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Rural Well-Being

From Vision to Action



Proceedings of the Fourth
Annual World Bank Conference on
Environmentally Sustainable Development

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Introduction

Ismail Serageldin

David Steeds

The Fourth Annual World Bank Conference on Environmentally Sustainable Development was convened in September 1996 to focus attention on the need to promote rural well-being. We believe that transforming agriculture with a special emphasis on smallholder farmers, coupled with a broad-based effort at promoting rural well-being, is vital if we are to reduce poverty and promote widely shared growth, food security, and sustainable resource management.

Rural people play a critical role in the global effort to encourage sustainable development: the natural environment and human agricultural activity confront each other directly in the rural areas. Unsustainable farming methods such as excessive pesticide or fertilizer use reduce biodiversity and pollute water. In some parts of the world poor farming techniques are the leading cause of deforestation, as farmers continually seek out more fertile soil. At the same time environmental damage can also harm agriculture. Destruction of watersheds will often dry up sources of irrigation, while pollution can destroy fisheries and reduce crop yields.

The rural sector also plays a critical role in the effort to reduce poverty, because the most severe poverty in the world remains rural. Three out of four of the world's poorest people—approximately one billion—live in rural areas, surviving on less than a dollar a day. And despite the growth of urbanization in the developing world, current predictions are that the majority of the

poor will continue to live in rural regions for the next twenty to thirty years.

Given the linkages among the rural sector, the environment, food security, and poverty, the purpose of the Fourth Environmentally Sustainable Development Conference was to explore where the international development community should be heading to bring about rural development and achieve rural well-being. Four key goals need to be pursued:

1. *Poverty reduction.* To meet the overwhelming moral challenge of reducing poverty, development efforts must help people where they live. Rural people would not stream to overcrowded cities if they did not believe they would find better opportunities and improved social services there. Investment and sectoral policies must make rural areas more attractive and economically viable places to live.
2. *Widely shared growth.* The effort to foster rural development and reduce poverty will not succeed without broad-based economic growth. No country has succeeded in fighting poverty over the long-term without positive economic growth. Moreover, in most countries, notably in East Asia, growth in the agricultural sector has preceded growth in the industrial sector.
3. *Household, national, and global food security.* It is widely expected that food demand in the developing world, given moderate economic growth, will double over the next thirty years.

Yields must rise if these demands are to be met without encroaching on new lands. This can be done, but it will require a sustained commitment to research, with public efforts supplementing private ones, and it will require improved incentives that encourage more efficient farming methods.

4. Sustainable natural resource management.

Farmers are the stewards of the majority of the earth's renewable natural resources. Public policies must acknowledge their role in protecting the environment and provide them with the skills, knowledge, and incentives to do so effectively.

To discuss ways to achieve those goals for this conference, the World Bank assembled more than 100 leading experts in environmental and development issues, including elected national officials, heads of international organizations, founders of nongovernmental organizations (NGOs), and Nobel prize winners. Numerous academics, government officials, scientists, and development practitioners also participated. The conference, which was held at The George Washington University in Washington, D.C., lasted three days. The first and third days were dedicated to plenary speeches and discussions, and the second day was devoted to a series of roundtable discussions, during which experts presented new information and debated specific topics in greater depth. A series of associated and concurrent events held during the same week rounded out the conference. More than 1,000 people attended the plenary sessions, and many more attended the roundtable discussions as well as the associated and concurrent events.

The conference provided an opportunity for participants from many organizations and countries to share visions, overall strategies, and specific rural development experiences and approaches. It was also an opportunity to build collaborative alliances with partners and to agree on a common vision and general strategies for rural development.

James Wolfensohn, World Bank Group president; Enrique Iglesias, president of the Inter-American Development Bank; Omar Kabbaj, president of the African Development Bank; and Fawzi Al-Sultan, president of the International Fund for Agricultural Development (IFAD), were

among the leaders who addressed the participants and offered the full commitment of their institutions to the rural development agenda.

The consensus that emerged from the conference is reflected in the Bank's new sector strategy, *Rural Development: From Vision to Action*. This document, endorsed by the World Bank Board, outlines in detail the steps the Bank will take to foster rural development starting immediately. The key recommendations are:

- *Take a broad rural focus, as opposed to a narrow agricultural sector focus.* The rural sector strategy focuses on the entire rural productive system. Water resource allocation and comprehensive watershed management are replacing irrigation and drainage as the focus. The management of natural resources in sustainable production systems is taking the place of a separate consideration of agriculture, forestry, or livestock. Human capital development, infrastructure, and social development are being integrated into rural development strategies and programs.
- *Work with partner countries and the broader international community to integrate rural concerns in overall country development strategies.* The rural sector strategy stresses the formulation of country assistance strategies as critical to building consensus both within the Bank and among stakeholders in countries.
- *Address long-ignored issues.* We must not be timid on issues such as land reform, and we must greatly increase our commitment to food consumption policy. Gender will be an important aspect of many of these issues.
- *Address old issues in new ways.* The Bank has acquired considerable knowledge about what works and what does not. We will implement the promising new approaches more widely. For example, we will involve stakeholders in the development and execution of projects through all stages, deliver rural financial services to the poor using new approaches, and promote sustainable resource use through community-based management.
- *Involve the entire World Bank Group in promoting rural development.* Coordination among the different actors must be greatly improved to ensure that efforts are not duplicated or hampered.

The subtitle of the conference, “From Vision to Action,” was chosen carefully. With population growing at 200 people a minute and 95 percent of that increase taking place in the developing countries, we need to move swiftly to eliminate the backlog of problems that leave some 800 million human beings hungry and malnourished. We must redirect economic activity into sustainable pathways. In this regard a broad consensus emerged on what needs to be done now:

- *Reduce distortions in agriculture.* One of the ironies of contemporary economic policy is that advanced industrialized countries have often favored agriculture in policies, while the countries that rely most on agriculture for employment and income have often done the opposite—favoring cities over rural areas. For the rural poor the combined impact of these policies has often been very harmful. Efforts to reduce distortions and establish more even-handed policies toward agriculture must, therefore, be given priority in industrial and developing countries alike.
- *Invest in education and social services.* Rural well-being cannot be gained through investment in economic development projects alone. Education, particularly education for girls, is needed to help people move up the development ladder. Social services, including health services, are also critical for people to maximize their potential and to stem unnecessary urban migration.
- *Promote greater participation and build local capacity.* The evidence is clear that development works best when all stakeholders in the process participate fully. Diverse examples—demand-driven sanitation projects, microfinancing for entrepreneurs, user-managed irrigation systems, and locally run natural resources management projects—all indicate the importance of decentralization and local participation. The development community

must build on, not replace, local knowledge and skills.

- *Increase the use of partnerships.* No institution can be expected to spearhead the development process alone. Rather, everyone involved in the development process, including the donor agencies, national and local governments, NGOs, and the private sector, must work together.
- *Nurture social capital.* Social solidarity, networks of reciprocity, and other manifestations of group and community cohesion are associated with more effective development projects and reduced vulnerability among the poor. In many instances successful development will occur only when combined with efforts to nurture this social capital, whereby issues such as trust and shared understanding serve to promote the search for common solutions. Sensitivity to these issues should permeate project planning and implementation.

This volume contains the presentations of all the plenary speakers as they were delivered or from written texts. In addition, it contains a summary of each of the thematic and regional roundtables as well as summaries of many of the associated and concurrent events. The volume also reprints the background papers submitted by those who participated in the roundtables. In most cases, these are the full, unedited text. In others, for reasons of space, some material was cut; notably, duplicate or background charts and tables submitted as appendices were often eliminated. Full text statements from the associated event on Ethics, Values, Spirituality, and Rural Well-Being are also included.

This volume, which contains a thought-provoking combination of broad-ranging policy statements and sharply focused academic inquiries, should prove useful for a wide audience concerned about sustainable development and the future well-being of the poorest among us.

The Challenges of Agriculture, Food Security, and Natural Resources Management

Ismail Serageldin

Vice President, Environmentally Sustainable Development, World Bank

Every second, three more human beings are added to the population of the planet, 200 every minute, 90 million each year. Nearly 95 percent are born in developing countries. Everyone agrees that the world's population will exceed 8 billion people by 2025, an increase of 2.5 billion in the next thirty years. Much, but not all, of the increase will occur in developing country cities, where urban populations will more than triple. Most analysts agree that, given moderate income growth, food needs in developing countries could nearly double. The challenge to world agriculture is enormous.

Sources of Food Security

Future increases in food supplies must come primarily from rising biological yields, rather than from area expansion and more irrigation. Why? Because land and water are becoming increasingly scarce. Most new lands brought under cultivation are marginal and ecologically fragile and cannot make up for the land being removed from cultivation each year because of urbanization and land degradation. The sources of water that can be developed cost-effectively for irrigation are nearly exhausted, and irrigation water will increasingly need to be reallocated for municipal and industrial use. Therefore, production on existing land will need to nearly double.

The challenge is worldwide and is both technological and political in nature. The technological challenge is enormous, requiring the

development of new, high-productivity, environmentally sustainable production systems. It is not more of the same. Private firms must be induced to develop and apply much of the new technology required. However, there are large areas of technology development that are of little interest to the private sector, including subsistence crops or truly public goods such as some aspects of natural resources management. It is here that public sector finance is critical—at international, national, and local levels. Yet in many countries research capacity and funding are stagnating or even declining.

The political challenge has received much less attention: all major regions of the world must contribute to cost-effective and sustainable food supply growth, including Eastern and Central Europe, Africa, and Latin America. The challenge can be met only if international and domestic policies, institutional frameworks, and public expenditure patterns are conducive to cost-effective and sustainable agricultural development. Otherwise, the required technologies will not be developed and adopted, the supportive infrastructure will not be built and maintained, land and water will not be allocated to their highest-valued uses, and farmers will not have incentives to maintain and improve the natural resources on which their livelihoods depend.

No country has had a sustained impact on reducing poverty without continuing positive economic growth. For most developing countries agricultural growth is essential to economic

growth. Very few low-income countries have achieved rapid nonagricultural growth without corresponding rapid agricultural growth. Most of the developing countries that grew rapidly during the 1980s experienced rapid agricultural growth in the preceding years. For example China's remarkable annual economic growth rate of 9.5 percent during the 1980s and 1990s was preceded by rural and agricultural policy reforms in the late 1970s and early 1980s. Indonesia and Thailand also experienced strong agricultural growth prior to the period of high nonagricultural growth, which continues today.

Agriculture is the primary interface between people and the environment. Almost 70 percent of the land that is colonized by human beings is used to grow food and fiber. Seventy percent of the world's water is used for irrigation and agriculture: in developing countries between 80 and 90 percent of developed water supplies are used for agriculture and irrigation. Farmers have long been the custodians of the biodiversity we use for the crops on which we depend for our very existence. It is estimated that there are some 250,000–300,000 plant species, of which 10,000–50,000 are edible. Yet about 150 species account for almost all human consumption. Action in the rural world is an imperative. This poses a major challenge.

It is essential that the enormous increases in agricultural output required over the next thirty years be achieved with greater regard for natural resources. The environment degradation we have known in the past must be reversed. It must be stopped. I do not believe that it is conceivable, possible, or feasible to assume that further increases in food production in the industrial countries will be sufficient to meet the food needs of developing countries. In fact the only answer for long-term food security is the transformation of agriculture in developing countries. And that will require a transformation of the productive systems of smallholder farms.

The complexity of the agriculture, food security, and sustainable natural resources management issue is well captured in the following seven statements:

- It is not just *production* but also *access*.
- It is not just *output* but also *process*.
- It is not just *technology* but also *policy*.

- It is not just *global* but also *national*.
- It is not just *national* but also *local*. But a national balance is not enough. We know that in many nations, including the United States, there is hunger despite massive surpluses. The pangs of hunger are felt at the household levels, and thus more careful understanding of the nutrition and access of poor households is essential to designing a strategy for food security.
- It is not just *rural* but also *urban*.
- It is not just the *amount* but also the *composition* of food.

Dimensions of Food Security

All of these dimensions make the issues of food security part of a bigger whole in which many policies come together to confront the nexus of problems relating to population growth, environmental sustainability, poverty reduction, agricultural production, distribution, and marketing.

Recognition of this multilayered and multifaceted character of the food security problem leads one to recognize that a whole range of policy and technology responses are required. *There is no single magic bullet to deal with food security.* One must address the issue of when and where to pursue which policy. And here the richness of the tapestry of responses that emerges underlines how important it is to recognize that different actors have different roles to play.

Whichever way you look at the problem, you always end up with the fact that the rural world is the center of the transformation that is necessary to address the issues of sustainability, poverty reduction, hunger, and food security. Ironically, nearly three-quarters of the poor and hungry live in rural areas where food is produced. These people are concentrated in poor, slow-growing countries, and often in regions with poor agricultural potential. Lack of opportunity and poverty have been the main factors pushing the rural poor into cities. Yet a century of migration from the countryside to cities has not been able to reduce the number of poor people living in rural areas. The concentrated poverty and hunger of rural populations is intolerable and must be eliminated in the first decades of the

twenty-first century. This requires concentrated attention on agricultural and rural development throughout the developing world, especially in slow-growing and food-deficit countries.

Despite ongoing urbanization nearly three-quarters of the poor will continue to live in rural areas well into the next century, so it is crucial to address rural poverty now. The majority of the rural poor depend on agriculture for most of their meager livelihoods. Others depend on associated nonfarm activities. Many of the rural poor live in regions where arable land is scarce; agricultural potential is low; and drought, floods, and environmental degradation are common. Of the nearly 1 billion poor identified in fifty-nine poverty profiles completed by the Bank, 72 percent live in rural areas. Basic human services—education, potable water, health care, and sanitation—are far less available in rural areas. The problems of malnutrition, low life expectancy, and high infant mortality are more severe in rural areas.

Ensuring adequate growth of the world's food supplies is therefore not enough. It matters where agricultural production takes place and who receives the associated income. Only if more rapid agricultural growth occurs in countries with impoverished rural populations can rural farm and nonfarm incomes rise sufficiently to enable the rural poor to afford more and better food. And only if the many millions of male and female smallholders are equipped to participate in agricultural growth will rural poverty be reduced and wages for unskilled labor rise in rural and urban areas. This calls for further policy and institutional changes, other supportive international actions, and for concentrating development activities on the smallholder economy.

A Framework for Action

To rise to the challenge, we must address, within a coherent framework, policies and institutions. I also believe we should give special attention to microfinance and agriculture research.

Removing Urban-Bias Policies

On the policy front the most essential thing is to remove the persistent urban bias in policies that

discriminate against the rural world and agriculture. For many countries this bias has dramatically slowed agricultural growth, economic growth, and the reduction of poverty. Governments should make sure that fiscal, trade, and foreign exchange regimes, as well as taxing, pricing, and subsidy policies, do not discriminate against agriculture. Surely both urban and rural worlds deserve to be treated fairly.

Building Effective Institutional Structures

Policies are translated into reality by effective institutions. For bringing about a transformation and renewal of the rural world, many institutions, especially those dealing with credit, titling, distribution, marketing, extension, research, infrastructure and social services, must perform in an effective, enabling fashion. Regrettably, in most developing countries these institutions have tended to be top-down, centralized, and ineffective public institutions. These institutional structures need to be changed. User associations, community-based groups, and effective local governments are badly needed. They should be complemented by decentralized public services, broader public-private partnerships, and a vibrant civil society. These are all part of the responsive institutional framework needed to meet the needs of the growing rural world, and must be nurtured. Communities with well-functioning local organizations are much better equipped to take charge of their own development.

Institutional and legal structures that give smallholders secure access to their land are also essential. When farmers have security of tenure they invest in their land for long-term benefits, produce food more efficiently, use sustainable farming practices, conserve resources, and are less likely to be poor. Governments should ensure that farmers have secure property rights and that communities have secure rights over common-property resources such as grazing areas, forests, and woodlots. With the collapse of the Soviet Union, the new political climate in South Africa, and the move toward markets everywhere, there is now considerable interest in strengthening land administration and undertaking land reform. New approaches to

land reform rely on voluntary and negotiated transactions between willing buyers and sellers, while providing grants to the landless poor to enable them to purchase land. Also important are programs to strengthen land administration and land titling. Land titling can generate many benefits, including improved efficiency of land markets, reduction in conflict over land, enhanced access to credit, and improved incentives to invest in agricultural production.

Also critical are relevant research organizations; responsive, demand-driven extension systems; and institutions providing effective rural finance. Institutions are needed that will in fact empower the poor, the weak, and the marginalized—especially women—to play a greater role in controlling their own destinies.

Increasing the Incomes of the Very Poor

Microfinance is a proven instrument to assist the very poor. Studies show that the very poor, especially women, repay their loans at the phenomenal rate of more than 97 percent and that the benefits of such loans translate into improved conditions for the entire household, especially children. Very poor women can pull themselves out of poverty through successive loans of this type.

Higher income for the poor results in increased investments in education, nutrition, and household welfare, leading to an improvement in the quality of life. In developing countries the microenterprise sector employs an estimated 30 to 80 percent of the economically active population. The lack of access to financial services, such as savings and credit, is a key constraint faced by microentrepreneurs. It is estimated that fewer than 10 million of the few hundred million people who run micro and small enterprises have access to financial services. The ability to procure loans and deposit savings by poor entrepreneurs helps build stronger microbusinesses and leads to greater participation by the poor in economic growth.

The people-centered approach to microfinance was pioneered by specialized nongovernmental organizations and commercial banks such as the Grameen Bank (Bangladesh), SEWA (India) BRI-Unit Desa (Indonesia), K-Rep

(Kenya), and Prodem/BancoSol (Bolivia), among others. They have demonstrated that poor people, traditionally excluded by the formal financial sector, can be a market niche for innovative banking services that are commercially sustainable. The poor are indeed credit-worthy and can be given credit without collateral. They are not asking for handouts or subsidies, but only for the opportunity to improve their lot. The results have been spectacular, especially when the credit is also supported by some essential nonfinancial services.

Contrary to what some may think, the microfinance sector is significant and growing fast. A 1996 worldwide study of microfinance institutions found that they numbered over a thousand (institutions that had been in operation for three years and reached at least a thousand borrowers). Although a handful of giants with more than a million borrowers each (the Grameen Bank and BRI-UD, for example) dominated the picture, there were also at least 6,000 smaller institutions not covered by the survey. The difficulty appears to be scaling up in capacity building at the grass roots.

The figures, however, are still stunning: by September 1995 the one thousand microfinance institutions had US\$7 billion outstanding in 13 million loans. In 1994 alone they issued 33 million loans to their clients. The growth rate was an amazing 31 percent between 1993 and 1994—also a risk factor if they are to maintain their outstanding repayment rates, which usually stand at nearly 97 percent. The majority of the successful credit programs reach out to women. On the savings side they have reached 45 million poor people and mobilized US\$19 billion in deposits.

However, despite the enormous successes of microfinance institutions, two areas still need to be addressed. First, these programs need to expand their coverage—fewer than 2 percent of low-income entrepreneurs have access to financial services from sources other than money lenders. Second, the key to their effectiveness lies in their sustainability: they must ultimately be able to function without continuous subsidies.

If 10 percent of all low-income entrepreneurs are to gain access to institutional finance by 2005, and 30 percent by 2025, financial systems will

need to be transformed. Financial intermediaries' total portfolios in microloans, now about US\$2.5 billion, would need to be about US\$12.5 billion by 2005 and about US\$90 billion by 2025, serving about 180 million low-income entrepreneurs. These rapid increases in lending levels are reasonable and reflect growth rates that are lower than actual growth rates in the past five years. The main challenges will be in expanding the capacity and resources of those retail intermediaries who are committed to providing financial services to low-income entrepreneurs.

If these challenges are to be met, all major actors need to share the objective of providing sound, responsive, market-based financial services to the majority in ways that are advantageous to both the clients and the institutions that serve them. The goal should be to provide access, not subsidies, to low-income entrepreneurs.

Directing Agricultural Research

Even with effective policies, responsive institutions, and a proactive outreach program to provide the poor with access to financial services, rural renewal will not occur if the technology of agriculture does not change. It is here that the importance of agricultural research is highlighted. The challenges facing global agricultural science in the next century are arguably greater than at any previous time. And these challenges must be met in a political environment that is a dangerous mix of complacency, fiscal constraints, aid fatigue, and fundamental disagreements about the magnitude of the problem and the appropriate paths to its solution.

Recent increases in the price of cereals have prompted many to sound alarm bells. While the increases can be understood in a short-term versus long-term perspective, the alarm is justified because the long-term is not automatic. It will require redoubled efforts to improve plants and encourage better farming techniques—including prudent management of water resources—to meet the ever-increasing food needs of a growing population without relying on the excessive use of chemical additives. This can be achieved only through more and better research. There is no doubt that if humankind does not invest adequately in research, productivity increases will

not occur. The good news is that, if we are wise, it is indeed possible to reap the advantages of sustainable productivity increases that science can provide.

The challenge ahead can be stated directly and simply, but meeting that challenge will chart new territory for agricultural science. The task is to sustainably intensify complex agricultural production systems while preventing damage to natural resources and biodiversity and improving the welfare of farmers. Doubling the yields of complex farming systems in an environmentally positive manner is an enormous challenge that is not going to be easy to meet.

The Consultative Group on International Agricultural Research. For more than a quarter of a century, the Consultative Group on International Agriculture Research (CGIAR) has been committed to mobilizing the best in agricultural science on behalf of the world's poor and hungry. Nine donor-members created the CGIAR in 1971. The CGIAR now consists of fifty-six public and private sector members—countries, international and regional organizations, and foundations—supporting sixteen international agricultural research centers. The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) are cosponsors of the CGIAR.

The mission of the CGIAR is to contribute, through its research, to promoting sustainable agriculture for food security in the developing countries. Productivity research to help alleviate poverty and improve natural resources management are the twin pillars of CGIAR research on food crops, forestry, livestock, irrigation management, aquatic resources, and policy; and in its services to national agricultural research systems in developing countries.

The CGIAR is focused on agricultural research. The products of CGIAR-supported research are public goods, unconditionally available to poor farmers and other users. Coupled with this is a commitment to hold fast over the long term, recognizing that it can take up to twenty years to move a research result from laboratories to farmers' fields. Scientific excellence is the hallmark of the CGIAR system. The Group

is best known for the green revolution. And while the green revolution has been criticized by some, it has without question been one of the most remarkable successes of humanity. The high-yielding crop varieties that were launched as part of the green revolution averted a massive famine that was looming in South Asia in the late 1960s and early 1970s. Indeed, the improved crop varieties that were part of the green revolution are still spreading, reaching 70 percent of basic crops in the developing world.

The breeding of these new varieties has saved enormous amounts of land. If yield levels in India had remained at 1960 levels, India would have had to bring a huge amount of extra land under production to achieve the levels of food production it reached in 1990. The story is similar for nearly all countries in the world for almost any cereal crop. The amount of land spared in all countries benefiting from the green revolution totals some 300 million hectares, an area the size of India. Just think how many more forests would have had to be burned and destroyed, how much more biodiversity would have been lost if not for the green revolution.

A doubly green revolution. But now we need to go beyond these achievements. A huge institutional agenda remains unfinished. We need to launch a doubly green revolution: one in which genetically diverse new crop varieties are constantly being brought forward, where we minimize pesticide use through integrated pest management, and we improve farm water efficiency and nutrient management in terms of complex farming systems that are more efficient at the smallholder level. We need a greater focus on environmental sustainability and the poverty impacts of the developments proposed, especially the benefits they bring to poor women farmers. These are the hallmarks of the new doubly green revolution that the CGIAR is pursuing. And in doing so, its programs focus on increasing productivity, protecting the environment, saving biodiversity, improving policy, and strengthening the national research systems.

Increased productivity involves not only grain quantity but also the quality of the crops. Beyond issues of taste, storability, and transportability, there is also the issue of nutritional content. The nutrient content of the plants is an

interesting challenge that agricultural research should be pursuing.

Investment in agricultural research has generated stunning rates of return in developing countries: very few investments have returned more. Returns to investments in agricultural research based on benefits to the poor in developing countries run from a low of 42 percent to 191 percent. These are *ex post* rates of return, not anticipated rates of return. This means that a few pennies invested will bring enormous returns to all the people of the world—primarily to those of developing countries, but also to the industrial world, which benefits too.

Toward the Millennium

Today's problems are complex. Science can help us to solve them, but the mobilization of science has to be reshaped as science itself changes. Science must be used in getting the facts—defining the problems and the degree of uncertainty and risk—thereby helping to frame the debate about priorities and new technologies.

Getting the Facts, Defining the Problems

The world has seen an explosion of information and scientific achievements. Yet, that very multiplicity of information makes it essential to define our problems accurately—to get the facts right.

So much of the debate among policy makers, advocacy groups, and the press is based on partial figures and incomplete or inaccurate information. Sensible discussion and appropriate policies are thereby made elusive. What virtue is there in carrying out an impassioned debate on food production in China when the protagonists use vastly divergent figures on the acreage under cultivation, figures on which the yield estimates depend?

Now is the time to be bold and to ensure that new breakthroughs in geographic information systems (GIS) and computing will make it possible for more accurate figures to be obtained on the kinds of questions that determine policy. Beyond using GIS/computing, databases, and scientific interpretation, the international scientific community can state problems accurately,

define areas of uncertainty and risk, identify new technologies, and help set the boundaries of debate.

Setting the Priorities for Research

Research and science decision makers clearly face myriad complex and difficult choices. Let me list just a few real world choices.

Favored versus less-favored areas. Focusing resources on favored areas means higher food output and lower food prices for urban and rural consumers. How should we weigh this goal against that of reducing poverty in marginal areas in which as many as 500 million poor people in developing countries now live? How do we allocate resources between traded food grains and subsistence roots and tubers? How do we help the people we want to help—the poorest, women, and those who cultivate fragile environments?

Traditional versus exotic crops. The Sahel is one of the most difficult environments in the world. What is the best approach to raising the productivity and incomes of poor farmers in this region? Should investments be made to improve the yields of traditional crops, millet and sorghum, or to improve the stress resistance of higher-yielding, nontraditional maize? How much should be devoted to developing new export crops?

Time horizon choices. What should be the time frame of expected impact? Often improved agronomic practices such as spacing, seeding time, weed control, and planting depth can have short-term yield impacts. Genetic improvement, however, particularly involving complex characteristics, takes much longer to achieve but has higher long-run yield potential. How much should we invest in small incremental improvements versus the development of radical new technologies, such as transgenic techniques for apomixis and plant resistance? What is the appropriate discount rate for food-deficit, poor countries with limited research budgets?

Environmental improvement versus yield maximization. Frequently this is posed as a major tradeoff in setting priorities, but it cannot persist as such. Clearly the major challenge to agricultural science is to turn this apparent win-lose sit-

uation into a win-win situation. This is a non-trivial scientific task that is long-run and interdisciplinary. How much should be invested in fundamental research as opposed to applied systems improvement?

International versus national research investment. What should be the distribution of resources among local, national, regional, and international research? Should every country have its own research system? How much should donors invest in the CGIAR versus strengthening national programs? What role should multinational firms play in global research systems? What are truly public research goods—nationally and internationally?

Research for new technologies versus research on removing impediments to applying known technologies? This is not a trivial question. It is estimated that if the average developing-country farmer produced at the level of the average Iowa farmer, the world could feed 10 billion persons on the land currently under production.

Production processes versus postharvest technologies? As much as 15 percent of production is lost between the farm gate and the consumer. Furthermore, the transportability and storage of food will grow in importance as the number of urban consumers grows.

The integration of traditional knowledge and modern science. Traditional knowledge, including identification of indigenous species, must be documented before it is lost. It must be integrated in a two-way exchange of ideas with modern science, and the small-scale farmers, who are the custodians of this knowledge, should benefit from these efforts. How much of the available resources should be dedicated to this effort?

The Special Challenges of Biotechnology

Biotechnology could help develop hardier plants with resistance or tolerance to drought, salt, and herbicides. Plant characteristics could be genetically altered to adjust maturation speed, increase transportability, reduce postharvest losses (for example, shelf-life), as well as water content, stem size, and the like—all aspects of great relevance to poor farmers in low-potential environments.

Biotechnology is also relevant because it is seen to be scale-neutral. Unlike mechanization, for example, it has no intrinsic bias against the smallholder farmer. In the case of livestock, essential to the smallholder farmer, biotechnology provides the most important defense against disease (for example, vaccines for east coast fever in east Africa).

The biotechnology revolution is here. However, it raises important questions relating to ethics, biosafety, and intellectual property rights.

Ethical issues. For many, including myself, not everything that is technically feasible is ethically desirable. For some, transgenic tinkering with nature raises fundamental issues, which must be respected. Conversely, this must be weighed against the possible benefits that biotechnology, with adequate safeguards, can bring to the poor and the environment. Ethically, we cannot accept the notion that deprivation should forever be imprinted on the genes of the poor and destitute—that misery is their inevitable destiny. Both sets of issues need to be boldly confronted.

Safety issues. The correct balance has to be established when weighing the benefits against the risks of biotechnology.

In addition to the concerns of possible health or environmental impacts of these transgenic organisms in food crops, the fear exists of transgenic plants turning into weeds, providing paths for new genes to move into wild plants that become weeds, or creating new viral strains from virus-containing transgenic crops.

Such concerns are real. They must be examined dispassionately.

Intellectual property rights. A huge transformation in biotechnology is taking place, with an enormous increase in market capitalization in the last year. In the United States market capitalization of biotechnology firms increased by more than US\$30 billion to reach more than US\$83 billion. In the United Kingdom it jumped from ECU 261 million to ECU 1.2 billion. This is being accompanied by a consolidation of the big private sector companies, dominated largely by pharmaceutical companies, and with a large number of smaller “niche” specialty biotechnology firms. In the United States these biotechnology firms now employ more than 120,000 people and spend about \$8 billion annually on research.

Patents are essential for these private sector firms to mobilize the funds to continue to make huge investments. They will recoup their investment only if they are able to market it. Efforts are under way to further extend the life of patents, and the Moorhead-Schroeder bill in the U.S. Congress is seeking to extend the life of a patent by more than 20 years.

What is covered by a patent is also in the process of being defined. The so-called Markman hearings, at which judges hear witnesses and decide the exact coverage of the patent before going to adjudicate whether infringement has occurred, are helping to develop case law on the coverage of patents. In addition a number of lawsuits among the primary actors in biotechnology are helping to define the boundaries or the rules of the game.

The situation on the ground is very complex. More than forty companies hold 410 patents relating to *Bacillus thuringiensis*. Egypt has recently filed for a patent of its own concerning *Bacillus thuringiensis* resistance. Another indication of patenting complexities is that six collaborating companies are also engaged in lawsuits over patent rights infringements. Nobody said this was going to be easy.

Those who argue for the patenting of such research point to the experience with computers and informatics—a explosion of new products and technologies, ever lower prices, and a wider reach to serve everyone. Those who challenge the use of patenting of both process and product point out that the patterns observed in other industries, such as the pharmaceutical industry, in which breakthroughs are few and far between and the costs can be considerable to both the producers and the consumers. Which is it likely to be?

Concluding Remarks

Let me conclude by returning to the broader context. Meeting the challenges of reducing poverty, ensuring food security, and managing natural resources sustainably requires many actions. Agricultural science research is absolutely necessary but not sufficient to bring about the desired outcomes.

To double agricultural output while preserving the natural resources on which production is

based, and to do it in a manner that benefits the poor and increases food security will require:

- Rapid technological change in agriculture in the industrialized and the developing world. The private sector will have to undertake an increasing share of the necessary research and diffusion. Public sector financing will be needed for areas of limited interest to the private sector, such as genetic resource conservation, common property resource management, integrated pest management, and research on subsistence crops.
- Massive increases in the efficiency of irrigation water use through changes in water policies, water rights, and institutions for allocating water and through technical improvements in water conveyance and use.
- Dramatic improvements in the management of soils, watersheds, forests, and biodiversity by local and community-based institutions.
- Accelerated private investment in the rural economies of the developing world.

- Enhanced support from the international community to the agricultural and rural development programs of poor countries. If countries are to pursue optimal food strategies, they must have stable, long-term access to world markets. Countries may then focus on producing the goods in which they have a comparative advantage, exporting them in exchange for goods that they cannot produce efficiently, including food. Only with stable, long-term access to world markets can countries comfortably refrain from costly food self-sufficiency policies (which are not the same as food security policies).

The challenges are also technological and political. They require dramatic improvements in national and international policies, institutions, and public expenditures. The role of research is fundamental. The 1.3 billion poor who subsist on less than a dollar a day have waited far too long for these changes. Let us get on with the job.



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