT's research (Box 4.3, p. 34).

In many cases, NGOs and CSOs have complementary areas of expertise or resources (e.g., local contacts, expertise in community welfare issues, language skills) and similar goals (to improve livelihoods), all of which can encourage productive partnerships. Their local expertise is often invaluable for initiating constructive discussions of local needs and channeling resources to people for experimenting with technologies or practices that might meet those needs. In some of the increasingly unstable areas where CIMMYT is called upon to work, NGOs may be virtually the only lifeline to poor farm households. Here we highlight some kinds of partnerships with NGOs that are important for the future.

## The Patronato of Sonora: Local support for global research



“The Patronato” (formally known as the Patronato para la Investigación y Experimentación Agrícola del Estado de Sonora) is an association of commercial and communal farmers in the state of Sonora in northwestern Mexico. CIMMYT researchers have high regard for the Patronato, based on decades of cooperation and support. Millions of farmers around the world would share this regard, if they knew the debt of gratitude they also owe the Patronato. More than 1,300 cultivars of wheat and triticale, released in 51 countries and grown on approximately 58 million hectares, can trace their ancestry to the fields and resources that the Patronato has provided to CIMMYT in the Yaqui Valley in northwestern Mexico. The dry environment in the Yaqui Valley is well suited for globally oriented wheat research because it can be managed to simulate agro-ecological environments throughout much of the developing world where wheat is grown.

Yaqui Valley farmers were the first to experience the benefits of the new wheats developed in the 1950s and early 1960s by the Government of Mexico/Rockefeller Foundation program that was the forerunner of CIMMYT (see Box 1.2, p. 4). In 1964 these farmers decided to create their own organization—the Patronato—to provide consistent support for agricultural research. The organization was subsequently expanded to include farmers throughout Sonora.

Most of the Patronato’s funding comes from farmers’ donations, based on a yearly quota (currently 0.00125% of their production per hectare) collected at planting. The Patronato also receives support from private companies and the State of Sonora.

In addition to providing funding for CIMMYT’s wheat and maize research, the Patronato generously provides access to over 200 hectares of prime agricultural land close to the government’s Northwestern Agricultural Research Center (Centro de Investigaciones Agrícolas del Noroeste, or CIANO), where CIMMYT also has the good fortune to work. In the course of developing this strategy, Patronato farmers have been actively involved with CIMMYT and CIANO in providing feedback for research and priority setting.

**Seed production.** One area in which alliances with NGOs and CSOs will continue to be crucial is in sharing information about seed production, especially for maize. The public sector has largely exited the business of selling seed to farmers, and for years to come, many of the world's maize farmers will remain far too poor and isolated to constitute an attractive market for private seed companies. By partnering with NGOs, local research and extension organizations, and the private sector, CIMMYT can share knowledge on producing good quality seed and create links between community seed producers and organizations that can provide information on new varieties. Through this work, communities gain better information about the new maize and wheat varieties and practices that are available to them, establish profitable local seed production enterprises, and improve crop production.

**Seed relief.** Relief agencies have the networks and expertise to help people return to productive, stable livelihoods in the wake of natural disasters, famine, or civil disorder. CIMMYT can partner with these organizations by providing appropriate seed and knowledge to help restore farming communities and rehabilitate the agricultural sector, including local research capacity. Ideally, CIMMYT seeks to establish partnerships with relief agencies before disaster strikes, enabling institutions to avoid bureaucratic impediments and respond more quickly.

**Organizations dedicated to nutrition and health.** Agriculture is a food delivery system for better nutrition and health. By forming proactive links with organizations focused on health and nutrition, including the many NGOs and advanced research institutes active in this arena, CIMMYT can ensure that food production systems become part of an overarching strategy for delivering health and nutrition in rural communities, including those devastated by HIV/AIDS. Aside from the work to develop nutritionally enhanced maize and wheat varieties for the Harvest Plus Challenge Program, current projects, study how food systems must change to overcome problems of rickets and arsenic poisoning.

THE PERCEPTION THAT CIMMYT'S WORK IS LESS POLITICIZED THAN THAT OF OTHER PLAYERS HAS PROVIDED A GREAT DEAL OF COMFORT FOR PARTNERS AT ALL LEVELS. THIS HONESTY ALLOWS CIMMYT TO CREATE COLLABORATION AND UNDERSTANDING WHERE OTHER ENTITIES, ACTING ALONE, COULD OR WOULD NOT.—SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT

### ■ Partnering with private foundations

CIMMYT has much direct experience of the ways in which private foundations encourage and support innovation in international agricultural research. Private foundations (the Rockefeller and Ford Foundations) were among the first to understand the potential of international agricultural research for development. Foundations continue to expand the boundaries of international agricultural research in many ways: they often bring new groups of partners together; they continually facilitate and support new approaches for working with farmers; they provide resources to explore promising applications of basic research; they invest in studies of emerging issues at the farm level; they help to create new channels for learning about and sharing technology; and they consistently support capacity building.

The value of this contribution cannot be overstated. It permits new thinking and experimentation in areas that other partners (sometimes representing more conservative constituencies) and CIMMYT itself may tend to avoid. To continue to challenge our assumptions, learn about different approaches to research and development, and integrate them into our work, we will seek greater collaboration with foundations (the Rockefeller, McKnight, and Gatsby Foundations, among others).

## Partnering with the private sector to reach maize farmers

CIMMYT develops improved maize and other products specifically to meet the needs of poor farmers, and by providing this technology to local seed companies free of charge, we can assist them in delivering improved seed at affordable prices. They gain access to our research products and resources (including information on seed production), and further improve them based on their local knowledge and expertise. Through their access to local seed markets, small seed companies help immensely in enhancing the impact of research at the farm household level, especially in less accessible rural areas where larger companies rarely operate.

CIMMYT will seek partnerships to license its products (including maize varieties and hybrids) to private companies in specific regions or countries. These partnerships will be formed in such a way that CIMMYT does not compromise its policy of providing free and unlimited access to its germplasm to any of its partners. The technology will remain in the public domain, and CIMMYT will retain its freedom to operate. It remains a challenge to find evenhanded ways of dealing with private companies when several operate in the same geographical area and wish to acquire our advanced germplasm for commercialization, but in some cases there are solutions. For example, the same CIMMYT maize inbred, which possesses high combining ability and other special attributes, might be used by two different seed producers to produce two different hybrids or varieties, depending on the proprietary parents that they use.

### ■ Strategic partnerships with the private sector and advanced research institutes

CIMMYT will establish more strategic and productive relationships with the private sector and advanced research institutes. Despite the frequently cited constraints to linking with these organizations, especially intellectual property constraints, the role of these organizations in developing and using new technology with important agricultural applications is widely acknowledged.

The private organizations with which CIMMYT works range from very small, local seed companies, which have little funding to conduct research and marketing programs, to multinational agriculture-biotechnology-chemical companies. Similarly, advanced research institutes include large and small institutes and universities, public and private, in both industrialized and developing countries.

The objectives of these partnerships are varied as well. They help us to acquire technology for our own use or for use across developing countries. They help to amplify the impact of research at the local level—for example, by providing improved seed to poor farmers at accessible prices (Box 4.4). They are important for CIMMYT to remain informed about scientific developments and trends.

Among advanced research institutes, academic institutions are particularly significant partners because of their long-term impact on research capacity and on the kinds of research that are done. The impact of the development community's investment in international agricultural research can be extended by creating better links between academic institutions in donor nations and CGIAR Centers. Young scientists in industrialized countries would encounter more opportunities and motivation to become involved in science to alleviate poverty and hunger. By influencing the academic research agenda in industrialized countries to take these problems into account, academic institutions would also increase their relevance and links to developing country researchers and academic institutions.

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What is CIMMYT's strength in partnerships with the private sector and advanced research institutes? CIMMYT offers unique, genetically diverse germplasm of maize, wheat, and wild relatives with numerous traits of interest, such as broad adaptation, stress tolerance, and improved nutritional and industrial quality. We offer important information, both phenotypic and genetic, about that germplasm in a broad set of environments. We offer an international network in which we are a trusted partner. This network is an important avenue for advanced research institutes, which often lack wide contacts in developing countries, to implement their research at the farm level. The groundwork done by CIMMYT in development and training creates potential markets for the private sector and a pool of expertise from which private organizations often recruit staff.

Each partnership with private companies and advanced research institutes has its particular advantages/disadvantages and requires specific kinds of contractual agreements (including material transfer, intellectual property, and confidentiality agreements). CIMMYT gives high priority to ensuring that these agreements are congruent with international conventions, such as the International Treaty on Plant Genetic Resources for Food and Agriculture, and its own policies. Good legal counsel, especially with respect to intellectual property law, is essential to CIMMYT's future, both to ensure that CIMMYT fulfills its role as custodian and producer of global public goods, and to ensure that CIMMYT and its partners in developing countries can still access the best science for the benefit of farmers.

### ■ Other international and regional development organizations

CIMMYT will continue to pursue and strengthen its partnerships with a large number of international and regional development organizations, such as the World Bank, United Nations Development Programme, United Nations Environment Programme, and the United Nations Food and Agriculture Organization. Global and regional fora will also feature prominently among our partners—e.g., the Global Forum on Agricultural Research, the New Partnership for Africa's Development, the Southern African Center for Cooperation in Agricultural and Natural Resources Research and Training, the Asia Pacific Association of Agricultural Research Institutions, the Association for Strengthening Agricultural Research in Eastern and Central Africa, and the Southern African Development Community, to name only a few. Regional fora are especially important partners for setting priorities and developing more effective strategies for delivering technology for farmers.

### ■ Science-based advocacy for developing and delivering public goods

A wide range of stakeholders consulted during the development of this strategy advised CIMMYT to give greater attention to its role as an advocate to ensure that research truly fosters sustainable development. Building on a stronger capacity for policy analysis, we will participate more fully in the public debate on issues of importance to us, and our stakeholders, with the goal of influencing the process through which those issues are addressed and resolved.

CIMMYT's advocacy work will be informed by its unique scientific and humanitarian perspective. It will be done in partnership with others (IFPRI, for example) and focus on two specific objectives.

First, we will advocate when there is a good chance that by doing so we can increase the range of choices available to our partners and to the poor. One example is the debate over transgenic crops. CIMMYT, along

with other CGIAR Centers, can help assess the potential usefulness of genetic engineering for public plant breeding programs, objectively examine the potential risks and benefits of transgenic crops for poor producers and consumers, and encourage enlightened private-sector participation in using new science to resolve the problems of poor people. Another area where advocacy is sorely needed is the development of regional biosafety policies.

Second, we will advocate the use of technologies to benefit the poor, when advocacy is needed to turn research into impact. There are countless examples of promising technologies that never made it off the shelf because adoption was blocked by external constraints. For example, the formal and informal mechanisms that regulate the availability and sharing of seed may be ineffective, preventing farmers from obtaining better varieties. In the presence of such constraints, poor farmers rarely have the clout to bring about needed policy changes. CIMMYT, along with other CGIAR Centers, can provide that clout.

All of this work will emphasize accurate, science-based information and analysis. We will focus only on issues for which we and our partners can offer substantive, competent input. CIMMYT will not recast itself as a policy advisory organization and will certainly not make judgments about the political structures or orientation of any country or territory. To do otherwise would be irresponsible, given that our participation in apolitical innovation networks is crucial for achieving our mission.

### ■ Working as a global innovation network: A systemic approach to knowledge management

A fundamental change in CIMMYT's mission and strategy is an emphasis on knowledge sharing and innovation networks. The knowledge produced by CIMMYT and its partners will almost certainly become as important a "global public good" as improved varieties or practices. How will CIMMYT work with its diverse array of partners to create and share knowledge?

The acquisition and sharing of knowledge are complex processes, and innovation is not just a simple outcome of those processes. Anyone can be a knowledge and innovation catalyst, and anyone might be a user. It is often difficult to identify the elements that lead to innovation and understand how they fit together, but without that understanding, it can be challenging to foster innovation or to determine why it occurs in one setting and not another. There are countless examples of research organizations and networks that work well, and others that do not. For CIMMYT—which cannot work well without effective partnerships—it is crucial to know whether its own approaches to managing knowledge, partnering, and networking are leading to effective innovation.

### ■ The strategic shift towards catalyzing innovation

Who uses the knowledge—the information and technology—produced by CIMMYT? National agricultural research systems, other CGIAR Centers, the private sector (especially local seed and input providers), and NGOs may all incorporate knowledge from CIMMYT into their own efforts—for example, as inputs into further research, as seed for multiplication and distribution, and/or as technology packages (in the case of national research organizations or NGOs) that are used in rural development.

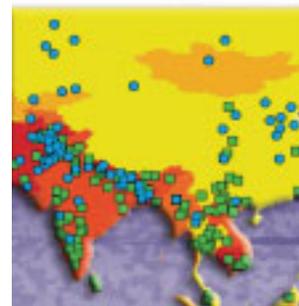
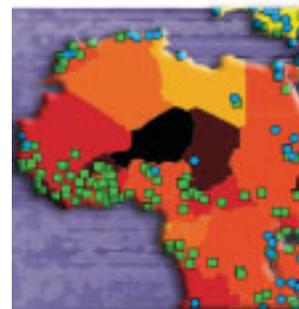
These same partners are all important sources of knowledge for CIMMYT as well. CIMMYT must be highly attuned to their heterogeneous and evolving needs, and to their changing capacity to generate, share, and apply knowledge. *This collaborative role is necessary for CIMMYT to succeed in its strategic decision to act not just as a technology provider but as a catalyst in an innovation network.* To take on this role, CIMMYT must make it a standard practice to conduct research priority setting, planning, and evaluation in collaboration with key stakeholders whenever possible.

## ■ The elements of a global knowledge system

The quality and usefulness of the knowledge that we create and share with others depends, to a great extent, on our own access to information and knowledge. CIMMYT must hone a strategy that allows access to new science (overcoming intellectual property barriers), databases, online journals, and other resources so that information is available to scientists and partners regardless of their location. CIMMYT must also continue to invest in tools to combine, interpret, and use a wide variety of data in further research.

It is human interactions that give these resources their value, however. CIMMYT will need to foster greater learning at the individual, group, and inter-organizational levels. Our new program structure is based on interdisciplinary teams to ensure the lively exchange of ideas to solve complex problems. CIMMYT, as the link in a network of a great variety of partners, is in a unique position to foster knowledge sharing across types of research (exploratory, highly innovative, “blue-sky” research; strategic global research; and adaptive research), across regions, and from farmers’ fields to the laboratory and back again. By paying greater attention to this ability to span boundaries, CIMMYT will reinforce its role as a catalyst for innovation. We can facilitate “communities of practice” (groups with similar expertise and interests) that include researchers and practitioners around the world who are committed to addressing farmers’ needs. By continually engaging with these partners, we will generate valuable new paradigms (in other words, new models or sets of assumptions) for understanding what we are learning from our work, how we are learning from our work, and when these new perceptions call for new solutions to research problems.

As part of this learning process, we will strive to ensure that all partners share information about the benefits, implementation challenges, and shortcomings of technologies, and continuing (or emerging) needs of farmers and collaborating institutions. Formerly the effort to sustain these information flows may have been seen as a transaction that detracted from CIMMYT’s “real work” of applied science. In the future, supporting such information flows will be one of the foremost mechanisms through which CIMMYT adds value to the networks in which its science plays a crucial role.



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Although we have described this approach to knowledge management as if it were an isolated element of our strategy, it is not. The platform for developing new knowledge is based on:

- An agenda of strategic research challenges, understood in their real-life contexts and identified through our network of partners (Chapters 2 and 3).
- Effective partnerships and shared research paradigms to tackle the research challenges (Chapters 4 and 5).
- Information and tools for effective problem-solving (Chapters 3 and 5).
- A strong human resource base for knowledge creation (Chapters 4 and 5).
- A continual learning perspective that captures feedback from our partners and beneficiaries so that the knowledge creation cycle is dynamic (Chapter 5).

The practical implications for CIMMYT may be summarized as follows:

- Actively exchange information across organizational boundaries, and use that information to inform the work of CIMMYT and its partners—in other words, function as an open rather than a closed system with respect to information.
- Participate in diverse networks and partnerships, valuing them as multiple sources of information and expertise, as channels to improve the validity and usefulness of CIMMYT's products and services, and as a way of extending impact.
- Recognize that our most important assets are people, because they create and maintain scientific knowledge, networks, and relationships.
- Reward risk-taking and creativity, foster wide-ranging conversations across disciplines and programs, and intentionally learn from mistakes as well as achievements.
- Value individuals who embrace these principles, and develop procedures and an organizational culture to sustain them.

### ■ Conclusion: Committing to change

Clearly, to transform itself into the kind of organization envisioned in this strategy, especially with respect to sharing knowledge and fostering innovation, CIMMYT must make a strong commitment to working in new ways. We must draw on such practices as participatory priority setting and planning, strategic human resource management, critical interdisciplinary dialogue, partnering for technology dissemination, and innovative approaches to understanding impact from a systems perspective. The next chapter reviews some of the steps that must be taken for CIMMYT to move from strategy to practice.

## Next steps: Preliminary views on implementing the strategy



### **In this chapter:**

A critical step for implementing the strategy will be to hold planning and priority setting meetings with stakeholders to delineate the research agenda and provide information to:

- *Determine CIMMYT's overall research priorities and resource allocations.*
- *Identify areas where new skills or a different disciplinary balance are needed.*
- *Identify which new activities and resources are required.*
- *Identify which partners are positioned to undertake specific activities more efficiently or effectively than CIMMYT.*

Based on this information, CIMMYT will implement the program/disciplinary matrix through:

- *"Enabling strategies" for key activities (e.g., funding, partnerships, advocacy, intellectual property, human resources management, communications, capacity building).*
- *An integrated network of worldwide research locations, each with considerably more autonomy and with a critical mass of staff.*
- *A new management team.*
- *Attention to governance and accountability, including a strong, independent legal office.*
- *The development of an impact assessment culture.*

In 2006, CIMMYT will conduct an external evaluation of progress consistent with our commitment to practice the principles of continual organizational learning. To prepare for a future of constant and unpredictable change, we must be self-critical, be willing to acknowledge and learn from our shortcomings, and be self-correcting. We must continually evaluate not only the usefulness of our technologies, but the robustness of our paradigms. Open and wide-ranging dialogue with our allies and critics will be essential to ensuring that CIMMYT continues to tackle difficult questions in new and creative ways.

## ■ Implementing change

The major elements of this strategy emerged from a consultative and participatory process involving CIMMYT staff and a broad cross-section of stakeholders. In developing this strategy, we strove to respond to concerns emerging from the consultation (Box 5.1), but the ultimate proof of success lies not in these pages but in how the principles of the strategy are put into practice.

Organizational change of the magnitude discussed in this strategy does not happen quickly or easily. Much work remains to be done, and difficult decisions remain to be made. The broad agenda presented in Chapter 3 represents the scope of research that is needed to fulfill CIMMYT's mission—in other words, the agenda that it would be desirable to fund. Given that resources are limited, however, CIMMYT and its partners will have to be extremely selective in the research they decide to undertake.

This chapter provides a preliminary view of some of the steps (Figure 5.1) that will be involved in implementing the strategy, especially with respect to priority setting. It concludes with observations on measuring impact, ensuring good accountability and governance, and learning to become a learning organization.

## ■ Setting priorities and allocating resources

The most critical step for moving from strategy to reality will be a series of planning and priority setting meetings held throughout 2004 with stakeholders. These meetings will initiate a continuing process of joint planning and priority setting for CIMMYT and its partners. These partners helped to articulate the strategic choices that CIMMYT needed to make, and their views are equally essential for helping to specify the concrete actions needed to move forward.

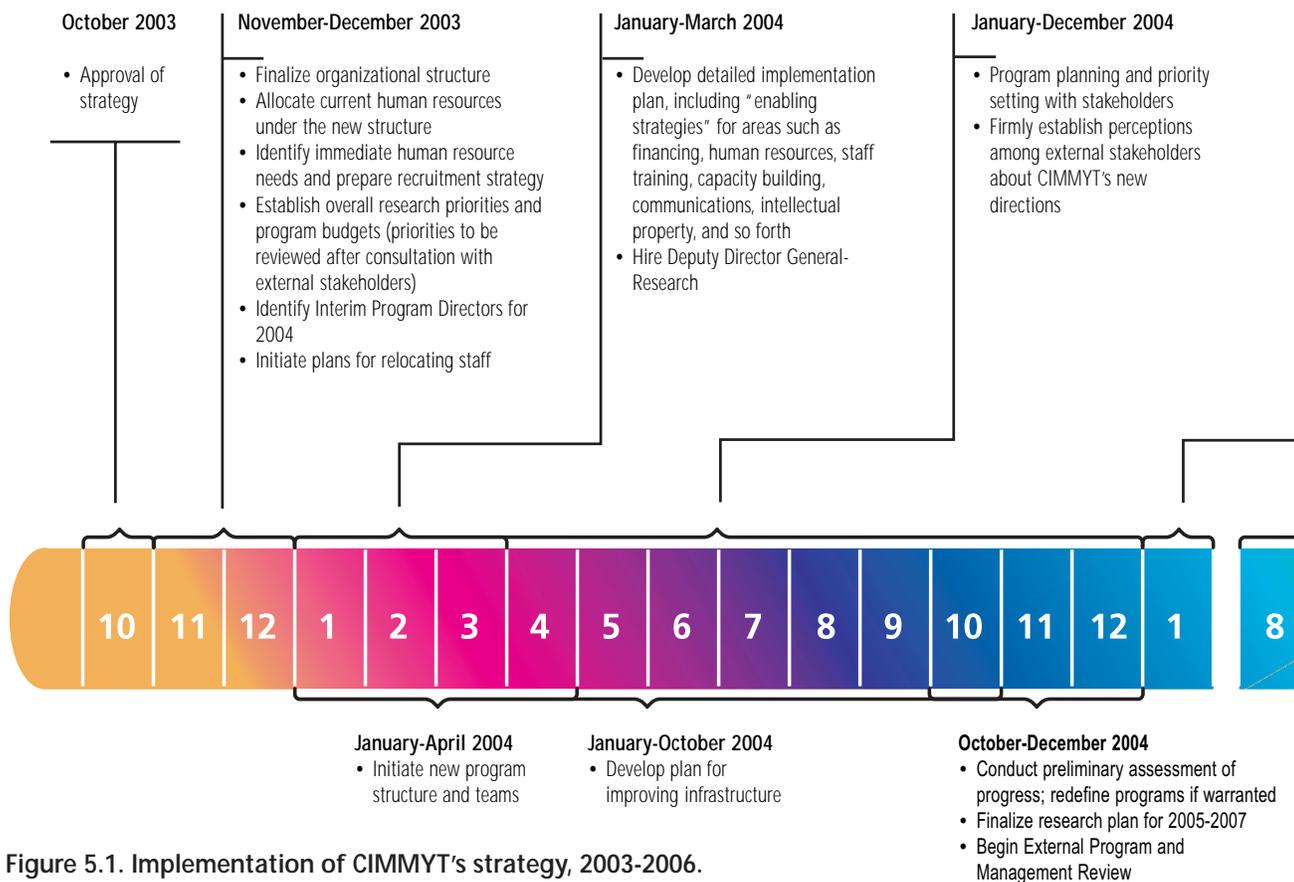
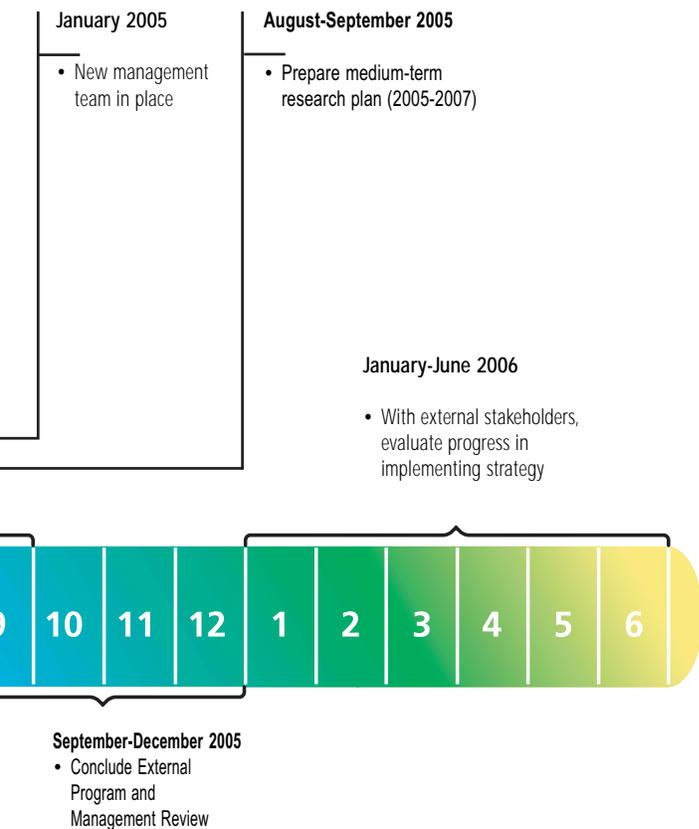


Figure 5.1. Implementation of CIMMYT's strategy, 2003-2006.

Aside from delineating the research agenda for each program over the next three to five years, the meetings with stakeholders will provide information to:

- Determine CIMMYT's overall research priorities and resource allocations, including the relative allocation of resources to maize and wheat and across regions. (Appendix 1 presents an approach for initiating the discussion of the allocations.) Current short-term projects, and the resources associated with them, will be managed under the new research programs.
- Identify which new activities and resources are required to carry out the broader research agenda.
- Identify which partners are well-positioned to undertake specific activities more efficiently or effectively than CIMMYT—information that will determine how overall goals can be accomplished collaboratively.
- Identify areas where new skills or a different disciplinary balance are needed. Adjustments in staffing will be made over the next three to five years.



## Responding to stakeholders' concerns through the new strategy

CIMMYT's external stakeholders and staff identified a number of concerns that the new strategy seeks to address. For example, CIMMYT was advised to eliminate crop and disciplinary "silos" and to emphasize systems thinking; the proposed global and eco-regional program structure aims to respond to this advice. Greater emphasis on leveraging partnerships should help to reduce concerns that CIMMYT researchers are "spread too thinly." By increasing decision-making authority in our various research locations and implementing joint priority setting with stakeholders, we should improve CIMMYT's ability to be a good collaborator and respond much more rapidly to changing local needs.

A number of stakeholders noted that insufficient funding and increased reliance on short-term, downstream projects are great handicaps for CIMMYT. These circumstances clearly are not unique to CIMMYT, as our donor stakeholders have noted, but they must be addressed. We will redouble our efforts to attract new resources, to allocate scarce resources to high-priority activities, and to use resources as efficiently as possible.

Finally, and partly as a result of the trends in research funding mentioned above, some stakeholders felt that CIMMYT had moved away from a clear focus on its mission. In developing this strategy we sought to reach consensus on CIMMYT's mission, to make our mission known widely and publicly, and to engender broad support for the research agenda that will fulfill this mission. Our success in this regard can be judged only in the years to come, as this new strategy comes into practice.

STAKEHOLDERS WOULD LIKE TO SEE CIMMYT MOVE BEYOND DISCUSSION OF NEW STRATEGIES AND TAKE THE ACTIONS NECESSARY TO REMAIN RELEVANT AND SUCCESSFUL. —SUMMARY OF MERIDIAN INSTITUTE REPORT ON STAKEHOLDERS' PERCEPTIONS OF CIMMYT

In developing the overall plan of work, CIMMYT will pay particular attention to opportunities for harmonizing its efforts with those of other CGIAR Centers.

### ■ **Developing an implementation plan**

In parallel with the planning meetings described above, CIMMYT will develop a detailed plan for implementing its strategy. One of the first priorities is to arrive at a clear definition of the program/disciplinary matrix proposed in Chapter 3. Another is to develop the “enabling strategies” that are vital to implementation. The mix of strategies remains to be determined, but it is likely that specific strategies will be needed for financing, partnerships, advocacy, intellectual property, communications, human resources, capacity building, and knowledge/information management.

As CIMMYT’s global partnership, research, and administrative agendas take shape, a team comprising the Director General, Deputy Director General for Research, and Director of Corporate Services will oversee their implementation. Program Directors will provide leadership in implementing their respective programs. As noted, we envision that groups sharing a common disciplinary focus will interact across programs. Over time they may evolve into communities of practice that extend well beyond CIMMYT’s organizational boundaries.

We will also modify management practices and improve management information systems and information and communications technology to support our new ways of working, and we will train staff in skills that are essential for implementing the new strategy. Criteria and mechanisms will be developed to evaluate the progress of individuals, teams, and CIMMYT itself in delivering on the goals we have set in developing this strategy.

### ■ **Recreating CIMMYT as an integrated network of research locations**

Changes in how CIMMYT works across research locations are also vital to implementing this strategy. The traditional hierarchy of a centralized headquarters and subsidiary regional offices is not conducive to the holistic research perspective and extensive local partnerships that CIMMYT will require to fulfill its mission. CIMMYT aspires to

function more as an integrated network of worldwide research locations, each with considerably more autonomy. In regular consultation with stakeholders, staff at these locations will develop and lead CIMMYT’s research agenda and drive its research impacts. As mentioned, the first of these local consultations will occur in 2004.

We believe strongly that basing people in the same place encourages them to work more effectively together. Staff will be grouped at any given location to create the appropriate critical mass of scientific, development, and administrative skills to better achieve our goals. These teams will act as catalysts for innovation and information sharing—locally, in the region, and throughout the world.

We will no longer base all of CIMMYT’s research directors at one headquarters location, and we expect to reinforce staffing in our Asian and African locations. We will also shift some activities to new locations; for example, some of our more advanced research initiatives will be housed in laboratories in industrialized countries. Activities that were once centralized may be distributed across locations to be made more effective, such as the development of locally adapted varieties. Other activities, such as the ex situ conservation of genetic resources and pre-breeding, will remain centralized to be efficient and effective. A given location will engage in downstream and upstream research to varying degrees, depending on local needs and circumstances, but most upstream research will be conducted through links to partner institutions. Finally, to be flexible to serve those who need CIMMYT most, the size and placement of CIMMYT’s various research locations will be dynamic.

### ■ **Measuring CIMMYT’s impact and progress towards implementing the strategy**

As CIMMYT engages in new ways of working, how do we intend to measure our impact, given that our research will become more interdisciplinary and collaborative? In the immediate term, measurable impact indicators for the respective programs will be determined as priorities are set for each program, beginning in 2004. Each program will be held accountable for performance against its own milestones on an annual basis. At the Center level, CIMMYT will plan for an overall external evaluation of progress in 2006 (allowing a two-year interval for implementation of

CIMMYT SEEKS TO FUNCTION AS AN INTEGRATED NETWORK OF WORLDWIDE RESEARCH LOCATIONS. TEAMS IN THESE LOCATIONS WILL ACT AS CATALYSTS FOR INNOVATION AND INFORMATION SHARING—LOCALLY, IN THE REGION, AND THROUGHOUT THE WORLD.

the strategy). The evaluation will gather external and internal stakeholders' perceptions and compare these with the corresponding surveys that formed the analytical foundations of this strategy (Box 1.1, p. 3).

In particular, the evaluation will assess the extent of progress towards the following goals:

- An increased focus on poverty reduction and natural resource conservation in our research, framed in the context of sustainable livelihoods.
- The use of more consultative approaches and strategic partnerships to develop and execute the research agenda, including the use of new approaches to knowledge sharing.
- A more effective alignment of financial and human resources in support of our research agenda.

By holding ourselves accountable to these goals, we will ensure that the philosophy of this strategy is translated into new practices with tangible results. Evaluation will also highlight areas where the implementation of the strategy needs fine-tuning or strengthening, as well as areas where new information or changes in the external environment suggest that the strategy itself may need adjustments.

At a more general level, impact studies will extend well beyond current analyses to measure multiple effects of the work of multiple partners on food security, livelihoods, incomes, and the environment. We recognize that these impacts are not easy to measure, especially in the short term. Despite the numerous conceptual and practical

challenges involved in assessing these kinds of impacts, however, this activity is essential for assessing CIMMYT's progress in achieving its mission. We will maintain rigorous guidelines for impact assessment, and we will incorporate these guidelines into every program. We will continue to invest and collaborate in developing methods. By institutionalizing impact assessment in this way, CIMMYT will generate the objective feedback needed for effective self-assessment and accountability, expand the knowledge base for impact assessment, promote a strong impact assessment culture throughout the Center, and strengthen our ability to become a true learning organization.

### ■ **Accountability and governance**

Impact studies provide some indication of the value of investing in CIMMYT to meet research and development goals, but they do not provide an idea of the day-to-day effectiveness of CIMMYT's science or the probity of its management. Several external and internal mechanisms help ensure that CIMMYT acts with integrity and efficiency to fulfill its responsibilities to those it serves and those who fund it. For example, CIMMYT benefits from regular public assessments mandated by the CGIAR, which also establishes a peer review mechanism to facilitate self-assessment by each Center.

CIMMYT's Board of Trustees will remain the link between external and internal processes for ensuring sound management and outstanding performance at CIMMYT. The Board is the ultimate architect and arbiter of CIMMYT's research and management strategies and policies, as well as of management's performance in carrying out those policies.

Internally, CIMMYT's research and management are monitored and evaluated by its research and administrative management teams. In addition, independently of the CGIAR, CIMMYT commissions reviews on issues of concern to the Center. It also provides scientific and financial information to funding organizations and undergoes periodic reviews. An important accountability check in the short term will be the External Program and Management Review of CIMMYT, which is currently planned to begin in late 2004.

CIMMYT is party to a number of legal agreements, including conventions such as the International Treaty on Plant Genetic Resources for Food and Agriculture as well as licensing agreements and other contractual relationships, which are overseen by CIMMYT's legal counsel. The maintenance of a strong, independent legal office is absolutely essential to preserving CIMMYT's integrity and effectiveness as a public research organization.

Beyond formal reports, reviews, and contracts, however, scientific accountability within CIMMYT depends considerably upon achieving teams that work productively together and with external partners. These groups will be self-regulating and reflective, and they will be empowered through multi-source assessment to review the way CIMMYT's programs are managed and conducted. Program activities will be aligned clearly with resource availability and output and impact productivity. The allocation of operating budgets between and within programs will serve as an additional and clear means of rewarding excellence. The Deputy Director General for Research will ensure effective cross-program and external interaction and collaboration.

### ■ Financing the research agenda

Funding was a key concern raised by many of the stakeholders consulted in developing this strategy. A number of stakeholders mentioned the greatly expanding agenda for international agricultural research and the need to show impact in different ways—for example, not in simple terms of rising yields per unit of land, but in measurable improvements in livelihoods and the quality of the natural resource base. Stakeholders also mentioned the rising cost of research, especially with respect to biotechnology. They asked if CIMMYT would be able to fund its research program adequately.

As mentioned earlier, the ambitious research agenda presented here represents the full spectrum of research that will enable CIMMYT to fulfill its mission. Specific elements of the agenda may change upon further consultation with our stakeholders, but when it is fully defined, with clearly identified priorities, we will know

whether the most urgent priorities are supported by current funding, and we will also know which activities should be suspended—either immediately, or if the financial situation should become more difficult. With this information, we will develop a focused strategy to finance the elements of our research agenda, based on their relative importance to our stakeholders. This strategy will be closely supported by public awareness and communications efforts.

Our fundraising will manifest the same qualities of partnership that will define our research. Collaborative priority setting will be followed by collaborative project development that includes roles and resources for each partner. Project development will increasingly be done on a regional or bilateral basis under the aegis of the eco-regional programs, which will have greater familiarity with grass-roots organizations and local donor priorities. We will explore opportunities to link maize and wheat research and technology development projects with other rural development activities financed by donor agencies. Wherever possible, we will link with other CGIAR Centers. We will continue to communicate closely with CGIAR donors to identify and encourage shared priorities.

Although much can be done through individual projects, they rarely offer stable resources to support core activities and explore new ones over the long term. Three additional sources of support seem worth exploring to expand our resource base:

- Pursuing new public-sector funding from non-ODA windows, in collaboration with local partners (e.g., science and technology or agricultural development funding, in conjunction with national counterparts from developed and developing countries).
- Seeking stronger support from the private sector (both financial and in-kind through staff secondments, access to private-sector research infrastructure and/or products).
- Mounting a philanthropic major gifts campaign at the global level to establish an endowment for international public goods research for agricultural and technology development (preferably with other CGIAR Centers).

CIMMYT NEEDS A STRONG, CLEAR UNDERSTANDING OF HOW A LEARNING AND KNOWLEDGE CULTURE IS DIRECTLY TIED TO ITS MISSION, INSPIRES SUPERIOR PERFORMANCE, AND IS A SOURCE OF ITS STRENGTH AS AN ORGANIZATION.

Each of these alternatives represents a different challenge, from negotiating potential conflicts of interest to making a significant investment in time and resources. On the other hand, the need for a stable financial base will only intensify. If we must expand our resource base, we are well advised to start sooner rather than later.

### ■ The learning organization: Anticipating and adapting to change

Previous chapters have described the increasingly complex challenges involved in fostering sustainable livelihoods for the poor, the shifting configuration of actors and “rules of engagement,” and the new tools that may accelerate the pace of scientific breakthroughs. The world that CIMMYT entered in 1966 is not the world in which it lives today, and we have little reason to expect that this strategy will be a flawless guide to the future. At most, it can articulate the vision and principles that will inform our choices in the years to come. Almost as soon as the ink is dry, a key assumption may change dramatically.

How should CIMMYT plan for a future of constant and unpredictable change? The only solution is to practice the principles of continual organizational learning. First, even though we will hold ourselves accountable to the elements of this strategy, we will regularly evaluate—along with our stakeholders—the validity of our operating premises (for example, the role of maize and wheat in the livelihoods of the poor, our particular areas of expertise and those of our partners, and the state of science). The important goal is not to have a “Strategic Plan,” but rather to engage in a permanent *process* of strategic planning. (Approaches such as scenario planning, which we undertook in developing the current strategy, may become a standard feature in future planning efforts.)

Second, we are committed to furthering an organizational culture, structure, management style, and performance incentives to stimulate the acquisition, sharing, and evaluation of knowledge. Learning must be everybody's business. We will need a strong, clear understanding of how a learning and knowledge culture is directly tied to our mission, inspires superior performance, and is the source of our strength as an organization. Staff training to build skills in participatory planning and evaluation, in teamwork—working across disciplines, cultures, and organizational boundaries—and in continual self-reflective learning at individual, team and organizational levels, will be important to make these concepts a reality.

Finally, if we wish to be a true learning organization, we must be self-critical, willing to acknowledge and learn from our shortcomings, and be self-correcting. We must continually evaluate not only the usefulness of our technologies, but the robustness of our paradigms. This plan already represents a significant paradigm shift, in moving away from a crop and technology focus to a people-centered livelihoods focus, and from a linear understanding of technology dissemination to a non-linear understanding of how farmers innovate and systems change. No doubt more revolutions in our thinking await us. Open and wide-ranging dialogue with our allies and critics will be essential to ensuring that CIMMYT continues to tackle difficult questions in new and creative ways.

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# Appendix 1

## A STARTING POINT FOR ADDRESSING RESEARCH RESOURCE ALLOCATION

How should CIMMYT allocate its resources between crops and among regions, taking poverty and other factors into account? Should the pattern of resource allocation change in future? Who are the alternative suppliers of CIMMYT's products and services, and how should their activities influence CIMMYT's research planning?

A simple congruency model, such as CIMMYT's Resource Allocation Tool (RAT), can serve as a starting point for addressing these often complex questions. Like most congruency models, the CIMMYT model is grounded in the assumption that resources should be allocated across research activities in proportion to the likely value of the research output that will be generated by investing in each activity. If this cannot be reliably estimated, an alternative approach is to allocate resources to different research activities in proportion to the importance of the target areas or "needs" represented by each activity.

The RAT takes as its starting point the distribution of maize and wheat consumption in the developing world. Actual consumption data for the year 2000 are used for the baseline runs. Projected consumption data for 2020 can be substituted to obtain a picture of how CIMMYT's priorities are likely to change over the short- to medium-term. The model uses consumption data rather than production data, in recognition of the fact that a significant proportion of the maize and wheat consumed by the poor in developing countries is not produced domestically but imported.

An important feature of the RAT—one designed to make it more relevant for making strategic resource allocation decisions—is that the maize and wheat consumption data are modified by the application of weighted indices reflecting factors of importance to CIMMYT's mission.

These indices were constructed at the country level to account for three factors: the importance of maize and wheat in human livelihoods; the incidence of poverty; and the presence of alternative suppliers of CIMMYT's goods and services. In addition to these indices, the RAT incorporates a set of variables that allow sensitivity analysis to be performed on four factors of interest:

1. **Maize : wheat price ratio.** The RAT analysis can be conducted in terms of physical units of maize and wheat consumption, or in terms of the value of maize and wheat consumption. Sound arguments can be made to justify either approach. If the analysis is conducted in terms of value, however, it is necessary to assign prices to maize and wheat. Ideally, local consumer prices would be used, but since these are not available for all countries, the RAT analysis is based on international reference prices for maize and wheat. Since international reference prices change through time, a variable has been incorporated to allow changes in the ratio of maize to wheat prices.
2. **Food vs. feed use of maize and wheat.** Given CIMMYT's mission to serve the poorest of the poor, it can be argued that maize and wheat destined for human consumption (food use) should be assigned higher priority than maize and wheat destined to be fed to animals (feed use).

3. **Overlaps in CGIAR mandates.** CIMMYT's global mandate to conduct research on maize and wheat overlaps with the regional mandates of two other CGIAR Centers, IITA and ICARDA. Variables have been incorporated in the RAT to allow discounts to be applied to maize consumed in West and Central Africa and to wheat consumed in CWANA region.
4. **Potential for spillovers.** Brazil, China, and India are clearly important partners for CIMMYT, and our investment in research targeted at their needs comprises a significant part of CIMMYT's overall portfolio. However, since the potential for capturing research spillovers is much larger in these three countries than in all other countries, it would not be rational for CIMMYT to invest in the needs of these three countries at the same level of intensity as we invest in the needs of other countries. For this reason, a variable has been incorporated in the RAT that allows a discount to be applied to maize and wheat consumed in Brazil, China, and India.

Using the assumption that the allocation of CIMMYT's resources should be roughly congruent with the importance of maize and wheat in the livelihoods of the poor, the weighted distribution of maize and wheat consumption generated by the RAT provides guidelines that can be used in deciding the allocation of CIMMYT's resources between crops and across regions as we move towards 2020.

It is important to stress that guidelines derived from the RAT are not strict resource allocation parameters. The actual allocation of resources will depend on at least two additional considerations.

1. **Research efficiency.** To say that a certain proportion of CIMMYT's resources should be allocated to research for a specific region is not to say that the same proportion of CIMMYT's resources should be allocated *within* that region. For efficiency, often it will make sense to conduct research for a specific region elsewhere. A good example is the Mexico-based breeding program for wheat improvement. Although the breeding work takes place in Mexico, products have been successfully transferred to many other regions, including Asia, CWANA, Sub-Saharan Africa, and South America.
2. **Availability of funding.** To say that a certain proportion of CIMMYT's resources should be allocated to research on a specific crop or for a specific region does not mean that funding will be available for that purpose. If CIMMYT were funded entirely through core funds, the flexibility to change research resource allocations would be far greater. As most of CIMMYT's resources consist of funds provided for specific uses, CIMMYT's ability to shift resources is constrained. For this reason, it is unlikely that the allocation of resources will match the targets generated by the RAT. The RAT can, however, serve as a means for CIMMYT to anticipate research needs and make its case to funding agencies accordingly.

# Appendix 2

## APPROACHES AND TOOLS TO ACCELERATE IMPROVEMENTS IN THE LIVELIHOODS OF MAIZE AND WHEAT FARMERS AND CONSUMERS

This appendix provides detail on new approaches for making the science of CIMMYT and its partners more effective. We focus on here on approaches to help CIMMYT achieve its scientific goals, and capacity building to extend scientific innovation and impact. A third domain of new work—global advocacy for sustainable agricultural development interventions—was described in Chapter 4.

Before we describe these new approaches, three points are worth emphasizing. First, readers should not assume that all of the scientific approaches described here have priority over current approaches. Many are simply new tools that will complement and extend CIMMYT's expertise, especially its core proficiency in plant breeding. In several cases, these tools will not be developed or even applied by CIMMYT itself, but they will be needed to make our work more efficient.

Second, although CIMMYT's new strategy places considerable emphasis on applied research, strategic research, such as the current effort to develop apomictic maize (maize plants that produce clones of themselves), will remain an important part of our portfolio.

Third, like CIMMYT's renewed commitment to advocacy, its commitment to capacity building will restore effectiveness and visibility to an area of work that stakeholders have counseled us to strengthen. As such, it represents an important "new" undertaking for CIMMYT.

### ■ Breeding approaches appropriate for resource-poor farmers

CIMMYT has an important role to play in developing and advocating farmer-oriented plant breeding and seed dissemination approaches. Current approaches in developing countries often have been adopted from temperate areas in industrialized countries, which have frequently tended to focus on developing varieties under agronomically ideal conditions. Breeding programs in some industrialized countries have since questioned this approach, which is even less suited to breeding programs in some developing

countries, where the ideal conditions of the research station have very little in common with the environment in which poor farmers raise their crops. Over the past two decades, CIMMYT has developed and helped others to implement alternative maize and wheat breeding approaches that systematically improve tolerance to abiotic stresses so varieties are more resilient under farmers' conditions. Varieties must also satisfy farmers' criteria for what is a "good" variety. Models for participatory breeding and variety selection have enabled small-scale farmers to provide information for setting breeding priorities and developing varieties that meet their specific needs. These approaches have also given farmers better information on varieties to make informed choices.

Breeding programs in developing countries also have far fewer resources than breeding programs in industrialized countries. How can scarce resources be used effectively to make an impact in breeding for extremely difficult target 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 of limited resources by bringing together innovative partners from a range of organizations to use new approaches to breeding and seed dissemination.

Although CIMMYT has made considerable progress in collaboratively developing varieties that match poor farmers' conditions and preferences, the next challenge is to refine and institutionalize these approaches. The world has a wealth of knowledge on crops under ideal conditions but less on crops under stress, and breeders have only just begun to exploit genetic variation for abiotic stress tolerance. Too many breeding programs in developing countries still work at a remove from farmers' conditions, and many varieties are still released on the basis of trials conducted under ideal agronomic management. A large number of farmers still lack access to improved seed or use outdated improved varieties. Most

of all, in an environment that currently favors purely individual (e.g., proprietary) or national approaches to these problems, opportunities for collaboration may be overlooked. 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.

#### **Targeted traits for future genetic improvement.**

Throughout this document, we have emphasized the importance of continued research that improves the tolerance of maize and wheat varieties to a variety of stresses—insects and plant diseases, low and irregular water availability, and poor soil fertility. We will also pay increasing attention to consumers' needs for improved grain quality. Given the realities of globalization, more farmers will need to meet the high standards set by industrial manufacturers if they are to earn income from their maize and wheat crops. CIMMYT has an important role to play in providing the value-added traits that will enable greater numbers of farmers to benefit from meeting those standards (e.g., improved micronutrient and protein content, improved quality for specialized food and feed products). Traits that contribute to improved grain storage will also increase in importance as larger numbers of farmers seek to market their produce.

### **■ Biotechnology tools to unlock and leverage genetic potential**

Biotechnology is a broad field of science, ranging from techniques such as tissue culture and embryo rescue, to more recent advances in structural and functional genomics and genetic engineering. The management and use of genetic resources is already being augmented through molecular fingerprinting, and the efficiency of plant breeding is already being enhanced by marker-assisted selection (MAS). Although MAS is the most relevant biotechnology application to plant breeding at CIMMYT, effective MAS results from a growing body of information from large-scale fingerprinting, mapping, and functional genomics, which provides a more comprehensive understanding of the genes and pathways that contribute to desirable phenotypes.

**Molecular fingerprinting.** Important applications of fingerprinting for CIMMYT—and the CGIAR Challenge Program on Genetic Resources—include improved management of genetic resources in CIMMYT's 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) may provide better discrimination among maize and wheat genetic resources. In addition, the application of functional genomics to genetic resources may provide more detailed analysis of potentially useful genes for breeding programs. CIMMYT must determine whether to acquire or outsource fingerprinting and must also develop database systems to provide this molecular information to scientists around the world.

**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 to map specific genes and genomic segments responsible for particular phenotypes. The need for mapping is changing with the prospects of functional genomic approaches to directly identify the gene(s) involved in a particular phenotype. Mapping will probably remain important for several years to come, however, as a method 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 will be useful in mapping studies, and it must determine whether to analyze them in-house or through partnerships.

**Marker-assisted selection (MAS).** Perhaps the most promising application of molecular genetics to breeding is the use of molecular markers as indirect selection tools. Once a trait is dissected into its genetic components and we have identified markers that are linked to each of the contributing genetic loci, the markers can be used to select for the genes (and thus overall the trait) using a relatively simple laboratory procedure. This process may reduce costly field analyses (including plant phenotyping), allow germplasm to be screened early in the growth cycle, screen for traits that would not otherwise be detectable in a given

location, and select for several traits at once. CIMMYT will maintain and build its capabilities in this area. A major issue for future resource allocation is that CIMMYT will require a high-throughput laboratory for routine analysis of markers, along with information systems that provide results rapidly to researchers. Efforts 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 increase efficiency of the identification of linked markers, as they will allow linked markers identified in one crop to be used in others as well. Furthermore, advances in genomics will allow the simultaneous identification of many traits (and markers) for MAS.

**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 (see the section on bioinformatics, p.51). Aside from the innovations emerging 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, a great deal 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, and has initiated discussion on a similar project for wheat.

One of CIMMYT's primary contributions to advancing genomics research will be to continue providing key maize and wheat segregating populations and lines that represent extremes in phenotypic expression of important stress-related traits, such as tolerance to drought, nitrogen-deficient soils, and acidic soils and resistance to ear rots, rusts, stem borers, and storage pests. Another important contribution will be to continue providing molecular maps with genes and genetic regions (quantitative trait loci or QTLs) identified for tolerance/resistance to these stresses. By combining the genetic resources and trait knowledge available at CIMMYT with genomic tools and knowledge in the public and private sector, CIMMYT will be able to identify key genes responsible for important traits, use this information in its breeding programs, and provide it to partners.

**Gene discovery for pre-breeding research.** The promise behind pre-breeding research is simple but challenging to fulfill: to identify the gene or gene complex that confers the disease resistance, micronutrient content, input-use efficiency, or other characteristic of value to a breeding program, and make it available in a form that is easy for breeding programs to use. The efficacy of pre-breeding research is measured in the successful expression of newly identified and transferred traits of value in locally adapted, finished varieties. CIMMYT's pre-breeding research will be made more effective by merging the operations of CIMMYT's genebank—including the collection, characterization, and regeneration of genetic resources—with all of its pre-breeding research into an applied genetic resources approach that takes much greater advantage of new science. CIMMYT will interact closely with plant breeders, both within and outside CIMMYT, in setting priorities for pre-breeding research and evaluating the utility of pre-breeding products. The value of collaboration with a range of partners in this effort cannot be underestimated, especially as more tools become available.

**Genetic engineering.** The ability to modify specific genes in a genome or to introduce an entirely novel gene is an important tool for producing knowledge about gene expression and physiological processes. This approach has been adapted to investigate potential genes for enhancing drought tolerance and disease resistance in bread wheat. Genetic engineering can also provide completely new products for farmers. Its use is most powerful and critical in developing varieties with traits that exhibit an insufficient range of genetic diversity within the species, as appears to be the case for such nutritional traits as beta-carotenoid (vitamin A precursor) content in wheat, and iron and zinc content in maize.

### ■ Crop information systems to amplify the power of genetic research

New fields of molecular biology, particularly functional and comparative genomics, will contribute to food security only if genotypes are intimately linked to phenotypes for accurately catalogued germplasm. The CGIAR Centers and national agricultural research systems

are rich in phenotypic information. In fact, this information and its collection of genetic resources are arguably CIMMYT's 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. To do so, CIMMYT 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.

Specific components of the proposed venture in information management include a genebank management system (including molecular maps and plant pedigrees), GIS, bioinformatics, and data management systems related to GxE interactions. The goal is to permit information contained in each of these subsystems to be linked, permitting powerful new insights into the relationships between genes, environment, and the productivity of crops and agricultural systems.

***Geographic information systems and remote sensing.*** Ever-increasing availability of spatial data is going to have an enormous influence on CIMMYT for adoption and impact assessment; decision-making; improving research efficiency; communication and diffusion; information management; and technology targeting.

Geo-databases will be accessed through a variety of applications, complex and simple. At the complex end of the spectrum, there will be improvements in the ability to model and simulate complex spatial phenomena by incorporating higher resolution and real-time inputs, along with more sophisticated geo-statistical tools. At the simple end, it is likely that there will be an explosion in interfaces that permit "spatial browsing" by an ever-increasing number of end users. It is entirely possible that spatial technology will become so ubiquitous and embedded in so many new applications that it will no longer be distinguishable as a separate entity.

Developments in three major areas are of particular interest for CIMMYT: global positioning system (GPS) technology, high-resolution imagery and satellite sensors, and timely (real-time) data provision. GPS technology, combined with mobile computing devices, will have a huge impact on field data collection. Direct transfer from mobile field devices into centralized geo-databases is also likely to become standard. Rapid advances in remote sensing technologies are likely to continue. Second-generation QuickBird and IKONOS satellites to be launched within the next two years will bring spatial resolutions down to 50 cm or less. Hyperspectral and radar sensors are likely to develop further and provide many opportunities for agricultural applications, such as monitoring soil moisture, tillage practices, leaf water content, chlorophyll, soil salinity, and plant conditions and diseases. The volume and quality of remote sensing data will probably increase, and costs will probably decrease. Remotely sensed crop monitoring is likely to replace conventional agricultural censuses. Early warning systems for food security threats (e.g., drought, diseases) should become more widespread and precise.

***Bioinformatics.*** Bioinformatics can be broadly defined as tools that manage, analyze, and interpret biological data, i.e., tools that acquire, store, query, analyze, and visualize. The application of bioinformatics to structural and functional genomic data has pushed bioinformatics to the forefront of the interface of computer science, biology, and mathematics. Prior to development of genomic technologies, for example, there was little need for large databases that stored a single kind of data (e.g., mRNA arrays). With the development of these large databases, research is needed on the most efficient methods for integrating this functional genomics data with structural genomics data found in public repositories such as Genbank. There is a further need to integrate structural genomics data with germplasm and breeding databases.

CIMMYT has made only minor investments in bioinformatics to date. Given the large investment USDA is making to develop genetic databases for the major crops, including maize and wheat, CIMMYT need not develop similar systems, but it will need to link to them. CIMMYT's investment in systems to handle genomic data is even more limited. A comprehensive and integrated system will be needed to manage future genomic data, whether

produced at CIMMYT or by its partners. The platform will require links to a number of crop information systems, genebank systems, breeding simulation software, and the genetic databases mentioned above.

***Understanding complex genotype-environment (GxE) interactions.*** A better understanding of complex GxE interactions is needed for developing system-based solutions to farmers' problems. The use of international trials, coupled with more sophisticated statistical analyses of international trials data, remote sensing, crop modeling, GIS, and improvements in CIMMYT's field trials (Box A.1, p. 56), will open the way for much more precise development of varieties and crop management options (such as conservation agriculture) that work well together in specific target environments to improve the sustainability of agriculture.

CIMMYT's extensive partnerships make it possible to quantify GxE interactions by conducting experiments at agronomically representative sites worldwide. The knowledge acquired through this research is directly relevant to farmers' conditions. For example, these partnerships facilitate a better understanding of how certain traits overcome yield barriers (e.g., the mechanisms associated with drought resistance in maize; the advantages possessed by bread wheats developed from wild grasses).

Although GxE interactions are so dynamic that it has been difficult to locate and quantify losses associated with biotic stresses with much precision, new approaches and tools are providing useful information. With data on the performance of individual varieties in representative on-farm sites over a range of agro-ecologies, GIS can provide valuable predictive information on the locations where a given variety is most suited and which resistance traits it should carry to ensure high, stable grain production. With this information in hand, scientists can identify locations where pressure from these stresses is extremely high, and they can predict shifts in pest and disease incidence associated with climate change. The identification of these hot spots will also facilitate the search for resistance alleles within CIMMYT's genebank accessions. It may be essential to expand our partnerships to test germplasm in these key "hot spot" locations—which may not necessarily be where the poorest people live, but where a certain stress is most destructive and we can learn the most about it.

## ■ Biophysical systems research

***Soil and root health research.*** The intensification of agricultural production, particularly in marginal cropping systems based on monoculture, has often disturbed the soil ecological and structural balance. As a result, significant biotic soil-borne constraints can arise, including microscopic nematodes and root-rotting fungi. These pathogens, especially in combination with drought and micronutrient deficiencies, can reduce yields by as much as 60%. Scientists and farmers in many parts of the world are not even aware that these problems exist, despite their magnitude.

CIMMYT will devote considerable attention to these "underground problems" in the years to come. Research will be highly systems-oriented and interdisciplinary. New technologies, particularly in molecular biology, will enhance our understanding and clarify the importance of factors affecting soil health, plant productivity, and ultimately the long-term environmental sustainability of cropping systems. 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 has been found for many of these constraints, and CIMMYT has obtained molecular markers for these traits through partnerships with advanced research institutes. In the future, genetic engineering (based on a better understanding of gene function) may play a major role in developing resistant varieties.

Emphasis will also be given to studying the underlying effects of crop management on soil health, thereby improving our understanding of which cropping practices (including diversification, rotations, and soil management) are most appropriate for maintaining healthy soils for healthy plants. Particular attention will be given to assessing and maintaining soil health under zero tillage to ensure that this resource-conserving practice remains viable over the long term.

***Extending the use of conservation agriculture.*** Conservation agriculture is a suite of technologies, including the retention of crop residues as mulch on the soil, direct seeding without tillage, crop rotations, and in some cases green manure cover crops. Over 70 million

## Improving the efficiency of field research

To maintain an enduring strength in plant breeding, CIMMYT continually improves the efficiency and value of its field research. We will be rigorous in how we design and conduct field experiments, choose among breeding methodologies, handle the resulting data, and manage our experiment stations in general.

More powerful statistical tools are expected to 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.

To reduce the effect of soil variability in field trials, CIMMYT may conduct micro-level soil analyses at selected sites and adopt precision farming protocols in conjunction with GIS tools. Better knowledge of complex stresses found in farmer's fields or storage facilities, and the ability to simulate them faithfully on experiment stations, will increase the effectiveness of our work and its direct relevance to farmers' conditions.

hectares are under conservation agriculture around the world, largely in the Americas and Australia. The principles of conservation agriculture appear to have extremely wide applicability, spanning a range of elevations, latitudes, soil types, and rainfall regimes. The technology may be adapted to cereals, oilseeds, pulses, and even cassava and potatoes (although harvesting causes soil movement). The principles and benefits of conservation agriculture are independent of scale, although the practices and limitations to implementation are very different on small farms, especially with respect to mulch (many small-scale farmers use crop residues for animal feed), seeding equipment (generally uninteresting to large-scale manufacturers), and input and credit systems.

This agricultural revolution has spread through farmers rather than the research establishment, and the greatest impediment to its further spread remains the mindset of scientists and farmers steeped in the tradition of tillage-based agriculture. Conventional research systems, which rely on developing technological components and delivering them to farmers, are not suited to working on conservation agriculture. In addition to being very site-specific, the practices involve many components and considerable changes in the way farmers manage their agricultural systems. Innovation systems focused on innovative farmers are required, in which multiple stakeholders with different specialties and knowledge interact.

However, innovation systems do not develop spontaneously – they need a catalyst to bring stakeholders together. CIMMYT will continue to interact with conservation agriculture networks and farmers' associations and use its expertise to catalyze innovation systems in the poorer rural populations where it operates. In this process, research does not necessarily provide technology; it acts as an integrator to help solve problems emerging within the new system. CIMMYT can facilitate the exchange of information on small equipment and its local adaptation and manufacture, and use its experience in developing input supply systems to improve the provision of specialized inputs for conservation agriculture. Through research on GxE interactions and soil and root health, CIMMYT can also provide component technologies and knowledge relevant to conservation agriculture systems.

### ***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 closely linked with river basin models, e.g., to immediately determine the consequences of plot-level water savings on water balances at the river basin level. Information technology will facilitate the sharing of information on “what works, where, and why.” Geographic information systems will become seamlessly linked to simulation models to guide the development and diffusion of new technologies on a wider scale. The new science of innovation systems will help integrate the efforts of different stakeholders to more effectively deal with productivity and sustainability improvements through improvements in natural resource management.

### **■ New directions and methods in social science research**

CIMMYT will use a wider spectrum of methods and tools from the social sciences to benefit from alternative ways of understanding technical innovation and identify new strategies for addressing the complex needs of the poor. One area in which social science methods and perspectives

will play an increasingly important role is 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 not explicit or easily articulated. It is embedded in modes of social organization, customs, and people’s minds, and it 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 will become a greater priority for CIMMYT, which offers a unique vantage point for examining factors that affect the productivity of maize- and wheat-based farming systems in developing countries. Policy analysis could have a significant influence in shaping policy decisions affecting the maize and wheat sectors in developing countries. CIMMYT is particularly well positioned to analyze these factors, diagnose constraints to technical change, and prescribe policy interventions to overcome them.

### **■ Building capacity through a strong learning and mentoring service**

To extend the impact of its work, CIMMYT will establish a strong service to build human capital among research partners, rural communities, and our own staff. This learning and mentoring service will empower people to develop, deliver, and use information and products that provide new options for research or livelihoods. As part of CIMMYT’s approach to managing innovation and knowledge more effectively (see Chapter 4), this service will:

- Coordinate, support, and innovate in 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.

This service will operate from a location that benefits from excellent information and communications technology and support, including advanced scientific information search and retrieval facilities as well as writing and publishing capacity. Courses and other learning opportunities will be offered wherever resources are available for participants to achieve their learning objectives.

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.

Much of the information gathered in developing this strategic plan indicates that CIMMYT must work more closely with others to provide more learning opportunities in support of scientists in national research systems. CIMMYT must also seek new ways to reach farm households and local networks that have limited access to information and alternatives for improving agriculture.

Because learning needs will vary greatly, CIMMYT will place greater emphasis on flexible combinations of short courses that can be locally adapted and taught. With other CGIAR Centers, we 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.

## Acronyms and abbreviations

CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CONDESAN	Consorcio para el Desarrollo de la Ecorregión Andina
CSO	Civil society organization
GIS	Geographic information system
GPS	Global positioning system
GxE	Genotype by environment
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Center for Research in the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IPGRI	International Plant Genetic Resources Institute
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
MAS	Marker-assisted selection
NGO	Non-governmental organization
RAT	Resource allocation tool
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture