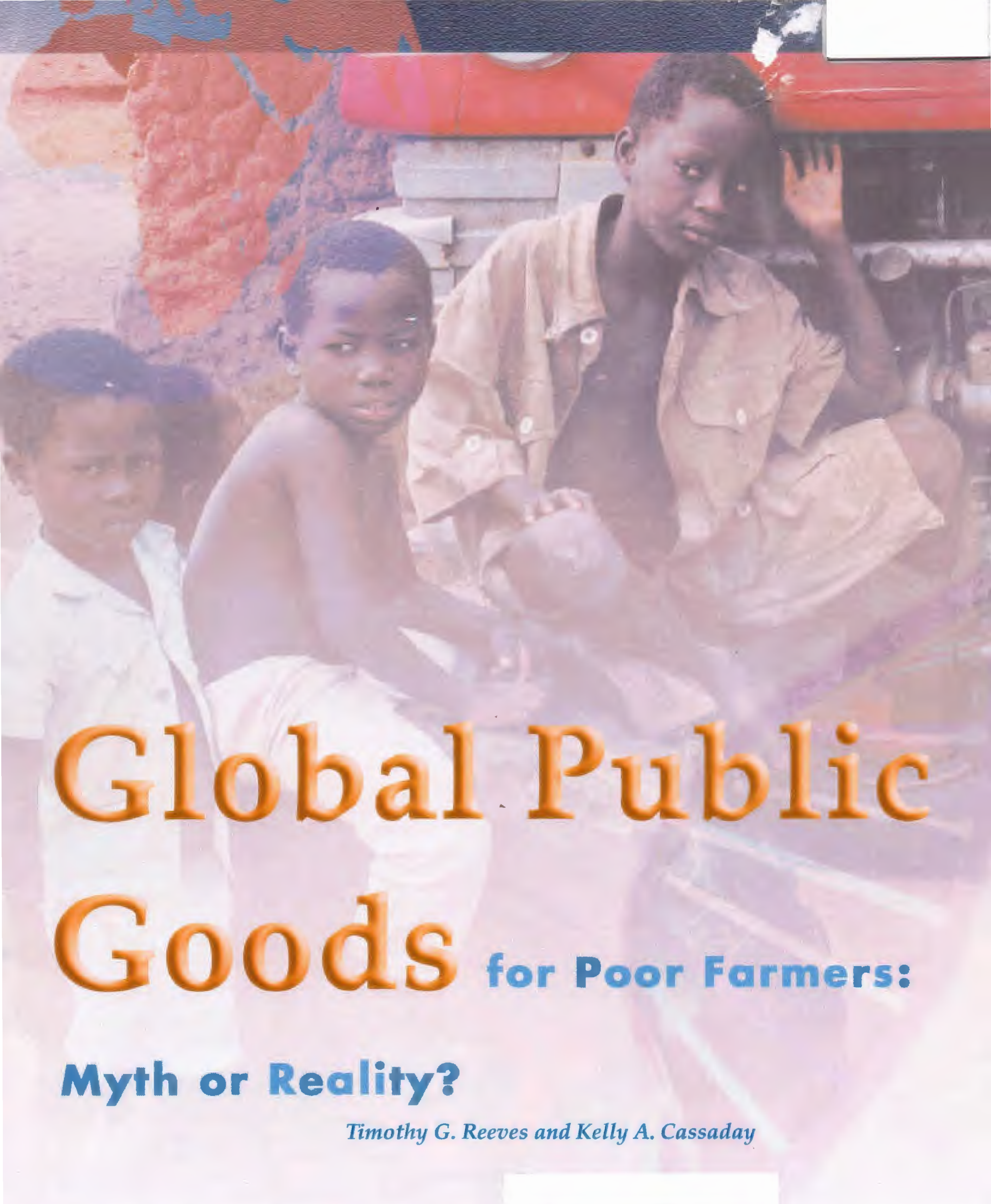

Global Public Goods for Poor Farmers:

Myth or Reality?

Timothy G. Reeves and Kelly A. Cassaday

CIMMYT

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Are Global Public Goods a Vanishing Commodity?

At the start of a new century, the international agricultural research and development community is undergoing a transformation. Powerful forces are acting to expand research opportunities as never before, but at the same time they seem to have raised barriers to research that are greater than any that have been seen in the past. For many years, international agricultural research organizations have worked very effectively to improve the lives of poor people in developing countries. As research funding diminishes, and as quiet scientific controversies become incendiary public debates over patenting life forms and rights to genetic resources, many are questioning how much longer international agricultural research can continue to help poor people. International agricultural research has provided improved seed, better agricultural practices, and information that have helped poor people immeasurably, but the rules of research are changing. Will the new rules transform these so-called "global public goods" into vanishing commodities, or into commodities that poor people cannot hope to access? That is the central question explored in this paper.

The vast majority of the world's poorest farmers still produce crops using farm-saved seed and traditional crop management practices that have been passed down from generation to generation. These can be regarded as a form of "global public goods." Before we discuss why global public goods are important for the world's poor people, and whether developing countries will have access to them ten or twenty years from now, it is useful to explain what we mean by "public goods" and describe some of the problems associated with providing them.

The Potential and Problems of Public Goods

Economists have strict definitions of public goods, but for our purposes it is probably sufficient to describe a public good as a product or service that is easily accessible to all people (it is difficult to exclude anyone from using it) and that can be used by many people at the same time (its use by one person does not preclude its use by any other person). Because the degree of accessibility and the degree of nonrivalry can vary, some public goods are more "pure" than others, but for simplicity we will ignore this distinction. In agriculture, examples of public goods include a high-yielding wheat variety, a labor-saving conservation tillage practice, a market information program broadcast over the radio, and public research in general (Winkelmann 1994)—in fact any nonproprietary technology that is freely available to large numbers of people at little or no cost.

Although they may be highly desirable, public goods are not readily produced by profit-oriented private firms, because it is difficult for the producer of a public good to capture enough benefits to compensate the cost of production. To avert so-called "market failure," governments usually provide public goods because it is agreed to be in the interest of society. The Government of India has invested heavily in agricultural research and extension, for example, to improve agricultural production and eliminate the famines that once ravaged the subcontinent. The government stepped in for a number of reasons, including the fact that private companies lack incentives to invest in a large research and development system to produce improved crop varieties that many farmers are too poor to buy. Even if most Indian farmers could afford to buy improved seed, many may choose not to, since they can easily acquire a small supply from a friend or neighbor and multiply it up on their own. Private firms are understandably reluctant to invest in the provision of products or services from which many individuals can be expected to benefit without helping to pay for the cost (a problem that economists term "free riding").

In summary, public goods are goods from which the supplier has difficulty in directly recovering investment costs and earning profits. Difficulty in recovering investment costs and earning profits does not mean that the benefits generated by investing in public goods are small, however. On the contrary, the benefits of public goods may be enormous, even though this may not be readily apparent when they are spread across a large number of beneficiaries. In India, for example, hundreds of millions of people now have access to more food at lower prices, and a major famine has not occurred in many years.

The issues of who pays the costs of public goods and what quantity of public goods is appropriate are contentious ones. In the case of agricultural research that is targeted at the poorest of the poor, those who pay the cost—typically taxpayers in medium- and high-income brackets—often receive a relatively small portion of the benefits. At the same time, the main beneficiaries—peasant farmers and the urban poor who spend a large proportion of their incomes on food—may not have a say in deciding how government priorities are established. For these reasons, agricultural research is often funded at socially suboptimal levels.

The provision of public goods, including agricultural research, becomes more complex as the number of supplying organizations increases and as their constituencies become more diverse. In many countries, including the United States, every state or province has its own agricultural research organization, which is funded by local taxes and responsive to local needs—and therefore more likely to place local interests above national interests. Although certain types of research can be expected to produce large benefits at the national level, individual states lack incentives to carry out this research, because a large portion of the benefits can be expected to "spill over" to other states that are not sharing the costs. Recognizing that this is the case, national governments generally establish national research organizations to provide goods and services that are deemed necessary for all, but which will not necessarily be provided at the local level (for example, national standards for grading agricultural products).

Compared to the provision of national public goods, the provision of international (or global) public goods is an even more daunting prospect. As Kindleberger (1986) observes, "The tendency for public goods to be underproduced is serious enough within a nation bounded by some sort of social contract, and directed in public matters by a government with the power to impose and collect taxes. It is...a more serious problem in international political and economic relations in the absence of international government." Peterson (2000) agrees that it is problematic for institutions to provide global public goods in optimal amounts because no international authority exists to support agreements, but he points out that "international regimes" may compensate to some extent. These regimes can be thought of as "institutional structures designed to solve particular public goods problems in the absence of a world government" (Peterson 2000).

In this paper we propose to examine one particular global public goods problem: the provision of international research on improved maize and wheat technology to poor farmers in developing countries. In particular, we focus on how changes in the international environment are transforming the legal and social conventions (the "regime") governing international agricultural research and affecting the flow of improved maize and wheat technology to developing countries. We begin by describing the international research system that develops and delivers improved maize and wheat technology for poor farmers. We then address several issues that will influence whether and how this system continues to operate. Aside from the public goods problems described earlier, these include such divisive issues as the rights to genetic resources and intellectual property protection. We describe strategies that the International Maize and Wheat Improvement Center (CIMMYT) has used to continue delivering global public goods to poor people, and conclude with a brief statement of why, despite the present uncertainty in the global research outlook, there will still be a place for international agricultural research and its products.

Research and Development for Global Public Goods: Origins and Achievements

In the two decades after the Second World War, changing perceptions about the potential socioeconomic effects of applied science led to a realization of the crucial role that research could play in hastening the economic development of poor countries. As noted by Press and Washburn (2000), the role of university research in developing technologies that altered the course of the war (penicillin and streptomycin as well as nuclear weapons) heightened government awareness that "academics were uniquely capable of undertaking crucial research initiatives," and public funding for research grew rapidly.

During the same period, European nations divested themselves of their colonies and protectorates, leaving a number of newly independent nations to make their way toward economic development with limited resources. By the mid-1960s, a number of these new nations seemed to be faltering on the path to prosperity. The prospect of famine and unrest in developing countries, especially in Asia, underscored the need for a new kind of development assistance. As it became increasingly clear that industrial development did not necessarily lead to sustained economic growth, "agriculture was gaining ascendancy in the economic strategies of developing countries" (Baum 1986). Confidence in the efficacy of publicly sponsored research began to merge with the conviction that agricultural research could stabilize and strengthen the economies of developing nations.

The case for agricultural research as a means of fostering economic growth in the developing world was compelling. The Asian subcontinent had been on the brink of famine in the mid-

1960s, but in an exceptional international effort, researchers had developed new wheat and rice varieties that yielded much more than the wheat and rice varieties Asian farmers already grew. When these new varieties were grown in India, Pakistan, and Bangladesh, they produced enough grain to make the difference between life and death for millions of people. The scale of this achievement, termed the "Green Revolution," was so widely recognized that Norman E. Borlaug, the plant breeder who had developed the wheat varieties, was awarded the Nobel Peace Prize in 1970. Governments, development banks, international organizations, and private foundations became convinced that funding international agricultural research—which efficiently produced technology that could be used in a wide number of developing countries—could have enormous international benefits, both economic and social. These organizations established a consortium, the Consultative Group on International Agricultural Research (CGIAR), to support agricultural research in developing countries. This consortium funded what have come to be called the Future Harvest Centers of the CGIAR.[1]

One of the first research centers in this consortium was the institute in which Norman Borlaug had conducted most of his research. Established in 1966, the International Maize and Wheat Improvement Center (better known as "CIMMYT," its acronym in Spanish), remains committed to improving the productivity, profitability, and sustainability of maize- and wheat-based cropping systems in developing countries. To a great extent, CIMMYT and the other Future Harvest Centers were modeled on the plant science departments of US universities, especially the publicly funded land-grant universities, which had been highly successful in employing science to improve agriculture. The difference was that CIMMYT's mission was international, and to meet the needs of developing countries the Center emphasized applied rather than basic research. Like many land-grant universities, the Center also had a role in educating researchers by providing highly specialized training to thousands of scientists from developing countries.

As it completes its 35th year, CIMMYT has many achievements to its credit. CIMMYT-related wheat varieties are planted on more than 64 million hectares in developing countries (more than three-fourths of the area planted to modern wheat varieties in those countries). CIMMYT-related maize varieties cover nearly 15 million hectares in non-temperate environments of developing countries (almost half of the area planted to modern maize varieties in those environments). Genetic diversity and the conservation of maize and wheat genetic resources have greatly improved. Innovative crop management practices designed to reduce environmental degradation and conserve resources have been developed and farmers are using them.

All of these products and services originated in an extensive, international, collaborative research network that relied on the open exchange of knowledge and technology in the public domain. This network presently involves research and development organizations in more than 100 developing nations as well as similar institutions in numerous industrialized nations.[2] The benefits of collaboration between CIMMYT and national research organizations in developing countries have been impressive. Depending on several economic and technical assumptions, estimates of the value of the additional grain production attributable to international wheat

1 See www.cgiar.org and www.futureharvest.org.

2 For an idea of institutions with which CIMMYT collaborates, and for information on who funds our research, see our Annual Report (CIMMYT 2000) (www.cimmyt.org/whatiscimmyt/AR99_2000/content.htm).

breeding range from US$ 2 billion to US$ 4 billion per year (Cassaday et al., forthcoming). In the case of maize, the calculations are more complicated, mainly because of the large size of the private maize breeding industry, but the economic value of the additional grain production attributable to public international maize breeding efforts is likely to exceed US$ 2 billion per year (Morris, personal communication).

The social benefits of this research, though difficult to measure, are also likely to be large. Additional maize and wheat production alone certainly cannot be credited with reducing malnutrition in the developing world, but the prevalence of malnutrition in developing countries declined from 46.5% in 1970 to 31% in 1995 (Smith and Haddad 2000), partly because more food was available to more people. Food has certainly become more affordable for consumers. Between 1982 and 1995, real world wheat prices fell by 28%, and world maize prices dropped by 43% (Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1999). Cheaper food is important for poor people in developing countries, who spend 50-80% of their disposable income on food compared to the 10-15% spent in Europe and the US (Pinstrup-Andersen and Cohen 2001).

International agricultural research has also benefited the environment. By breeding plant varieties with genetic resistance to pests and diseases, public research organizations made farmers' use of harmful, expensive agrochemicals unnecessary.[3] It has been argued that by increasing agricultural productivity per unit of land, research has prevented farmers from cropping more ecologically fragile land and from invading forested areas. Recent calculations (Grace et al. 2000) indicate that if the developing world had attempted to meet its food requirements in 1995 without the improved varieties of food crops[4] developed since the Green Revolution, an additional 426 million hectares of cropped area would be needed (a five-fold increase over cropped area in 1965). An even more important finding is that this land savings helped to reduce greenhouse gas emissions by 35%. Grace et al. conclude that, "without the Green Revolution...the atmospheric concentration of greenhouse gases would be significantly higher than they are at present and the actual onset of climate change may have hastened."

Many people would agree that those benefits are impressive and that it is a good thing that public sector research delivers them. Even so, it is becoming increasingly challenging to provide international agricultural research to poor countries. The environment in which CIMMYT seeks to fulfill its mission is changing radically. The international community faces several choices that will greatly influence support for international agricultural research and the conditions under which that research will take place. In the following sections we explore those choices. Some of them are related to issues that typically surround the provision of public goods, whereas others reflect concerns over the mission and responsibilities of public institutions dedicated to development.

Global Public Research for Poor People: The Changing Context

Development strategies must adapt to a new constellation of circumstances that influence how international agricultural research will be conducted and how research products will be delivered in the future. These include: declining

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[3] Morris and Ekasingh (forthcoming) point out that, unlike public breeding programs, private companies may not have placed much emphasis on breeding for resistance to diseases and pests, especially if the companies included an agrochemicals division.

[4] Chiefly wheat, rice, barley, maize, sorghum, millet, rye, and oats.

investment in public research and international aid for agriculture; increasing complexity of the agricultural problems that science is being asked to solve; growing dissent over the conservation, exchange, and use of genetic resources; the proliferation of intellectual property rights and proprietary agricultural technologies; the rise of biotechnology and the associated controversy over genetically modified organisms; increasing economic and political power of the private sector; rising pressure for public-sector institutions to behave like private institutions; and growing concerns over scientific and social equity. Because these issues are so closely related it is difficult to treat them separately, but we shall discuss each of them in turn, emphasizing the choices and dilemmas that they present to the international community.

Declining investment in international agricultural research

Between 1991 and 1996, development assistance fell by nearly 15%. From 1986 to 1996, development assistance directed specifically at agriculture fell almost 50% in real terms (Pinstrup-Andersen and Cohen 1998).[5] Much of the reduction occurred as the seven wealthiest countries that provided development assistance reduced their contributions. At the same time, many developing countries have reduced their own public spending on agriculture, partly under pressure from donor and lending institutions. The results of public underinvestment in agriculture may already be apparent. Pinstrup-Andersen and Cohen (1998) have found that, with the exception of China and India, in most low-income countries agriculture grew by less than 3% per year over 1990-96—not enough to keep pace with population growth.

Increasing complexity of research challenges

At the same time that the international community's disenchantment with agricultural research is affecting low-income countries, those same countries are facing agricultural challenges that most wealthy nations would find difficult to overcome.

Twenty years from now, the world's farmers will have to produce 40% more grain to meet demand for cereals, including wheat and maize (Pinstrup-Andersen, Pandya-Lorch, and Rosegrant 1999). In developing countries, the demand for wheat and maize will rise faster than demand for rice, the other major food staple.[6] In two decades, 67% of the world's wheat consumption and 57% of the world's maize consumption will occur in developing countries. Even with projected production increases, by 2020 wheat will constitute more than 50% of the developing world's net cereal imports. Maize will constitute 33% (Rosegrant et al. 1997).

Nearly everyone is aware that the world produces enough food to feed all of its people, but the challenge of supplying food to those who need it most is not as simple as it would appear. Simply increasing the "pile of food," observes Falcon (2000), "is by no means sufficient to assure food security among the poor. If developing countries with a large percentage of undernourished people are to solve employment, income, and food-access problems, most of the increased agricultural

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5 Paarlberg (2000), cited in RAFI (2000), reports that foreign aid to developing country agriculture fell by 57% between 1988 and 1996 (a drop from US$ 9.24 billion to US$ 4 billion, in 1990 dollars). He also reports that World Bank loans for agricultural and rural development fell 47% between 1986 and 1998 (from US$ 6 billion to US$ 3.2 billion, in 1996 dollars).

6 Demand for wheat will grow by 1.58% per year; demand for maize will grow by 2.35% per year.

output must be grown within the borders of these nations."

That is where the challenge becomes acute, because the agricultural problems of developing nations are extreme. They range from numerous physical problems (such as diseases and pests, drought, floods, severe environmental degradation, and infertile soils) to institutional problems (such as weak extension programs, research organizations literally immobilized by a lack of funding, limited access to agricultural inputs and credit, poor infrastructure, and poorly developed markets), to larger deficiencies in human and financial capital.

These challenges to agriculture are further complicated by the fact that agriculture itself is more complex. In the 1970s, agricultural research, whether it was international, national, or local, tended to be organized along commodity lines, focusing on specific, well-defined problems (e.g., breeding for higher yield, disease resistance, pest resistance; or determining optimal fertilizer application levels). During the 1980s, the focus of research shifted gradually to cropping systems, which tend to be characterized by problems involving interactions between large numbers of on-farm and off-farm enterprises. To respond to these problems, research organizations shifted from mono-disciplinary research to multi-disciplinary research. By the 1990s, more researchers recognized that they needed to give greater attention to environmental and sustainability issues alongside the more traditional emphasis on productivity. At the beginning of the new century, research organizations are also being asked to demonstrate the linkages between technology development and poverty alleviation, which implies focusing more attention on the role of policies and institutions in fostering positive agricultural change.

Clearly, no single institution or technology will meet all of these research goals. Partnerships and consortia are essential for assembling the human expertise, technology, and often the financial capacity needed to make a difference for poor farmers. The complexity of the institutional arrangements supporting international research is growing. Organizations need time to explore, access, and assemble promising research tools and technology. They need time to assess which organizations would be effective research partners. The large number of partners in international research efforts—including funding agencies, nongovernmental organizations (NGOs), private companies, and farmers (through participatory research)—makes it harder to reach agreement on how best to operate. Transactions costs increase, and partners have to establish clear guidelines and decision rules to govern their collaboration. The large effort to secure international collaboration may certainly be worthwhile, however (witness the results of CIMMYT's maize and wheat research). As Peterson (2000) points out:

> ***In addition to the benefits of international public goods that would not be supplied in the absence of international cooperation, international organizations may generate other benefits for participants. Efficiency gains due to scale economies in the provision of the public good, the greater amount of information made available through the supranational structures, and increased political prestige for those who participate in the agreement are examples. As with costs, these benefits increase with the number of participants and the degree of integration.***

Dissent over genetic resources

Herdt (1999) describes the controversy over the exchange, use, and control of plant genetic resources as the enclosing of the "global genetic commons." He notes that "changing technology and institutions have interacted throughout history to create property rights from what had previously been public goods," and that the ability to manipulate DNA has "generated a new class of asset whose ownership is now being contested by multi-billion dollar companies." As private companies have increasingly obtained intellectual property rights to plant traits, genes, and very small genetic components, many agencies in developing countries have come to believe that their genetic resources may prove potentially valuable to the emerging biotechnology industry. Angered by what they consider "bio-piracy," and concerned that they may one day be denied access to what they consider their own resources, many countries in which genetic resources have been collected are demonstrating less willingness to make genetic resources freely available for use by others.

Many issues related to the conservation, ownership, and exchange of genetic resources remain to be resolved at the national and international levels.[7] The net effect of the trends we have just described, however, has been to reduce the flow of genetic resources for research and create a great deal of uncertainty in the public sector about how to work in an environment where the rules of the game are changing, perhaps beyond recognition. Cassaday et al. (forthcoming) observe that the rules established through the international negotiations on plant genetic resources for food and agriculture, which are underway at the Food and Agriculture Organization (FAO), "could dramatically affect the origins, i.e., the genetic content" of all crops "vital to food security and economic development." They conclude that if the negotiations fail to develop a system that is conducive to international public plant breeding, "governments will have to be prepared to devote considerably greater financial and human resources to plant breeding and acquisition of materials than they seem prepared to provide today." In other words, the commitment to provide a particular set of public goods previously provided through international channels will shift to national governments working individually, which is likely to be a less efficient alternative.

The rise of intellectual property rights and proprietary technology

Preston (2000), reviewing trends and achievements at the US Patent and Trademark Office during the Clinton administration, reported that since 1993:

> *...patent and trademark filings have increased more than 70%. Patent filings have gone from 174,000 in 1993 to just under 300,000 this year, and trademark applications have increased from 140,000 to over 370,000. The sheer volume of all of this data has won the USPTO the distinction of having more data storage than the combined contents of every book in the Library of Congress.*

Obviously not all of these patent filings were related to agricultural research, but it is certain that applied agricultural research in biotechnology generated a good number of them. The proliferation of patents and other forms of intellectual property protection could possibly spread beyond the United States, because many countries are required to adopt intellectual property regimes as part of world trade agreements (Morris and Ekasingh, forthcoming).

As noted, the private sector traditionally did not invest in developing new plant varieties, mainly owing to the nonappropriability of benefits. Private investment in agricultural

7 It is hoped that international agreements such as the Convention on Biodiversity and the Food and Agriculture Organization's International Undertaking on Plant Genetic Resources for Food and Agriculture will contribute to their resolution.

research and development (R&D) increased in the 1930s and 1940s with the advent of hybrid maize seed companies (since the nature of hybrids is that the benefits become appropriable). In the 1990s, as the potential of biotechnology became clear, the "business of breeding" really began. Private companies poured money into R&D. Some observers believe that in the US the private sector's expenditure on research now exceeds expenditures by the public sector.

What motivated the rise in private-sector investment in plant breeding? Without a doubt, the potential for claiming intellectual property rights to plant varieties, genes, alleles, and other genetic components has driven this investment. Because the techniques of molecular genetics made it possible to identify the developer of a plant variety without question, it became far easier to claim intellectual property over plant varieties (Herdt 1999). In other words, plant variety protection (PVP), patents, and other types of intellectual property rights have made it possible for companies to appropriate benefits from investments in plant breeding, thereby converting what was once a public good into a private good.

Not everybody is comfortable with this development. As genetic resources in their many forms—plant varieties, the genetic components of plants, and the information associated with them—have gained in value, they are increasingly perceived to be strategic assets, and many observers are disturbed to see that the private sector is appropriating the rights to these assets. Critics are especially concerned by what they see as a fairness issue—many of the genetic resources used as inputs into modern breeding programs were improved by farmers over thousands of years of on-farm selection, and it is not obvious that these farmers (or their descendents) are being compensated.

Even though the new appropriability of genetic resources provides an incentive for private companies to invest in research, another fairness issue emerges when one considers that private companies develop products only for commercial markets. They rarely develop products for the many poor farmers, especially subsistence farmers, who cannot afford to pay for them.

The drive towards intellectual property rights has obviously changed the ethos of plant breeding in the public sector, which relied on "a willingness to share discoveries and materials for the common good" (Herdt 1999). Presently, public-sector scientists developing research products for poor people find it increasingly difficult and costly to access the products and processes required for their research. Because researchers may have to work with a number of patented "enabling technologies" to achieve their goals (these technologies can include molecular constructs, transformation processes, genes, and traits), the amount of time spent negotiating access to technology is likely to erode the time and money spent developing and delivering it.[8] Furthermore, one of the most difficult choices facing public organizations is whether to seek intellectual property protection over their own products. Their motivation is not so much to profit from this action as to prevent other agencies from appropriating rights to their research materials and making them difficult and/or expensive for others to access. Falcon

[8] The development of "golden rice," which contains higher levels of beta-carotene, a vitamin A precursor, was heralded as a major achievement on behalf of poor people. It took some time for the public to realize that poor people could not immediately gain access to golden rice because researchers had developed the rice using proprietary technology, and a host of licensing and other issues would have to be resolved before the nutritional promise of golden rice became a reality (see "New mechanisms for accessing and providing research products," later in this paper).

(2000) concludes that "the fear that 'outsiders' will patent existing products...has left national agricultural research systems and the international agricultural research centers in a quandary as to whether or not to employ patenting as a defensive strategy against bio-piracy."

Finally, another implication of the rise of proprietary agricultural technology is that researchers in the public arena no longer face a simple decision about *which technology* to use in their research. Because property rights link a technology with its owner, researchers more often than not are also deciding *which corporate entity* they must partner with—or pay—to achieve their goals. Although many observers worry that alliances with private organizations are nothing less than exploitative, others believe that the only realistic strategy is to build alliances that achieve public goals even if they also benefit private bank accounts.

Dissent over biotechnology

Widely differing perceptions about the potential benefits and drawbacks of biotechnology have colored an active and very public debate that covers a range of scientific, political, and ethical issues. Tripp (2000) observes that proponents of biotechnology "argue for the need to increase food production and point to the possibility of addressing the problems of marginalized farmers," whereas opponents "question the safety, relevance, and equity of the new technology." Some have gone so far as to mandate a moratorium on the release of genetically modified organisms (GMOs) and a complete cessation of research. Others have sought to ensure that the views of developing countries are represented in this debate, fearing that the most food-secure nations will take decisions with repercussions for the least food-secure nations. Organizations concerned with agricultural research are now deciding where they stand on these issues.

For international research organizations such as CIMMYT, one problem resulting from this dissent—which is fuelled in part by incomplete knowledge and false information—is that it threatens to close off many avenues of potentially productive research for developing countries. Pinstrup-Andersen and Cohen (2001), in an extensive review of this problem, observe that "positions for or against the use of genetic engineering in food and agriculture in industrialized countries are frequently extrapolated directly to developing countries," even though the perspectives and interests of groups in industrialized and developing nations differ greatly with respect to the technology. For example, rich nations can afford to worry about the health consequences of GM food and determine that it is better to abandon research and commercialization of GM food crops, whereas many poor nations may find it in their interest to explore GMOs' potential for increasing food production and agricultural export earnings. Research on GM food crops may diminish if industrialized nations decide that it is safer to use GM technology to develop pharmaceuticals, with the result that many technologies of potential use for agriculture in developing countries are not developed. Falcon (2000) comments that developing countries "express concern that key research initiatives with biotechnology will not be pursued because of what they perceive to be the private sector's focus on the wrong products, for the wrong reasons, at the wrong time." Pinstrup-Andersen and Cohen (2001) note that these divergent views are likely to lead rich and poor nations to adopt different policies and standards that "may conflict with the current globalization trends," and that "for globalization to continue in the area of food and agriculture, certain policies and standards need to be synchronized, and the biggest threat is that low-income countries will have to adopt policies and standards that are appropriate only for high-income situations."

The predominance of the private sector

As noted, private organizations have marshaled an impressive array of financial and human resources to support their agricultural R&D goals. Heisey, Srinivasan, and Thirtle (2000) have assessed investments by the public and private sector in plant breeding research in several settings (Australia, Canada, the UK, and the US). They found that "across industrialized countries and across crops, the general trend has been towards relatively greater private sector investment in plant breeding, and greater use of private sector varieties in farmers' fields." In the US, "it is likely that for field crops alone private plant breeding expenditures now surpass public expenditures by a considerable margin."[9] Morris (forthcoming) documents that in developing countries the private sector now invests more in maize breeding than the public sector.

Biotechnology research especially highlights the contrast between public and private investments in agricultural R&D. According to Sandburg (1999), the National Science Foundation provided US$ 30 million for plant genomics research in 1998 and US$ 50 million in 1999, whereas private companies spent US$ 1.5-2.0 billion. When the Novartis Agricultural Discovery Institute, Inc. (NADII, now known as the Torrey Mesa Research Institute) was established in California in 1998, funding for the first 10 years was anticipated to be US$ 600 million. (Funding for all 17 Future Harvest Centers of the CGIAR, by comparison, was US$ 340 million in 1998.) The financial clout of the multi-billion-dollar biotechnology industry, which had its origins in technology developed in the public sector, has come to have implications for how the public sector—including organizations such as CIMMYT—chooses to do its work. Some of these implications are discussed in the next section.

Pressures for the public sector to act like the private sector

The private sector traditionally has supported public-sector research in many ways, including direct research grants, donations, endowed chairs, and scholarships. More recently, however, private organizations seem to be financing a greater share of the research in universities[10] and public organizations under arrangements that have called the independence of the public sector into question.

In 1998, NADII reached a still-controversial agreement with the University of California-Berkeley in which NADII agreed to provide US$ 25 million over five years to the university's Department of Plant and Microbial Biology to conduct basic research on plant genomics. Under the conditions of the grant, department researchers do not work on specific products for Novartis (now re-named Syngenta), but Syngenta receives the first right to negotiate licenses on about one-third of the department's discoveries—discoveries from research funded by NADII/Torrey Mesa as well as by state and federal organizations. Syngenta benefits from gaining access to research that could yield commercial products, and the university gains access to Syngenta's proprietary gene sequencing database, an immensely valuable resource otherwise unavailable to the university. A committee formed by three professors from the department and two Syngenta representatives decides which research projects to fund through the

[9] See also C.E. Pray, 1999, "Role of the private sector in linking the US agricultural, scientific, and technological community with the global scientific and technological community," unpublished paper, Rutgers University.

[10] Corporations provided US$ 850 million to US universities in 1985 and US$ 4.25 billion less than a decade later (Press and Washburn 2000).

Torrey Mesa grant. The decision to award Syngenta the right to negotiate for 30-40% of the department's inventions was based on the fact that the Torrey Mesa grant would fund 30-40% of the department's annual research budget (Sandburg 1999).[11]

Many observers of events at UC-Berkeley felt that this arrangement blatantly challenged the university's mission as a public institution committed to preserving academic freedom—particularly the freedom to ensure that its research agenda remained independent of commercial interests. Others wondered how much longer the university could claim to serve the public good in any case, given that state funding for UC-Berkeley had fallen to 34% in 2000 compared to 50% twelve years previously (Press and Washburn 2000).

Similar doubts have been expressed in response to the trend among universities and other public organizations to patent their inventions. Universities that once regarded patents as "fundamentally at odds with their obligation to disseminate knowledge as widely as possible" have altered their way of doing business, so that "nearly every research university in the [US]...has a technology-licensing office" (Press and Washburn 2000). Many university campuses are now surrounded by clutches of start-up companies formed on the basis of university discoveries. Despite a handful of lucrative successes,[12] however, most licensing offices have yet to become a major source of income for the universities they serve (Press and Washburn 2000).

Strategies such as these have raised questions that have echoed throughout the public sector. Some of these questions are related to the future of public-sector research itself, whereas others are related to the increasingly blurry distinction between public and private research. If the public sector is unwilling to increase funding for research, will public research organizations continue to achieve their goals? Many fear that if public institutions cannot compete with the resources offered by the private sector, they will no longer attract and retain the best researchers. Others worry that public organizations will not conduct the kind of basic research that truly inspires innovation. Still others have expressed great concern that the public research agenda, which often addresses issues and meets needs of little importance to the private sector, will become distorted by the private sector's goals. Can intellectual freedom be protected if private rather than public funding increasingly supports public institutions? Finally, what really defines a "public" institution? Public institutions may profess to serve the public good, but will their financial statements and research portfolios give the lie to that assertion? We will return to some of these questions, and to how CIMMYT and other international research organizations are attempting to deal with them, later in this paper.[13]

The struggle for equity in science

Diverging investment in agricultural R&D by the public and private sectors, diverging perspectives in wealthy and poor nations about potential applications of biotechnology, concerns over the ability of public organizations to access new technologies and

[11] An even more controversial arrangement had been established—and challenged—earlier between Scripps Research Institute and Sandoz (Sandburg 1999), in which Sandoz was first awarded the right to license *all* of Scripps' inventions over the course of ten years. This arrangement proved so controversial that, following US congressional hearings, the terms of the agreement were altered to give Sandoz first rights to license 46% of Scripps' discoveries over five years, with an option to renew the agreement for another five years.

[12] For example, Stanford University earned US$ 61 million from its technology transfer efforts in 1999 (Press and Washburn 2000).

[13] For a clear and thorough discussion of these questions, see Morris and Ekasingh (forthcoming).

processes for research, and the complexity of the new technology itself have raised the twin specters of "scientific imperialism" and "scientific apartheid." We have already discussed fears that wealthy nations will dictate the scientific limits of poor nations, not only through the kinds of research they choose to undertake but through the positions advocated by civil society organizations and development assistance agencies. Pinstrup-Anderson and Cohen (2001), for example, have shown how opposition to biotechnology in developing countries by civil society organizations in industrialized nations has elicited the response from some developing nations that they would prefer to determine for themselves, on the basis of their needs and values, whether and how they will use GMOs and other products of biotechnology. Herdt (1999) cautions that the increasing use of intellectual property rights could "raise costs or discourage innovations in the developing world, or shift power unfairly to industrialized country firms away from developing country organizations."

A parallel concern is that results of research undertaken in industrialized nations will be increasingly beyond the reach of most developing nations, and that the technology gap will only become wider over time. With some notable exceptions,[14] most developing nations lack the financial and human resources to mount ambitious biotechnology research programs, either publicly or privately funded. Nor do many nations have the resources to access technology that has already been developed (including GMOs) and monitor its use. Serageldin and Persley (2000) state the problem simply: "The economic concentration of investment, science, and infrastructure in industrial countries and the lack of access to the resulting technologies are major impediments to the successful applications of modern biotechnology to the needs of global food security and to create wealth for the presently poor people and countries."

The struggle for social equity

If international research organizations such as CIMMYT are preoccupied by the prospect of growing inequity in science, it is because they are even more preoccupied by the prospect of growing inequity in society. One of the arguments in favor of international agricultural research is that its benefits are felt by the poorest members of society. Who are these people whose lives will be affected if agricultural research fails to help them? They include the nearly three billion individuals who survive on less than US$ 2 per day—two dollars for food, clothing, shelter, education, medical treatment, and other needs. They include the world's 160 million malnourished children. They include the people who live in rural areas in developing countries and depend on agriculture to provide income and food security—more than 70% of the population.

Should the interrelated trends discussed previously combine to inhibit international public agricultural research, fewer research organizations may survive to act as "agencies for equity." Although international agricultural research seems to be hemmed about with a growing number of constraints, at CIMMYT we believe that these constraints are not insurmountable. Our strategies for ensuring that international research empowers poor people and eradicates scientific apartheid—in short, our strategies for keeping public goods *public*—are discussed next.

[14] Argentina, Brazil, China, India, Kenya, Mexico, South Africa, and Thailand, for example, have all dedicated significant resources to biotechnology research.

CIMMYT: Freedom to Achieve a Global Humanitarian Mission

In adapting its research strategies to a volatile new research environment, CIMMYT is fully aware that "society benefits when the public sector has 'freedom to operate,' when it maintains public access to research tools subject to intellectual property protection by the private sector, and when it engages in fruitful collaborative research" (Heisey, Srinivasan, and Thirtle 2000). Here we outline some of the alternatives that will ensure that CIMMYT remains effective and true to its mission in the midst of great change in the way research is conducted.

Partnerships for a new research environment

Especially as a result of new intellectual property arrangements, public research organizations are entering into a larger variety of research partnerships than in the past. These partnerships range from traditional philanthropic arrangements to purely commercial alliances and include direct support for research, collaborative public sector research, licensing (different agreements for sharing costs and technology), market segmentation, technology grants for research in developing nations, and joint ventures (Falcon 2000). Here we will not discuss CIMMYT's more "traditional" research partnerships (although these, too, are changing as they come to involve a wider range of participants).[15] Instead we will describe (1) alliances between CIMMYT and the private sector and (2) partnerships between CIMMYT and other public research organizations in which processes or products of biotechnology are used.

Partnerships with private research organizations. Private and public research organizations increasingly agree that it is urgent to explore the ways that their interests may intersect for the benefit of society. For example, the development of drugs to combat AIDS and the breakthrough with golden rice have raised awareness that private corporations may have a moral responsibility to make their products available to poor nations (in other words, under certain conditions the private research sector should further the objectives of the public sector).[16]

With regard to agreements with the private sector, CIMMYT's policy is to enter into such agreements only if they enhance the Center's ability to achieve its mandate of service to the resource-poor and the environment. In simple terms, will an agreement help CIMMYT to more quickly develop new, appropriate technologies and deliver them to farmers' fields in developing countries? If so, the agreement is what we call a "win-win" alliance, and the

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[15] For example, a research consortium to address the challenging environmental and productivity problems in South Asia's rice-wheat systems has, at one time or another, involved national and international research organizations, nongovernmental organizations, farmers, local private machinery companies, and researchers from advanced public research organizations in industrialized countries. This consortium was recently recognized by the CGIAR as one of the most successful research partnerships established by the Future Harvest Centers. Information on the Rice-Wheat Consortium for the Indo-Gangetic Plains is available at www.rwc.cgiar.org.

[16] Representatives of seven of the world's academies of science (the Brazilian, Chinese, Indian, Mexican, UK, US, and Third World academies) recently issued a white paper (Anonymous 2000) on transgenic plants and world agriculture, stating: "Private corporations and research institutions should make arrangements for GM technology, now held under strict patents and licensing agreements, with responsible scientists for use for hunger alleviation and to enhance food security in developing countries. In addition, special exemptions should be given to the world's poor farmers to protect them from inappropriate restrictions in propagating their crops."

Center can participate. Within this framework, CIMMYT has established four agreements with private research organizations that provide access to expertise and technologies that otherwise would not be available.[17] Three of the agreements involve research on wheat: a project to evaluate the potential of hybrid wheat; a project with a private company in Spain to improve disease resistance, yield, and quality in durum and bread wheat; and a project with a private company in Mexico to improve the industrial quality of bread wheat.[18]

A fourth project aims to develop apomictic maize plants. Since 1990, a joint project between CIMMYT and France's Institut de Recherche pour le Développement (IRD)—a public research organization—has focused on understanding apomixis (the asexual reproduction of plants through seed) and how the trait might be transferred to maize. To accelerate progress in this potentially revolutionary area, in 1999 CIMMYT and IRD formally entered into an important research collaboration with three private seed companies (Pioneer Hi-Bred International, Groupe Limagrain, and Syngenta). The five-year agreement is aimed at further understanding apomixis, which is the natural ability of some plants to reproduce offspring identical to the mother plant through asexual reproduction.[19] In the plant kingdom, more than 400 species, most with little or no agronomic potential, possess this apomictic characteristic. Greater knowledge about this natural plant mechanism could provide the basis for its transfer to some of the most commonly grown agricultural crops, for instance, hybrid maize. For the agreement's seed-producing partners, enhanced knowledge of apomixis might create new options for improved multiplication and quality of seeds. For CIMMYT and IRD, the transfer of apomixis to maize offers the long-term possibility of delivering superior hybrid crop traits such as disease resistance and higher yields to the resource-poor farmers of the world through the inherent reproductive characteristics of apomictic plants.

Partnerships between public research organizations to explore the potential of biotechnology. CIMMYT conducts a wide range of biotechnology research and collaborates with a number of public-sector institutions in developing countries. Here we will describe a project recently initiated in Kenya. Scientists from the Kenya Agricultural Research Institute (KARI) and CIMMYT are using conventional as well as biotechnological breeding strategies to develop maize resistant to stem borers, which are estimated to destroy 15-40% of Kenya's maize crop each year. The Insect Resistant Maize for Africa (IRMA) Project is funded by the Novartis Foundation for Sustainable Development. The project was launched through a consultative meeting in which all groups concerned with the outcome met to discuss their views of the project, including representatives from KARI and CIMMYT as well as from farmers', women's, and church associations; extension services; various government ministries; the private sector; and a contingent of Kenyan print and broadcast media.

Over five years, researchers participating in the IRMA Project will develop integrated pest management strategies and use conventional and biotechnological means (including resistance based on Bt genes) to breed insect-resistant maize for major Kenyan production systems and insect pests. The project will also establish procedures to provide insect-resistant maize to resource-poor farmers; assess the impact of insect-resistant maize in Kenyan agricultural systems; transfer skills and technologies to

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17 In 1999, 3% of CIMMYT's research resources came from agreements with the private sector.

18 Details of these agreements may be found in CIMMYT's annual report (CIMMYT 2000).

19 For a technical overview of the quest to produce apomictic food crops, see Savidan, Carman, and Dresselhaus (2001).

Kenya to develop, evaluate, disseminate, and monitor insect-resistant maize; and plan, monitor, and document the project's processes and achievements for dissemination to other developing countries, particularly in East Africa.

The project calls on CIMMYT and KARI expertise in maize breeding, agricultural economics, biotechnology, entomology, and communications. It is important to emphasize that project researchers have agreed to identify and develop gene constructs that contain no herbicide or antibiotic markers. Maize varieties produced by the IRMA Project will carry only "clean" or "purified" Bt genes, circumventing concerns about unforeseen impacts on the environment or human health. While this approach costs more and takes longer, IRMA researchers are committed to addressing all reasonable issues that emerge regarding the technology.

Policies for a new research environment

As the research environment becomes more complex and public research organizations enter into more alliances with the private sector, CIMMYT has sought to develop clear, open policies with respect to intellectual property and new technology. These policies provide a public account of CIMMYT's strategies for making its research products available to the international community and for working with private organizations in ways that are absolutely consistent with its mission to help the poor.

CIMMYT's intellectual property policy and intellectual property management. In 2000, CIMMYT released its policy on intellectual property (CIMMYT 2000).[20] The preamble emphasizes the Center's concern over preserving public access to its research products:

> *As a publicly funded international research institute, CIMMYT regards its research products as international public goods. Yet, in the current political and legal environment, producing and keeping the products of its research in the public domain, free for use and development both by scientists and farmers, have become increasingly problematic. It is in this context that CIMMYT has examined, and will continue to examine, its policies and practices in regards to intellectual property rights.*

For the most part, the policy spells out procedures for managing intellectual property that were already in place within CIMMYT. One example is the procedure to hold the genetic resources designated under a 1994 FAO/CGIAR agreement in trust for the benefit of the international community, especially developing countries. The new intellectual property policy represents a departure from previous modes of operation, however, by establishing that CIMMYT will take steps to protect its inventions through patents, plant breeders' rights, copyrights, trademarks, statutory invention registrations or their equivalent, and/or trade secrets under the following conditions:

> *To support public and private partnerships which pursue mission-based research or which develop and apply research results; to assure ready access by others to research products developed or funded by CIMMYT; to avoid possible restrictions arising from "blocking" patents and to ensure CIMMYT's ability to pursue its research without undue hindrance; to facilitate the transfer of technology, research products, and other benefits to the resource poor including, where appropriate, through commercialization or utilization of research products; and/or to facilitate the negotiation and conclusion of agreements for access to proprietary technologies of use to CIMMYT's research and in furtherance of its mission.*

[20] See http://www.cimmyt.org/resources/Obtaining_seed/IP_policy/htm/IP-Policy.htm.

The policy further specifies that, in light of the "evolving legal and political environment," CIMMYT's Board of Trustees will "regularly review this Policy and its implementation in order to ensure that CIMMYT is well positioned to carry out its mission."

CIMMYT was one of the first Future Harvest Centers to release an intellectual property policy, and the press quickly noted the decision. The policy was described in *Nature*, which quoted a CIMMYT Board member as saying that "this is not an effort by the organization to 'get rich' by patenting discoveries, but to ensure broad distribution of plant materials through a flexible policy" (Dalton 2000).

Aside from its new policy, CIMMYT has several organizational avenues for managing intellectual property and related issues. For a number of years, CIMMYT has maintained standing committees on intellectual property, biosafety, and bioethics, and it has conducted a full intellectual property audit. In 2001, an Intellectual Property Management Unit will be established to provide further guidance and leadership on intellectual property issues.

CIMMYT's genetic engineering strategy. In developing the tenets of its genetic engineering strategy for wheat and maize, CIMMYT has emphasized the needs of its partners in national research organizations and the usefulness and safety of its products for farmers. Five points guide the Center's genetic engineering program:

- Plant varieties that are genetically engineered by CIMMYT are developed in concert with a national program partner to meet a delineated need.
- CIMMYT provides only transformed plants that carry "clean" events, meaning that only the gene of interest is inserted into the final product.
- No transformed plants that carry selectable markers, such as herbicide or antibiotic resistance, are provided to national programs for release.
- CIMMYT's focus on possible genes for transfer is only on plant, bacterial, fungal, and viral genes (i.e., not on animal genes, especially human genes).
- CIMMYT works only in countries that have biosafety legislation and regulations.

New mechanisms for accessing and providing research products

CIMMYT actively seeks new ways of accessing research tools and providing research products. It has been suggested that one potential means of reducing some of the complicated legal arrangements involved in accessing and disseminating new technology is a mechanism known as a "patent pool," which has been used in the US for 150 years, mostly in the manufacturing industry and more recently in the electronics industry (Clark et al. 2000).[21] This mechanism, which is regulated by the Antitrust Division of the US Department of Justice and by the Federal Trade Commission, is thought to offer "one way to address the issue of access to vital patented biotechnology products and processes" (US Patent and Trademark Office 2001).

A patent pool consists of two or more patent owners who agree to license one or more of their patents to one another or third parties. The pool has the advantage of allowing organizations to make all of the components needed to conduct a process or produce a technology available from one source. Ideally, according to Clark et al. (2000:8-9), such arrangements would make it possible to integrate complementary technologies, reduce transactions costs, clear blocking positions,

[21] The authors are grateful to Victoria Henson-Apollonio, Senior Research Officer, Intellectual Property, with the CGIAR Central Advisory Service on Intellectual Property, for drawing our attention to patent pooling.

avoid costly infringement legislation, and promote the dissemination of technology. These authors note that "the re-emergence of...patent pools suggests that the social and economic benefits of such arrangements outweigh the costs." They contend that patent pools can encourage "the cooperative efforts needed to realize the true economic and social benefits of genomic inventions. In addition, since each party in a patent pool would benefit from the work of others, the members may focus on their core competencies, thus spurring innovation at a faster rate." Should patent pools become more common in the biotechnology industry, public research institutes may have greater access to technology for their research—if the conditions are acceptable to their goals as public institutions.

Increasingly, the international community appears to be seeking a forum for reconciling the objectives of private and public research institutions with respect to developing countries. A white paper issued by seven academies of science in 2000 advocates the establishment of an international advisory committee to "assess the interests of private companies and developing countries in the generation and use of transgenic plants to benefit the poor—not only to help resolve the intellectual property issues involved, but also to identify areas of common interest and opportunity between private sector and public sector institutions" (Anonymous 2000). Such an advisory group could become a valuable resource for international research organizations working in developing nations. The current Central Advisory Service on Intellectual Property of the Future Harvest Centers—an international forum that has already been established—could possibly play this role, at least within the CGIAR.

Meanwhile, private research organizations have become increasingly aware of the importance of collaborating with public research initiatives, especially in developing countries, and this trend could be beneficial for international agricultural research.[22] Nash (2000) reports that the developers of golden rice, Ingo Potrykus and Peter Beyer, "struck a deal with AstraZeneca, which...holds exclusive rights to one of the genes Potrykus and Beyer used to create golden rice. In exchange for commercial marketing rights in the US and other affluent markets, AstraZeneca agreed to lend its financial muscle and legal expertise to the cause of putting the seeds into the hands of poor farmers at no charge." In January 2001, Syngenta, one of the world's largest agrochemical companies, published the first complete genome of a food crop (rice). With this information, Syngenta researchers can achieve highly specific breeding objectives very rapidly, because it enables them to identify particular genes (such as a gene conferring resistance to an important disease) that would be useful to transfer from one variety to others. The value of this information for public breeding research in developing countries is obvious. Syngenta, in a statement issued on 26 January 2001, said that in developing countries, "where rice is a vital crop, Syngenta will work with local research institutes to explore how this information can best be used to find crop improvements to benefit subsistence farmers. It is our policy to provide such information and technology for use in products for subsistence farmers, without royalties or technology fees." Many members of the development community welcomed this effort to channel important technology to the people who arguably have most to benefit from it.

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22 Perhaps this awareness builds on the belated realization by many pharmaceutical companies that they should develop more flexible and lenient policies for providing AIDS medication in developing countries.

Dialogue, advocacy, and information for research planning

CIMMYT researchers are committed to conducting an open dialogue on many of the scientific, legal, and institutional changes that are transforming the environment in which it seeks to fulfill its mission. For example, CIMMYT convened an international forum in Tlaxcala, Mexico, in late 1999 to initiate a dialogue on key issues related to public/private alliances in agricultural research. The participants were all highly respected, experienced individuals active with the private sector, major public research institutes in the developing world, multilateral donor agencies, academia, and the CGIAR. Participants produced a statement that reflected their consensus on how public and private research organizations could adopt complementary and mutually reinforcing forms of working together (CIMMYT 2000).[23] CIMMYT also participates in numerous international forums on biotechnology, including the Africa Biotechnology Stakeholders Forum, which addresses the special issues surrounding biotechnology in the African context.

Because it is a well-known research institution with decades of experience in developing countries, CIMMYT can also help educate a wider audience about issues that are important to agricultural development. The IRMA Project has a strong public education and awareness program related to the technology it develops, for example. This program is directed at the general public as well as farmers and other important groups who have an interest in the project's progress and outcomes. In addition, CIMMYT has publicly advocated that national governments—not the governments of industrialized nations—must take their own decisions with respect to GMOs and other products of biotechnology, and that those decisions should emerge from "serious discussion based on credible, science-based information" (Feldmann, Morris, and Hoisington 2000).

Through its own research, CIMMYT is careful to provide sound information for research management decisions related to new technology and the research environment. For example, a CIMMYT researcher and a colleague from a national public research program recently reviewed the ways that public and private plant breeding organizations could reorient their efforts (Morris and Ekasingh forthcoming). Concluding that "if public breeding programs do not change the way they operate, they will become marginalized," Morris and Ekasingh also caution that public breeding programs should not simply "withdraw completely from areas claimed by the private sector, because a continuing public-sector presence may be desirable for efficiency as well as equity reasons." They identify five "essential functions" for public breeding programs in the future: the conservation of genetic resources, training of plant breeders, varietal testing and evaluation, biosafety regulation, and crop genetic improvement for carefully selected products, traits, and crops (e.g., those that are important for subsistence farmers).

CIMMYT researchers have also published research and review articles on geneflow between GMOs and other crops; the efficiency of conventional breeding methods compared to molecular breeding; economic and social incentives for farmers to preserve genetic resources *in situ*; economic returns to conserving and using genetic resources; flows of wheat and maize genetic resources between developing and developed countries; the

[23] See http://www.cimmyt.org/whatiscimmyt/tlaxcala.htm.

implications of providing GM seed to farmers in developing countries; and many other topics.[24]

Global Public Goods for Poor Farmers: Still a Reality

Much of the recent investment in agricultural research has been made by the private sector to meet commercial needs and satisfy stakeholders, but it has not been used directly to generate global public goods. As private interests in agricultural research grow, what will be the fate of international agricultural research and the goods and services it provides? Will centers such as CIMMYT remain active forces for agricultural development, or will they merely represent an outmoded way of doing business?

We do not underestimate the challenges, but we strongly believe that international agricultural research will continue to be an effective force for change in the developing world. To some extent, the current fierce debate over intellectual property and other issues has obscured the fact that much of the history of agriculture, including agricultural research, consists of a series of upheavals and accommodations that occurred as public and private organizations sought to adapt to economic and institutional change (Heisey 2000). Although the research environment has become extremely volatile, it is to be hoped that the international community will mobilize its considerable authority and resources to support international research and ensure that poor people are not excluded from development opportunities through short-sighted policies, agreements, and purely commercial interests.

We know that if less technology is generated to help the poor, and if fewer poor people can access that technology, the cost of social equity will rise for every individual on earth. The consequences for the rural poor will not be small. Some people will pay with hunger and poor health; others will take their suffering to overcrowded cities or across borders to wealthy nations. At CIMMYT we believe it is urgent to join actively in the debates surrounding international agricultural research and discover more efficient ways of fulfilling our mission. The penalty for not acting, and for being excluded from new research opportunities, is going up exponentially—each year, and for each person.

[24] See, for example, Serratos, Wilcox, and Castillo (1997) on gene flow among improved maize, landraces, and teosinte; Dreher et al. (2000; 2001) and Ribaut and Poland (2000) on issues related to conventional and molecular breeding; and Smale (1998) on numerous genetic resources issues, including measurements of genetic diversity and the economics of genetic resource conservation.

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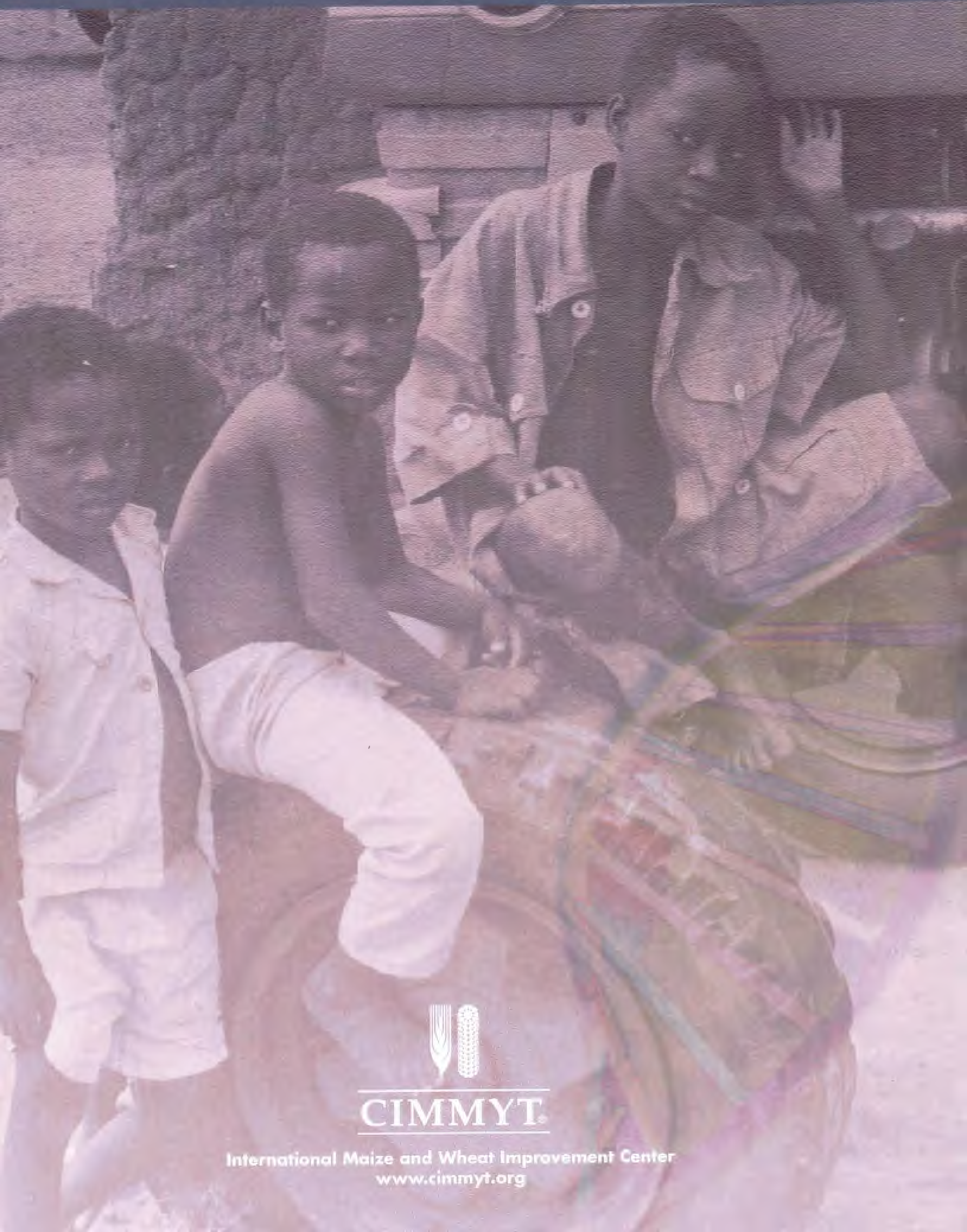

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