Consultative Group on International Agricultural Research

CGIAR ANNUAL REPORT 1999

SCIENCE FOR THE POOR AND THE ENVIRONMENT

CGIAR CENTERS **CIAT:** Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture), Colombia **CIFOR:** Center for International Forestry Research, Indonesia **CIMMYT:** Centro Internacional de Mejoramiento de Maiz y Trigo (International Center for the Improvement of Maize and Wheat), Mexico **CIP:** Centro Internacional de la Papa (International Potato Center), Peru **ICARDA:** International Center for Agricultural Research in the Dry Areas, Syria **ICLARM:** International Center for Living Aquatic Resources Management, Malaysia **ICRAF:** International Centre for Research in Agroforestry, Kenya **ICRISAT:** International Crops Research Institute for the Semi-Arid Tropics, India **IFPRI:** International Food Policy Research Institute, United States **IITA:** International Institute of Tropical Agriculture, Nigeria **ILRI:** International Livestock Research Institute, Kenya **IPGRI:** International Plant Genetic Resources Institute, Italy **IRRI:** International Rice Research Institute, The Philippines **ISNAR:** International Service for National Agricultural Research, The Netherlands **IWMI:** International Water Management Institute, Sri Lanka **WARDA:** West Africa Rice Development Association, Côte d'Ivoire

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OUR MISSION **To contribute to food security and poverty eradication in developing countries through research, partnerships, capacity building, and policy support, promoting sustainable agricultural development based on the environmentally sound management of natural resources.**

The Future Beckons

The marvels of science are exploding in myriad ways. Yet harnessing these marvels to end human misery is a responsibility that will require redoubled efforts.

Ismail Serageldin, CGIAR Chairman

Message from the Chairman, Ismail Serageldin

Five years ago, when the CGIAR concluded a program of renewal and launched a regenerated CGIAR, we agreed that "the success of every program we espouse, every project we undertake, every endeavor we support, has to be measured by the extent of their contribution toward alleviating poverty." That is a living commitment that requires frequent review and renewal. So it was appropriate that we returned to this theme at International Centers Week in 1999 (ICW99), our last meeting of the century, at which we decided to create a new vision to help us go out and meet the future.

The founders of the CGIAR created this unique institution to fight hunger, combat its cause, poverty, and inhibit the wider consequences of both. Their perceptive vision, formulated in the context of their times, has been fulfilled. Few of the outstanding scientific innovations of the past 100 years have had as great an impact on the lives of as many people as the "green revolution" technologies. They led to an agricultural transformation in much of Asia and Latin America, saving millions from the threat of starvation or death, preserving land and biodiversity, and reducing poverty by fueling broad economic growth.

Today, the global circumstances of poverty, hunger, and environmental degradation challenge us to transform agriculture yet again. The task is crucial and complex, involving both people and the environment. We have, for instance, to prevail over the bizarre irony that rural areas, where food is grown, are home to cruel poverty and hunger. We need, at the same time, to ensure that productivity is fully sustainable—that triumphs are not achieved at the expense of fragile natural resources.

The tasks appear formidable but, as M. S. Swaminathan, an elder statesman of the CGIAR, points out, "there are numerous opportunities now to harness the power of synergy between science and public policy to address contemporary development issues such as the growing divide between the rich and the poor, the feminization of poverty, the dearth of jobs, overpopulation, climate change, and the loss of forests and biodiversity." We must not—we dare not—lose those opportunities.

So, we are challenged to design a new vision for a new millennium, indeed, a new age. It is an age in which the marvels of science are exploding in myriad ways. Yet harnessing these marvels to end human misery, promote sustainable development, and empower the weak and the marginalized is a responsibility that will require redoubled efforts.

The new breakthroughs that we have been witnessing in the domains of molecular biotechnology involve more than just the ever-increasing speed and accuracy of genomic sequencing techniques, or a deepened understanding of the functioning of ever more genes, or the systematic unraveling of the encoding of proteins. All these developments are exciting. Far more than any single discovery, however, the changing face of the new science needs to be taken into account as we map our future course.

Today, the new science is more and more the preserve of the private sector in the industrialized North. The private sector mobilizes undreamed of amounts of research money, rapidly accelerating the pace of new discovery. This is commendable. But it is accomplished in a way that makes it increasingly difficult for those engaged in public goods research to deal with in terms of Intellectual Property Rights (IPR) and the need to access the toolkit of the new science productively, while continuing to make our output available to all. Resolving such conflicting approaches will require the negotiation and establishment of new boundaries, and the creation of new mechanisms.

But biotechnology and germplasm improvement are only a small part of the CGIAR vision. Furthermore, beyond crops, to tackle poverty, there is a crying need for intensified attention to policy, to environmental issues (including water and soil), to livestock, to the forestry and aquatic sectors, and to ethics and safety in all we undertake.

Very little of this can be done without the full involvement of national agricultural research systems (NARS) in the South. The widely differing capacity of NARS makes capacity building of the weakest among them especially urgent. Moreover, any simple unified approach that does not contextualize research within the ecological and socio-economic context of the various countries will be unrealistic. Of similar significance and urgency is attention to gender issues and to participatory methods at all stages of agricultural transformation. Agricultural research, if it is to be relevant and realistic, must be designed and carried out in collaboration with farmers and farmers' organizations. The farmer in the field and the scientist at the laboratory bench will then be united by devotion to a common cause. Looming over all these issues will be the need for adequate investment over the long term.

The future beckons. There are difficulties ahead. There are, as well, rewards, not just for scientists, managers, and investors who can combine to create and design a new vision, but for the poor for whom there is now no vision and little hope. Their destiny must be the vision of us all. The critical issue, therefore, is that every instrument of science-based agricultural transformation should be mobilized in our efforts to feed the hungry, liberate the poor, and protect the environment. We cannot accept the notion that deprivation is imprinted on the genes of the poor and destitute and that misery is their inevitable destiny.

Overview from the Executive Secretary, Alexander von der Osten

As public attention was riveted on the beginning of a new millennium, three A's prevailed: awe, anxiety, and anticipation. The CGIAR System faced the same three As, but for its own, special reasons. The breadth and complexity of the challenges looming in the new millennium could only be described as awesome. Anxiety was inevitable in the face of such challenges. Yet, there was broad anticipation that the CGIAR could and would overcome them.

The third System Review, which was brought to closure at the CGIAR Mid-Term Meeting in Beijing (MTM99), said that the work of the CGIAR constitutes "a profoundly significant achievement, with an impact on the lives of millions who would otherwise have been hungry, malnourished, or would have died." The CGIAR was urged to build on the bedrock of past achievement, designing new strategies, new research roles, and new structures to grapple with poverty, hunger, and protection of the environment.

The nexus of challenges is formidable. Despite the great advances made in the twentieth century, more than a billion people continue to live in extreme poverty. Some 800 million people are hungry. Most of the world's poor live in rural areas at a time when rural regeneration is receiving less attention and investment than it deserves. At the same time, the natural resources on which all mankind depends are under siege.

In the face of these complexities, the CGIAR System decided that looking ahead is vital. "More of the same" is untenable in the context of changed and changing conditions affecting the poor and disadvantaged. The task of harnessing dazzling scientific developments to support and fulfill the mission of the CGIAR requires continuing and consistent renewal. The CGIAR System decided to march boldly forward.

Thus, at International Centers Week, the CGIAR launched a visioning exercise. The Technical Advisory Committee (TAC) was mandated to carry out a forward looking assessment, with a five to ten year perspective, of what directions the CGIAR should take, how its research should be conducted, and with what partners it should work. TAC has responded to the remit decisively and in a participatory mode. The Centers have been fully consulted, and their accumulated wisdom and experience are being incorporated in the new vision of the CGIAR. Additionally, interested stakeholders have exchanged ideas and suggestions through an electronic "chat room." These and other consultations will strengthen the substance of proposals that are being crafted.

The challenges of the new millennium, it is worth repeating, are awesome. Financial uncertainty among some investors adds to the complexity of these challenges. CGIAR funding for the agreed research agenda is stable. The World Bank has maintained its support at $50 million and, in response to the assessment of the System Review, has approved three-year funding for the CGIAR. More than stability is required, however, if the CGIAR is to realize its potential contribution to poverty alleviation.

The need for expanded funding comes at a time when many OECD/DAC countries are disenchanted with Official Development Assistance (ODA) and when pressures on ODA budgets have increased. These circumstances frequently trigger constraints and allocation readjustments. Investments in the CGIAR are vulnerable to all such tendencies. A long-term strategy for CGIAR funding is therefore critically important.

On the positive side, several trends noted in the period of this annual report provide grounds for optimism:

First, both as catalyst and member, the CGIAR is able to influence as well as to draw strength from the global agricultural research system. The CGIAR now collaborates with a wide range of partners, including regional and national agricultural research systems (NARS) in the South, non-governmental organizations (NGOs), advanced research organizations in the public and private sectors of both South and North, and the farm community. All

Most of the world's poor live in rural areas at a time when rural regeneration is receiving less attention and investment than it deserves.

of these partners meet at and use the Global Forum for Agricultural Research as an instrument of consultation. The CGIAR System is institutionally linked with NGOs, the private sector, and the international scientific community through partnership committees.

Second, the governance institutions of the CGIAR System are fully engaged in dealing with both short- and long-term issues that affect the System's capabilities. They have been fine-tuned through experience and strengthened with the creation of an *ad hoc* Consultative Council of all stakeholders representing the CGIAR System. In a short period of time, this innovation in governance has proved its usefulness as a mechanism for supporting sharply focused discussion and decision-making by the CGIAR as a whole.

Third, CGIAR Centers are committed to mobilizing frontier science and technology to attack poverty and hunger and to sustainably manage natural resources. Close and productive working relationships between Centers and NARS have evolved. The scientific excellence of the Centers is universally recognized.

Fourth, it is now well established that CGIAR Centers are able to influence agricultural policy, programs, and progress in individual countries. By way of example, a series of well-documented presentations at MTM99 showed how linkages between CGIAR Centers and Chinese NARS had affected almost every aspect of China's agricultural transformation from capacity building through policy assessment to sustainable productivity.

Fifth, empirical evidence has clearly identified how and revealed to what extent agricultural research directly and indirectly alleviates poverty. The System's Impact Assessment and Evaluation Group has established scientific evidence of this chain of cause and effect, as has intensive field research that was presented during the year to an international audience at a symposium organized by CIAT.

The foremost message emerging from 1999 is that the CGIAR is poised for creative and productive change. The ultimate impact of this change will be on the lives of millions now barely touched by the potential of science and technology. Clearly, a sense of anticipation is apt.

The CGIAR is poised for creative and productive change.

About the Consultative Group on International Agricultural Research

The largest scientific network of its kind, the CGIAR works through global partnerships to promote food security, poverty eradication, and the sound management of natural resources—an ambitious and compelling agenda. Established in the 1970s, the CGIAR now pursues these objectives through the activities of 16 international research Centers. The CGIAR's 58 members—industrial and developing countries, private foundations, and regional and international organizations—provide vital financing, technical support, and strategic direction. A host of other public and private organizations work with the CGIAR as donors, research associates, and advisors.

The need for a special partnership within the agricultural research community focused on fighting hunger and poverty through productivity-oriented research was first recognized in the late 1960s, in response to the specter of widespread famine in parts of Asia. Leaders from 18 international organizations, foundations, and concerned governments formally joined together in 1971 as the first members of the CGIAR. Through their continuing support, hundreds of new wheat and rice varieties were developed, released, and planted in developing countries, adding an estimated $50 billion to the value of world food supplies over two decades.

To build on these achievements, new CGIAR Centers were founded to work with national research institutions in pioneering improvements in other key food crops, such as legumes, roots, tubers and other cereals, and to concentrate on better management of livestock. Centers were established to work on the problems of dry, semi-arid, and tropical regions, and to conduct research on forestry, agroforestry, water management, fisheries and marine resources. Centers were also set up to analyze national and international food policies, and to build the capacity of agricultural research at the national level.

Today, 16 CGIAR Centers around the world are harnessing cutting-edge knowledge to help meet the world's enormous food needs—with a steadfast allegiance to scientific excellence and the public good. The advances made through CGIAR research are international public goods; new plant varieties, pest control methods, and resource management technologies are available free to all interested parties. For more information visit *www.cgiar.org*

Future Harvest

Two years ago, the 16 Centers supported by the CGIAR created a new entity designed to build support for international agricultural research. Now called Future Harvest, this entity has evolved into a charitable organization focused on food and environmental research for a world with less poverty, less conflict, a healthier human family, well-nourished children, and a revitalized environment. Future Harvest supports research, promotes partnerships, and mobilizes the world community to meet the human and environmental challenges of today and tomorrow.

Future Harvest commissions research to examine the links between agriculture and critical issues such as peace, prosperity, environmental renewal, health, and the alleviation of human suffering. Outreach efforts are focused on innovative Internet-based and media relations strategies. More than a dozen world influentials serve as ambassadors for Future Harvest, including former U.S. President Jimmy Carter, Queen Noor of Jordan, Nobel Peace laureates Desmond Tutu and Oscar Arias, and Grameen Bank founder Muhammad Yunus.

During this new century, the earth will need to sustain an additional 75 million people each year. This task will require a commitment to science for food, the environment, and the world's poor. Future Harvest is working to ensure this commitment.

For more information visit *www.futureharvest.org*

The CGIAR's first public service announcement aired worldwide—including CNN International, Bloomberg Television (Asia, Europe, United States), Star Television, and television stations in China and Germany—with the message that "hunger is everyone's concern."

In the News

***Business World* (The Philippines)**
The CGIAR is ideally positioned to address the next compelling challenge that agricultural scientists must confront: combining conventional research with the promise of the genetic revolution.

***Science* magazine (United States)**
The critical advances of the Green Revolution—and other work by the 16 international agricultural research Centers that make up the Consultative Group on International Agricultural Research (CGIAR)—helped world grain harvests more than double since 1960.

***Frankfurter Allgemeine Zeitung* (Germany)**
Even though the CGIAR's budget comprises only 4 percent of the global expenditure on agricultural research, experts agree that its work is of strategic importance for the rest of agricultural research. More so, with returns on investment between 22 and 191 percent, CGIAR Centers exceed (those achieved by) similar private research institutions by far.

***The New Republic* (United States)**
The CGIAR labs and their offshoots have been spectacularly successful, as the ever-declining incidence of world hunger attests. Indeed, economists generally believe that agricultural research is one of the best ways governments can spend money.

***O Estado de S. Paulo* (Brazil)**
The CGIAR shows that 95 percent of population growth occurs in the poorest countries, and it is the only entity in the world that is dedicated exclusively to mobilizing the best that agricultural science has to offer on behalf of people suffering from poverty and malnutrition.

Op-ed by Jimmy Carter, *The International Herald Tribune*
Why has peace been so illusive? A recent report sponsored by Future Harvest and generated by the International Peace Research Institute in Oslo examines conflicts around the world and finds that unlike that in Kosovo, most of today's wars are fueled by poverty, not by ideology.

***The Washington Post* (United States)**
Water, water not quite everywhere, and not enough of it. And what very little fresh water the world has, it is squandering. That's the message of the CGIAR as it looks to the needs of the planet's farms and urban areas in the next century.

***The Financial Times* (United Kingdom)**
The world's major network of international agricultural research Centers, run by the CGIAR, has already pledged not to include such characteristics (genetic systems designed to prevent seed germination) in any plant breeding material they produce.

***The Hindu* (India)**
The CGIAR, with its worldwide network of international agricultural research Centers, has a critical role to play in applying the new scientific advances for the basic needs of humanity. The Centers represent the only authoritative international scientific organization capable of harnessing the tremendous capacities of science to address the problems of the poor in the developing world.

***The Globe and Mail* (Canada)**
"New ways must be developed to take advantage of this diminishing resource if humanity is to feed itself in the 21st century," said Mr. Serageldin, who heads the CGIAR. In an effort to improve water management, the group has compiled a massive electronic world water and climate atlas, a high-tech undertaking designed to assist local farmers, their bankers, government planners and even international financial groups.

***China Daily* (China)**
Chinese officials vowed to intensify China's collaboration with the CGIAR, "which has been most fruitful since it first started in mid-1980s," in the upcoming new millennium.

"Invest in agricultural research and cultivate peace," Future Harvest's first public service announcement, was produced in nine languages and aired on CNN International, CNN Español, CNBC Europe, Star TV Asia, as well as television stations in the United States.

Perspectives on Agriculture and Science

As the World Bank's leading advocate for increased sustainable agricultural production in developing countries, the Rural Development Department shares goals with the CGIAR.

Robert Thompson

The Challenge of Rural Development

Robert L. Thompson, the World Bank's new Director of Rural Development and CGIAR Cosponsor Representative, shares his perspective on the enormous challenge of overcoming rural poverty.

Despite today's record low food grain prices, more than 800 million people suffer from malnutrition. The vast majority live in the world's poorest countries, where poverty remains a principal cause of food insecurity.

Over the next fifty years, global food demand is likely to double due to both population and income growth. Increased incomes will change patterns of consumption in developing countries, raising demand for vegetables, fruits, meat, fish, and edible oils. Therefore the need to boost food production, while protecting the natural resources on which future food production depends, is urgent.

There is very little additional arable land in the world that is not highly erodible, subject to desertification, or forested. To increase agricultural production by expanding the area planted would require massive clearing of forests, resulting in the loss of wildlife habitats, biodiversity, and carbon sequestration capacity. These outcomes are all environmentally unacceptable. The only sustainable course is to enhance the productivity of cultivated land by using each hectare to the fullest, based on environmentally sound technologies.

The revolution in the biological sciences promises powerful new tools for genetic improvement of food crop and livestock species. But most of the critical research is in the private sector. Among the world's top 300 companies, spending on agricultural research and development surpasses $24 billion. Although the resulting knowledge creates opportunities, the risk that poor countries will not be able to maintain access to scientific advancements protected as intellectual property is real. The private sector's large investments in biotechnology research also have major implications for poverty reduction because their research funding priorities often miss the crops that are vital to the poor in the developing world.

Numerous studies have documented the high rate of return on investments in agricultural research, generally in the range of 50 to 80 percent per year. Unfortunately, public investments in agricultural research have declined significantly. For much of the 20th century, most agricultural research results were public goods, ultimately benefiting consumers in the form of lower food prices. Public investment in agricultural research directly benefited all consumers, especially the poorest, who spend the largest fraction of their income on food. It is essential that public support for agricultural research be sustained to complement private funding to assure food security for a burgeoning world population.

Rural development is central to the World Bank's poverty reduction mission, and the Bank has a long tradition of supporting the development of scientific capabilities in agriculture in developing countries. The Bank has been a steadfast partner of the CGIAR since its inception. Bank President James Wolfensohn has called for a comprehensive rural strategy as a cornerstone of the Bank's poverty alleviation efforts. With this intensified poverty reduction effort, the Bank will play an even stronger leadership role in international agricultural research.

As the Bank's leading advocate for increased sustainable agricultural production in developing countries, the Rural Development Department (RDV) shares goals with the CGIAR. CGIAR technologies underpin the Bank's rural lending programs that are directed at alleviating hunger and poverty, improving rural productivity and raising agricultural incomes, protecting the environment, nurturing partnerships, and building the capacity of national agricultural research and technology transfer systems.

The CGIAR's agenda is directly relevant to the work of RDV—from sustainable management of natural resources, to forestry and agroforestry, to improving water use efficiency in agriculture.

The CGIAR has a solid foundation of collaboration with the Bank. There are new synergies to be exploited to help confront challenges to the Bank's rural poverty agenda, such as:

- **Forest Policy Implementation** Because many of the world's poorest people are highly dependent on forests, the Bank's support for forestry must be based on the imperative of poverty reduction. A recent internal study of the Bank's forestry programs called for more strategic policies and partnerships to promote the coming together of conservation and development objectives. As the Bank reviews its forestry strategy, the CGIAR Centers' cutting-edge research on sustainable forestry management and work on forestry policy issues will be directly relevant.
- **Water Resources** IWMI and IFPRI were both involved in the development of *A Water Secure World: Vision for Water, Life, and the Environment,* which was released at the Second World Water Forum. In his speech to the Forum, Mr. Wolfensohn emphasized that lack of access to water is synonymous with poverty in the developing world. He also announced the formation of the Water Resources Management Group within the Bank. As the Bank strengthens its approach to the management of water resources, the CGIAR Centers can provide valuable assistance.

The challenge of rural development in the 21st century is formidable. The Bank welcomes and looks forward to increasing opportunities for collaboration with the CGIAR.

Charting a Course for System Change

Emil Javier is the new Chair of the Technical Advisory Committee (TAC), which is charged with developing priorities and strategies for the CGIAR and assuring the quality and relevance of the Centers' science. In this guest editorial, Dr. Javier discusses the new vision and strategy for the CGIAR.

At ICW99, the CGIAR asked TAC to develop, in close consultation with the Centers, Members, and stakeholders, a new vision for the CGIAR in 2010. More than 1.2 billion people continue to live in conditions that are below any standards of human dignity.

Food security and poverty reduction must remain the driving forces of the CGIAR. Our vision is a food-secure world for all. Our mission is to achieve food security and poverty reduction through scientific research, improved policies, and research-related activities in the fields of agriculture, forestry, and fisheries. And these goals must be accomplished while conserving and enhancing the soil, water, and biodiversity resources upon which long-term, sustainable agricultural productivity depends.

There is strong evidence of the linkage between agricultural research and poverty alleviation. Agricultural research helps to produce the technology and the knowledge necessary for sustained agricultural development, which is essential for economic growth. Rural economic growth, in turn, is the most effective instrument for poverty alleviation in countries where the majority of the poor live in rural areas.

The CGIAR has made its biggest impact on poor consumers as well as on poor producers in favorable areas. We now need to tackle food security and poverty challenges in the more marginal environments where large concentrations of poverty persist. This task calls for a research paradigm that is ecologically oriented and regionally focused and that draws into active play the indigenous knowledge and political will of the affected communities.

Advances in molecular biology, information science, and communications are generating new and more powerful research tools. The massive entry of the private sector into some of the traditional domains of public agricultural research represent significant opportunities for partnerships that will harness the full power of modern science and technology for agriculture.

The task ahead is enormous and daunting. We need to help put into place an integrated global research system for agricultural development—a system that effectively links community, national, and regional efforts with the efforts of research and development groups in developed countries and in the private sector. The CGIAR's network of international agricultural research Centers should play, with relatively small resources, a nevertheless leading role in such a global system in the foreseeable future. However, to be sustainable in the long run, this international network of research capability should be increasingly owned by the developing countries.

The task ahead is enormous. We need a system that effectively links community, national, and regional efforts with the efforts of research and development groups in developed countries and in the private sector.

Agricultural Biotechnology and the Poor

Gabrielle J. Persley wrote the overview chapter ("Promethean Science") and is co-editor with Manuel Lantin of* Agricultural Biotechnology and the Poor. *The book, published by the CGIAR, contains the major contributions presented at a CGIAR/U.S. National Academy of Sciences-sponsored conference held in October 1999 at the World Bank in Washington, DC.

Prometheus, according to Greek mythology, was a Titan, responsible for introducing fire to humans, a remarkable innovation at the time, but having benefits and risks, depending on its use. Promethean has since come to mean daringly original and creative. Since science is an elegant way of getting at the truth, it should therefore follow that molecular biology and other tools of modern biotechnology add elegance and precision to the pursuit of solutions to thwart poverty, malnutrition, and food insecurity in developing countries.

In the debate about biotechnology, the elegance of science in the pursuit of truth is not appreciated by all. The debate has tended to focus on the potential risks to human health and the environment. Biotechnology, however, has the potential to contribute to the solution of human problems, particularly in developing countries.

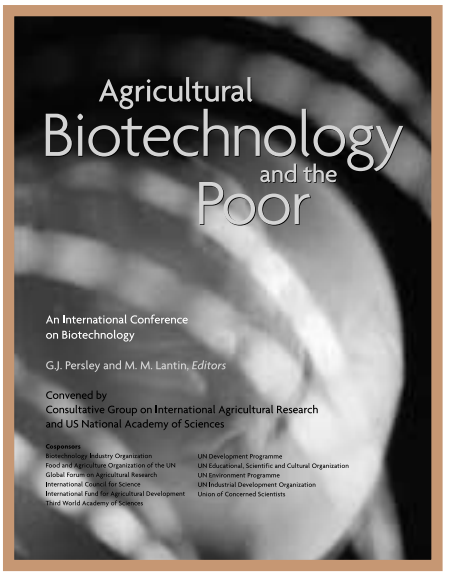
Despite the increasing availability of food, over 800 million people in developing countries are food insecure, and 200 million of these are malnourished children. It is a further paradox that food insecurity is so prevalent at a time when global food prices are generally in decline. The basic cause of this two-pronged paradox is the intrinsic link between poverty and food security. Simply put, people's access to food depends on income.

The most important global challenges are:

- Alleviating poverty, improving food security, and reducing malnutrition, especially among children;
- Providing sufficient income for the rapidly increasing numbers of urban poor; and
- Using new technologies for environmentally sustainable development.

Key issues that will affect the application of new developments in modern biotechnology for the public good are ethics, food and environmental safety, and intellectual property management.

In agriculture and forestry, biotechnology promises new ways to harness and improve the genetic potential of crops, livestock, fish and forests, and better ways to diagnose and control the pests and pathogens that damage them. The perils lie in the profound ethical issues surrounding the control and use of these powerful new technologies, and the assessment and management of risks to human health and the environment.



The CGIAR should enhance its role as protector of the interests of the poor and facilitator and bridge-builder in biotechnology partnerships, and facilitate public policy and innovative institutional arrangements. The CGIAR Centers could develop, for the benefit of poor countries, more innovative partnerships with the private sector and with universities and other advanced research institutions.

There are seven activities in which the CGIAR System could play a useful role:

- Facilitating sharing of information about developments in the use of modern biotechnology in developing countries;
- Identifying barriers to and opportunities for mobilization of science to address the problems of the poor, and identifying technical, policy, and institutional issues to be addressed at national, regional, or international levels;
- Providing further technical support for building the capacity of national agricultural research systems;
- Ensuring that CGIAR Centers comply with accepted biosafety standards;
- Improving the management of intellectual property by CGIAR Centers and the NARS;
- Strengthening efforts to develop and implement public/private partnerships and explore new modalities; and
- Communicating and addressing public concerns through an open, transparent, and inclusive dialogue on the benefits and risks of biotechnology.

Biotechnology is only one tool, but a potentially important one, in the struggle to reduce poverty, improve food security, reduce malnutrition, and improve the livelihood of the rural and urban poor. The uncertainties and risks are yet to be fully understood, and the possibilities are yet to be fully explored.

It is important not to deny people and nations access to new technologies, so long as they are fully aware of the potential risks and benefits and are able to make informed choices.

The CGIAR Centers are on the threshold of a daringly original and creative Promethean science.

Calling for a New 'Green Revolution'

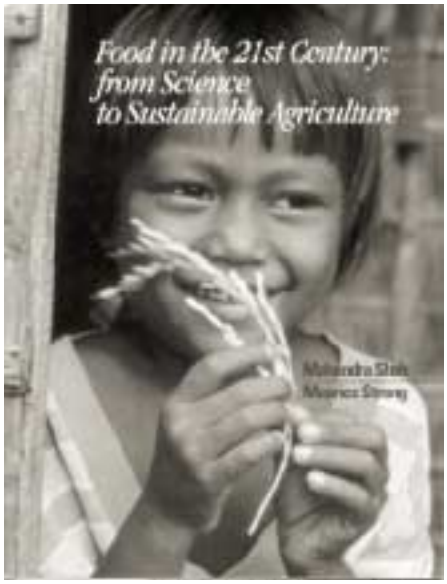
***Maurice Strong was Chairman and Mahendra Shah, Executive Secretary, of the third CGIAR System Review. The following is excerpted from their new book,* Food in the 21st Century: from Science to Sustainable Agriculture.**

Almost three decades ago, the world faced a global food shortage that experts predicted would lead to catastrophic famines. That danger was averted because a group of public and private development agencies created a network of international agricultural research Centers and a unique alliance, CGIAR, to support the Centers.

In what came to be known as the Green Revolution, CGIAR scientists found ways to increase the yields of some of the world's most important food crops, and the world's farmers put the innovations to use. As the new millennium begins, the world faces another food crisis that is just as dangerous—but much more complex—than the one it confronted thirty years ago.

Each year the global population climbs by an estimated 90 million people. This means, at the very least, the world's farmers will have to increase food production by more than 50 percent to feed some two billion more people by 2020. But the numbers don't tell the full story. The challenge confronting the world is far more intricate than simply producing more food, because global conditions are very different than they were on the eve of the Green Revolution. To prevent a crisis, the world community must confront the issues of poverty, food insecurity, environmental degradation, and erosion of genetic resources.

Food Security. Feeding the world in the 21st century will require not only food availability, but food security—access to the food required for a healthy and productive life. It means the ability to grow and to purchase food as needed. The basic statistics on food security are grim. In addition to the expected population growth, FAO estimates as many as 840 million people—a number that exceeds the combined populations of Europe, the United States, Canada, and Japan—currently do not have enough to eat. The companion problem of "hidden hunger"—deficiencies of vital micronutrients—affects even more people in the developing world. The shift away from the traditional food staples will make this challenge even more difficult. Simply increasing productivity of wheat and rice alone may not have the impact it did 30 years ago.



Poverty. Throughout the developing world, poverty is linked to hunger. For example, in sub-Saharan Africa, where malnutrition is rampant, every other person is poor. Rural poverty and accompanying malnutrition are usually tied to the small size or poor quality of farmland and limited off-farm incomes. In addition, more women than men live in poverty in the developing world.

The Environment. Thirty years ago, the Green Revolution's high-yield food crops were the critical factor in preventing global famine. But an increase in crop lands and the extensive use of fertilizer and irrigation were also instrumental. As the 20th century draws to a close, environmental concerns rule out using this mix of strategies, which worked in the past, to meet the food and agriculture crisis that looms ahead.

Genetic Resources. Environmentalists warn that as much as half of the world's remaining 2.5 billion hectares of tropical forest will come under pressure for agricultural expansion as the demand for food grows. The loss of forests would mean more than the loss of trees and the wood, fuel and other products they provide. Disappearing forests threaten the world's biodiversity.

Meeting these new challenges has been made even more difficult because so few opinion leaders are aware of the

Feeding the world in the 21st century will require not only food availability, but food security—access to the food required for a healthy and productive life.

urgency of food and agriculture problems. This lack of concern is reflected in the fact that public spending for agricultural research has declined sharply over the past three decades.

An Integrated Approach. Given the complex and interlinked components of the overall challenge of feeding the world in the 21st century, it is clear that solutions that deal only with one part—with crop productivity, for instance, or land use, water conservation, and forest protection—will not be sufficient. The issues are connected and must be dealt with as an interlocking, holistic system.

The CGIAR System in Action

The CGIAR system has the combination of resources and integrated approach needed to meet these complex aspects of the looming global crisis in food and agriculture. In fact, members of a distinguished international panel recently concluded that the CGIAR is the only authoritative international scientific organization capable of ensuring that the tremendous capacities of science are made available to address the problems of the poor in the developing world. CGIAR's assets include an unmatched mix of knowledge, skills, experience, and perspectives, as well as the ability to link scientists, farmers and environmentalists throughout the world. CGIAR's record of accomplishment and willingness to adapt itself to face new challenges began with the Green Revolution and has continued ever since.

A Record of Accomplishment

From its beginning, CGIAR's scientists have received world-wide acclaim for their accomplishments. Even more impressive than the accolades, though, has been the global spread of the fruits of CGIAR research.

- **More than 300 CGIAR-developed varieties of wheat and rice are in use by the world's farmers.**
- **The Green Revolution doubled productivity of such staples as wheat and rice. In India, wheat production on existing acreage nearly tripled, achieving self-sufficiency.**
- **More than 200 new CGIAR-developed varieties of maize are being grown in 41 countries.**
- **CGIAR work has produced improved varieties of legumes, roots and tubers, pasture crops, and other cereals.**
- **CGIAR's research has improved farming techniques and strategies for managing livestock disease, assessing fish stocks, protecting genetic resources, and effectively managing natural resources.**
- **Some 85,000 researchers and scientists have worked and trained at CGIAR centers.**
- **More than 600,000 accessions of germplasm are held in CGIAR genebanks.**

The CGIAR system has the combination of resources and integrated approach needed to meet these complex aspects of the looming global crisis in food and agriculture.

Leading with their Strengths

The CGIAR, the Green Revolution, and the campaign to defeat river blindness in Africa have all shown that determined and innovative forms of collaboration among the World Bank and other official bodies can deliver results.

Lawrence Summers, U.S. Treasury Secretary

Highlights from the Research Centers

Collectively, the CGIAR System's research covers a broad portfolio of humanity's most important food crops—rice, wheat, maize, barley, sorghum, millet, cassava, potato, sweet potato, yam, banana and plantain, chickpea, cowpea, beans, lentil, pigeonpea, soybeans, coconut, and groundnut—plus vital associated activities involving livestock, forestry and agroforestry, fisheries, and water resources management. Were it not for the CGIAR, research on many of these crops would cease because they are of little interest to private sector research.

CGIAR's numerous inter-Center partnerships have resulted in successes in genetic resources management, human resources development, crop and livestock improvement, and other areas critical to sustainable rural development. CGIAR science-based partnerships are vibrant communities of diverse stakeholders—the scientists themselves, farmers, representatives of public and private agencies, and civil society—who come together, form coalitions of the caring, all with a single purpose: improving the lives of farming communities in developing countries.

The World Bank's President, James Wolfensohn, recently called the CGIAR "one of the most successful partnerships in the history of development in terms of scientific advances, training and capacity building, and agricultural development."

Studies by the independent Impact Assessment and Evaluation Group show that virtually all developed country and crop programs were strengthened and that much of the parent genetic material used by national programs came from the CGIAR.

The impact of the CGIAR's scientific partnerships on poverty reduction and the livelihoods of the poor was reinforced through a series of special workshops and studies organized by CIAT during 1999. Among the key findings:

- Investments in agricultural research have increased agricultural productivity and incomes on millions of small farms throughout the developing world.
- Employment generation in agriculture has significantly improved rural well-being by benefiting landless workers, among the poorest of the poor.
- Cheaper food has created widespread benefits to the poor, especially those living in urban areas who have to purchase their food. Moreover, low food prices are the most direct form of assistance to public poverty reduction programs.
- Independent studies have consistently demonstrated that such research earns handsome rates of return (e.g. 65 percent on rice in India and Indonesia, and 50 percent on wheat in all developing countries).

As is illustrated in the pages that follow, all 16 CGIAR Centers draw on their particular strengths, and their own networks of national and international partners, to produce findings and scientific breakthroughs that make a beneficial impact on the fields, grazing lands, forests, and fisheries of the developing world's poor.

CIAT

Farmers and Scientists Transform Hillside Agriculture

More than half a billion people live and farm on the tropical hillsides of Latin America, Africa, and Asia. This important and diverse ecosystem covers 9 percent of earth's landmass and contains 50 percent of the world's tropical forests and 20 percent of the world's fresh water. Yet each year nearly 10,000 square miles of tropical forests and 13 billion tons of topsoil are lost, according to a new study prepared by CIAT.

At least 40 percent of the people in hillside regions live in absolute poverty. This poverty has caused widespread hunger and has led to political and criminal violence and drug trafficking in South America, Mexico, and Southeast Asia.

"The conditions of tropical hillside poverty and violence are also causing a mass exodus of the poor to cities around the world, increasing urban congestion, crime and disease," says Jacqueline Ashby, research director at CIAT and chief author of a new report: *Farmers' Knowledge Meets Formal Science: A People-Centered Strategy for Combating Poverty and Environmental Destruction in Tropical Hillsides.*

CGIAR scientists began working in 1993 to bring the latest scientific advances to bear on this neglected environment. The Center's collaborative work with farmers, NGOs, and national institutions has resulted in a novel program of "integrated research with a landscape perspective," which is being tested at three hillside sites in tropical Latin America. Under this approach, local researchers and development specialists work with rural communities to:

- devise computer-based, geographic information systems (GIS) that simplify the tasks of monitoring agricultural land use and choosing alternative courses of action at the regional, national, and local levels;
- train poor farmers to develop and test solutions to problems in agriculture and to disseminate them in rural communities, with only modest outside assistance;
- design and create grassroots organizations that can orchestrate efforts (involving rural communities and the institutions that serve them) to combat poverty and improve the management of natural resources in hillside watersheds;
- establish networks of local experimental sites, where scientists, farmers, and development specialists can work jointly to develop and evaluate a wide range of alternative technologies for agricultural production and natural resource conservation; and
- develop simple but reliable tools that enable local communities and institutions to collect and manage the information they need for making decisions and planning initiatives that promote local development and environmental conservation.

Poor farmers on tropical hillsides suffer from low and stagnant incomes, limited opportunities for employment, low agricultural productivity, poor access to education and health services, and a lack of political power and institutional support. CIAT scientists form local agricultural research committees and community watershed associations to work with farmers and local specialists in several countries of Latin America. These grassroots organizations serve as a catalyst, providing farmers with advice, credit, and improved seed.

This new approach to research was pioneered in 1993 in the Cabuyal River watershed, located in Colombia's southwestern Cauca Department. It drew upon many years of fieldwork aimed at improving crop varieties and farming practices in the region. It also built on more recent efforts to develop and introduce methods for farmers to participate in research.

By 1995, the integrated approach was sufficiently advanced for further testing and refinement in other countries where CIAT has a long history of collaborative research on staple crops. Partners then replicated the approach in three more locations and, with CIAT, trained more than 1,000 professionals from more than 400 municipal government, NGO, and community organizations. As a result of action plans formulated during the training, these institutions are introducing elements of the approach into their own programs in watersheds and municipalities elsewhere in Central America.

"With sufficient funds, municipal governments and communities can set up committees and watershed organizations to improve the livelihood of poor people through better land management," says Dr. Ashby.

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JOINED THE CGIAR: 1971

Science and the Small Farmer: How CIAT and the CGIAR Can Continue to Make a Difference

By Joachim Voss, CIAT's new Director General

The central challenge for CIAT and the other CGIAR Centers, is to make the best science, technology, and information available—especially to poor farmers. This challenge is easier said than done. More than anything, it requires mutual respect and participatory collaboration between farmers and scientists, with the aim of empowering the poor to increasingly control their own destinies.

To meet that challenge, we need to channel our efforts in three main directions. First, we must gain a clearer understanding of the context of our work with partners and clients across regions. What are their constraints and opportunities and how should the Centers act accordingly? Second, we need to expand the potential of biotechnology and infotechnology, creating possibilities of which scientists dream and farmers have yet to imagine. And third, we must balance increased productivity with sustainability in seeking to reduce poverty.

The changing context The global context of our research has changed dramatically in biophysical and socioeconomic terms. We now face a wide range of transnational challenges, from the whitefly explosion to climate change and from water scarcity to genetic erosion. Meanwhile, globalization and the opening of markets simultaneously threaten the livelihoods of and create potential opportunities for many small farmers.

These developments have come about in an increasingly explosive social context, marked by a widening gap between rich and poor. Meanwhile, shifts in public- and private-sector investment in research and the emergence of issues such as intellectual property rights have shaken up familiar patterns of work, and opened up entirely new possibilities.

Pushing the limits In this changing context, CIAT and other Centers have a great deal to offer for increasing agricultural productivity, developing new options for value-added processing, improving research organization, and moving small farmers into the knowledge economy. Our biotechnology research, for example, offers a powerful set of tools for increasing yield potential, and conserving the genetic base of agriculture. Yet to wield these tools effectively, we need to change public perceptions of biotechnology by using it for the benefit of the poor and the environment and by conducting credible biosafety evaluations.

Finding the balance I decided to accept CIAT's offer to serve as Director General mainly because I saw the Center pursuing a balanced approach to confronting these issues. I like to describe that approach with a simple formula adapted from Tim Reeves: G x E x I x M x P (genotype by environment by information by management by people).

By combining resources in creative ways, the Center has made remarkable headway in integrating germplasm improvement with better natural resource management, advancing the information revolution in the tropics, and building the social capital of rural communities. These achievements, I believe, mark the way forward for CIAT as an innovative Center capable of mobilizing the best that the world has to offer to fulfill its global and regional commitments.

CIFOR

Probing the Link between Agriculture and Deforestation

Boosting agricultural productivity in developing countries is a cornerstone of efforts to eradicate hunger and improve food security and is at the heart of the CGIAR's mission. Now, two CIFOR scientists are showing that increases in this productivity sometimes have an unintended side effect: increased deforestation.

The findings reported in 1999 by Arild Angelsen and David Kaimowitz have potentially widespread implications because they call into question an assumption underlying many agricultural and development programs around the world—namely, that helping poor farmers increase crop yields not only reduces poverty but also saves trees by reducing the need to clear more forest land for shifting cultivation. The two CIFOR economists discovered that in many cases more intensive agriculture is likely to *increase* forest loss by making farming on marginal lands more profitable.

In a report on this research in the journal *Science* (November 12, 1999), World Bank Senior Environmental Adviser John Spears called the work "extraordinarily valuable." He added that the World Bank is taking the findings into account as it develops policies to ensure forest protection.

Angelsen and Kaimowitz point to numerous instances around the world in which agricultural innovations have led farmers to clear forest land more rapidly than they otherwise would have done. In Brazil and others areas of the Amazon, for example, the introduction of better soybean varieties and mechanized production led to a shift from more environmentally benign coffee production to a massive soybean industry—largely at the expense of forest land. On Indonesia's island of Sumatra, a move to replace traditional shifting cultivation with more intensive smallholder rubber production on marginal lands did not have the intended effect of halting deforestation; instead, high world market prices for rubber and lowered production costs associated with surplus labor spurred farmers to cut down more trees to expand their plots of rubber trees.

The effect of agricultural intensification on forests is not clear-cut, the researchers emphasize. And their work by no means denies the need to boost agricultural productivity and introduce modern farming methods in developing countries to feed growing populations and contribute generally to economic growth and development. But, they contend, the agricultural research and development communities need to recognize that in the absence of countervailing measures there may be trade-offs between poverty reduction and forest conservation.

The research will enable policymakers, donors, researchers, and others to better understand the likely consequences of intensifying agriculture under certain conditions. It shows, for example, that labor-saving or capital-intensive technologies are more likely to lead to increased forest clearing than production systems requiring a large workforce. Market structure and price also significantly influence the outcome. Another key factor is whether the technological progress occurs on land that is adjacent to forest or that is already under intensive cultivation.

The issue is how to make new technologies and agricultural progress compatible with goals of forest conservation by identifying 'win-win' technologies and conditions.

Toolkit to aid sustainable management of forests 1999 brought a major output in CIFOR's long-term efforts to develop criteria and indicators (C&I) to guide sustainable management of forests: the do-it-yourself *C&I Toolkit.* It consists of a computer-based set of materials that guide users through the process of designing sets of C&I appropriate for use in a variety of forest settings—from community forests to plantations to nature reserves.

The *C&I Toolkit* can be used to create customized sets of C&I that take into account particular local conditions. It consists of 10 interrelated products, including *Guidelines for Developing, Testing and Selecting Criteria and Indicators for Sustainable Forest Management,* a C&I generic template, the CD ROM-based CIMAT (Criteria and Indicators Modification and Adaptation Tool), a resource database, instructional manuals, and additional materials on specialized aspects of the C&I-building process.

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JOINED THE CGIAR: 1992

CIMMYT

New Tillage Practices for Wheat in Asia

For decades the continuous rotation of rice and wheat—two crops or more per year—has provided food and livelihoods for hundreds of millions of rural and urban poor in South Asia. But as population and the demand for grain have surged, yield increases have slowed because weeds have proliferated and in many areas, irrigation water is an increasingly scarce commodity. Alternative tillage practices that foster greater resource conservation and productivity in intensive Asian cropping systems are being tested and promoted by the Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC), an alliance of national organizations, CIMMYT, other international Centers, and advanced research institutes.

Minimum tillage to sow wheat on time

Two new practices—direct drilling and surface seeding—allow farmers to prepare soils and sow wheat after the rice harvest in a single operation, where previously as many as 12 tractor passes were required. In many cases, farmers save 75 percent or more fuel, obtain better yields (earlier-sown wheat produces fuller grains), use about half the herbicide (weeds are shaded by early, lush wheat stands), and apply 10 percent less water.

The practices are simple: one involves use of a seed drill to sow wheat seed directly into rice stubble after harvest; the other, simply tossing of the seed onto the surface of a moist field (often into a standing rice crop). Many farmers in northern India are eager to buy seed drills—the special tractor attachment for sowing into unplowed soils. To help make the drills more widely available, CIMMYT staff are linking and advising farmer groups, local machine shops, and agricultural engineering specialists.

A boost from small-scale mechanization

The two-wheel tractor, originally produced and widely used in China, is being adapted for use in South Asia with an array of implements including pumps, threshers, reapers, winnowing fans, and trailers. One set of implements tills and sows in a single pass. Small tractor systems appear to be especially useful to smallholders, who are testing them with great success in Nepal. They allow timely sowing and reduce labor, in turn saving money, freeing farmers to pursue other profitable enterprises, and allowing children to attend school. Farmer Hari Ram Giri of Dekawar village says, "We have saved so much time with the tractor that we can do other income-generating work and, with the money earned, we have been building some additions to our homes." As in India, RWC partners are working with farmers to form purchase groups with local artisans to promote domestic production of tractors.

Hand tractors hit big In Bangladesh, the hand tractor is used widely as a rotovator. "It has helped make minimum tillage a reality on 70 percent of the wheat area," says Craig Meisner, CIMMYT agronomist in Bangladesh. "One to two rotovations over two or three days have substituted for six to eight passes with a local plow, which required up to three weeks." According to Meisner, for every day wheat is sown late, yields fall 1.3 percent. Timely sowing—together with new, high-yielding varieties that possess enhanced disease resistance, several improved management practices, and area increases—has contributed to a recent series of bumper wheat crops.

Bed planting and tillage systems A third recently promoted technique—planting of wheat on raised beds set apart by irrigation furrows—saves an average 30 percent water and allows more efficient weed control and targeting of fertilizer, among other benefits.

Conservation tillage is the next innovation in bed planting. For the past six years, CIMMYT has worked to develop appropriate planters and bed-shaping equipment so that farmers can maintain "permanent" beds and retain crop residues—giving bed planting a conservation tillage advantage. Dramatic reductions of tillage, combined with proper management of crop residues, should reduce costs another 20 to 25 percent and create a more sustainable production system for farmers.

CIMMYT researchers are working with partners in Asia to tailor the system to irrigated wheat settings there—in some cases beginning with conventional-tillage bed planting, and continuing with planting of reduced-tillage permanent beds.

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CIP

The Promise of Vitamin A

An estimated 250 million children in developing countries are vitamin A-deficient, putting them at risk not only for night blindness but also for the highly infectious diseases enabled by reductions in their immune function. Since the discovery of vitamin A's impact on children's health in the 1970s, aid groups have donated and helped distribute vitamin A capsules to malnourished children and lactating women. But because it is difficult to get supplements to some of the world's poorest or strife-ridden countries, many assistance agencies are now seeking to fortify local foods with vitamin A.

In a study in Kenya, new varieties of sweet potatoes *(Ipomoea batatas)* that are rich in beta-carotene, a precursor of vitamin A, have been introduced and promoted to women farmers. These varieties have been selected by CIP and Kenyan scientists to help alleviate vitamin A deficiencies, especially among the young.

The study was one of five two-year intervention programs undertaken by the International Center for Research on Women (ICRW) to explore ways to strengthen women's contributions to reduction of iron and vitamin A deficiencies. Other studies were carried out in Ethiopia, Peru, Tanzania, and Thailand. The Kenyan study was a collaborative effort by the National Potato Research Center of the Kenyan Agricultural Research Institute (KARI), CIP, the NGO CARE's program in the Homa Bay District, and farmers.

Sweet potatoes are a widely cultivated, traditional crop in Kenya. The major sweet potato-producing region is in the western part of the country, where vitamin A deficiency is common. At present, the sweet potatoes most commonly grown are white-fleshed varieties low in beta-carotene. In western Kenya, sweet potatoes are eaten as a supplementary staple food and are consumed whole (boiled) or are mashed and eaten with legumes, leafy vegetables, meat, or fish. Sweet potatoes are considered a woman's crop, as they can be grown on the small plots of land women receive from their husbands at marriage.

In the study, orange-fleshed sweet potatoes rich in vitamin A were introduced to 20 women's groups in two districts of western Kenya where vitamin A deficiency was high and where white sweet potatoes were a common secondary staple (the primary food is maize). Half of the women's groups received a package designed to promote the use and consumption of orange sweet potatoes. The package included nutrition education and training in food processing, packaging, preparation, and marketing.

Orange-fleshed sweet potatoes and sweet potato-based food products proved acceptable to both producers and consumers and helped increase vitamin A intake. Several of the new sweet potato varieties grown in the on-farm trials performed well with respect to yield and pest resistance and were high in beta-carotene.

Consumer preferences are a crucial factor in variety evaluation and selection. The appearance, taste, and texture of the new varieties were well accepted by community groups. Processed food products made by substituting sweet potato for other ingredients were also popular. And growing conditions in the study proved favorable for the growing of several crops of sweet potato per year. All of these factors could make the sweet potato an affordable, beta-carotene–rich food, available year-round.

The orange-fleshed sweet potato vines were widely distributed as soon as the study project was under way. Use of orange sweet potatoes should grow: KARI offices plan to continue to make planting materials available to farmers, and western Kenyan farmers traditionally pass vine cuttings to other farmers free of charge. On-farm trial data showed that the new orange varieties survived drought well and had higher yields than the traditional white varieties, both important factors for their sustained cultivation.

One of the key lessons learned was that orange-fleshed sweet potato varieties are adopted most when introduced within the context of extension and education on family health and nutrition. Mothers must be convinced that these new varieties are good for their children. In a foreword to one of his reports, Dr. Cyrus Ndiritu, director of KARI, confirmed these benefits: "Study results indicate that orange-fleshed sweet potato (including leaves) and sweet potato-based food products are highly nutritious and can significantly contribute to year-round alleviation of vitamin A deficiency."

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FOUNDED: 1971
JOINED THE CGIAR: 1973

The CGIAR is one of the most successful partnerships in the history of development in terms of scientific advances, training and capacity building, and agricultural development.

James Wolfensohn, World Bank President

Scientific collaboration has been the single most important determinant of CGIAR's successes.

ICARDA

Breakthroughs in Controlling the Hessian Fly

At just 3mm long, the Hessian fly doesn't look like much to the untrained eye. But cereal growers throughout the Mediterranean rim have long been suffering its devastating effect on their crop yields. Average losses of 36 percent yield of affected bread wheat and 32 percent of affected durum wheat in Morocco can be expected.

The potential scale of these losses is deeply troubling for Morocco, which has about four million hectares of spring bread wheat *(Triticum aestivum)* and durum wheat *(Triticum turgidum)* under production each year. Yields have been reduced to an average of about one ton per hectare because of Hessian fly infiltration and other constraints. The decrease in yields is costing the country dearly because it has to import replacement stocks of bread wheat and durum wheat, which is a staple part of the Moroccan diet, in particular the country's best known dish, couscous.

Hessian fly *(Mayetiola destructor)* is the major pest in the country's wheat. Damage is caused by the larvae, which feed on the lower stem, reducing the flow of nutrients to the ear so that the plant lodges or breaks off below the head as it begins to fill. Mild winters in Morocco permit up to three generations of Hessian fly per season. Although the biology of this pest had been studied in Morocco, no effective control method was previously available.

The solution for this long-term pest problem is not the use of expensive and environmentally-harmful insecticides. It is emerging from the successful plant breeding collaboration of Morocco's own National Institute of Agronomic Research (INRA), Mexico-based CIMMYT, ICARDA, and Kansas State University. Scientists from these organizations began collaboration 15 years ago to develop wheat varieties resistant to the Hessian fly.

Initial screening of plants for resistance is carried out in selected "hot spots" in the wheat-growing areas of Morocco and in INRA greenhouses. Then germplasm is exchanged between Morocco and the United States, which has a long-standing serious problem with Hessian fly. Kansas State University, in particular, helps identify resistance genes from this germplasm. In Morocco and ICARDA's Tel Hadya headquarters in Syria, adapted Moroccan cultivars and the newly identified sources of resistance are being crossed to obtain new varieties. These crosses are sent back to Morocco as segregating populations or fixed lines. Their ability to withstand Hessian fly attack and, just as importantly, their agronomic performance are tested in the field.

The greatest success has been the identification of 15 sources of resistance in bread wheat and the release of three new varieties—Massira in 1996 and Arrihane and Aguilal in 1998—to Moroccan growers. Several other new lines are in the breeding pipeline. They include three varieties developed using the doubled haploid technique.

Durum wheat presented the scientific teams with a greater challenge. Only one source of Hessian fly resistance has been identified in durum wheat. However, the collaboration between INRA (Morocco) and the CIMMYT/ICARDA durum wheat program for West Asia and North Africa paid off in the development of resistant lines by the introgression into durum wheat of the H5 resistance gene, which had been identified in the bread wheat work research.

As a result, three new lines are almost ready to be released as varieties. Named Telset 1, 2, and 3 to reflect the cooperation between Tel Hadya in Syria and Settat in Morocco, these new varieties combine the quality of durum wheat with the ability to grow well under drought and heat conditions in Mediterranean drylands. The breeding program continues for both types of wheat, and further improved varieties will be released in future years.

So what does this mean for the Moroccan wheat grower? Wheat yields in the country's dry marginal areas are increasing by 30–50 percent providing a substantial income boost to poorer farmers. One unofficial estimate suggests that use of the Hessian fly-resistant varieties throughout wheat-growing areas in Morocco would allow farmers to recover grain losses worth US$336 million. A study has shown that the internal rate of return on the investment in the development of resistant varieties is 39 percent—a high payoff.

INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS (ICARDA)
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JOINED THE CGIAR: 1978

ICLARM

Community-Based Fisheries Management in Bangladesh

More than 100 million people live in rural areas of Bangladesh. A third of the country is comprised of floodplains and wetlands where about 80 percent of households catch fish as a source of food or income. Fisheries contribute about 50 percent of the total production, but catches, especially of large, higher-value species, have been declining due to flood control, drainage, and overfishing.

Past government policies have stressed revenue collection rather than sustainable production from some 12,000 fisheries *(jalmohals)*. The system of leasing out fishing rights to the highest bidder has favored short-term exploitation and concentration of fishery wealth. Since 1987, ICLARM, with Ford Foundation support, has been conducting experiments and action research to improve fisheries management. Initially, it tested a licensing system that recognized individual fishers' rights. Since late 1995, the focus has changed to community-based fisheries management (CBFM).

ICLARM, the Bangladeshi Department of Fisheries (DOF), and five Bangladeshi NGOs have worked together in 19 water bodies: lakes, areas of open floodplain (beels), and rivers. Action research focused on development of local management arrangements, on decisionmaking and management actions by the fishing communities, on monitoring to assess impacts, and on documentation and comparative institutional assessment. The outcomes are naturally diverse and are best illustrated by examples:

- About 400 households around Ashurar, a largely seasonal beel in the northwest, depend on fishing for part-time incomes. In the mid-1990s, the government stocked the beel with carp, but the local households were unhappy because the fish escaped and because they had not been consulted about the action but were required to pay part of its costs. Through the CBFM project, Caritas, a large NGO, working in partnership with ICLARM and DOF, organized these households into groups represented in a management committee. The committee decided to protect the deepest part of the beel and to ban fishing in the rest of the beel in the early monsoon season. Monitoring indicates that total catch was 54 percent higher in 1998, after these measures had been undertaken, than in 1997.
- CBFM can result in enhancements. The traditional fishing community of some 90 households around Rajdhala Beel in northern Bangladesh was forced to work on a share basis for an outsider who leased the local fishery. After initial awareness raising by Caritas, the community started a non-cooperation movement. After lobbying by the fishers, NGOs, ICLARM, and DOF, the fishers obtained use rights to the beel. They have continued management by annual stocking of carp. The fishers now jointly invest in the stocking of carp (using NGO credit) and the guarding of the fish, and they share equally the returns, which were more than three times higher in the second year of group management (few fish were left in the first year).

Similar management arrangements have been developed through work with the Bangladesh Rural Advancement Committee (BRAC), the largest NGO in Bangladesh.

ICLARM's experience in Bangladesh has highlighted some characteristics of CBFM:

- empowerment of people who depend on fisheries by formation of local fishery management committees representing key stakeholders;
- NGO support for fisher organizations, human resource development, and credit for both fishery and additional livelihoods;
- fishery improvements—enhancement, restoration, conservation, and access limits—decided by local stakeholders who set and comply with rules;
- government recognition and enforcement of local decisions; and
- local recognition of subsistence fishing access for households in the community that do not fish for an income, provided that they respect sanctuaries and bans.

Through the partnership of ICLARM, NGOs and the government, various models of fishery management and institutional arrangements (sets of rules and rights) have been assessed. Most importantly, the emphasis of fisheries management has shifted to property rights recognition and local decision making. Communities, with their diverse stakeholders, have shown that they can cooperate to protect and enhance important economic assets that are a major source of food for poor and rich alike.

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ICRAF

Scientists Discover What's Choking Lake Victoria

Employing remote sensing technology, scientists from ICRAF have detected an important source of nutrients that is killing Lake Victoria, the world's second largest freshwater lake and the chief reservoir of the Nile River. These nutrients are feeding a carpet of water hyacinth that is rapidly choking the life out of the lake. The discovery has important implications for pollution abatement in other lakes throughout Africa, Latin America, and Asia.

While studying soil types around the lake, ICRAF scientists discovered a plume of sediments causing eutrophication—the process by which water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plants and weeds. Satellite images revealed that the nutrients were not coming solely from agricultural runoff but from low-lying, deforested "riparian" zones and other areas surrounding the lake that are not in private hands.

"We noticed a dramatic plume of nitrogen- and phosphorous-rich sediments that are feeding the water hyacinth. This is one of the major causes of Lake Victoria's environmental demise," says Pedro Sanchez, Director General of ICRAF. "It surprised us to be able to apply land technology to lake water, and it led us in a new direction in terms of diagnosing Lake Victoria's environmental problems."

Extending more than 27,000 square miles, Lake Victoria is Africa's largest lake and second in the world only to North America's Lake Superior. Bordered by Kenya, Uganda, and Tanzania, the lake region is one of the most populated areas in the world. Victoria serves as a source of employment for some 30 million people.

The lake has been slowly dying over the last decade from the oversupply of nutrients and untreated sewage that have led to massive fish kills, toxic algae blooms, and the rampant spread of the aggressive floating weed—water hyacinth. The hyacinth starves fish and plankton of oxygen and sunlight and reduces the diversity of important aquatic plants. In addition, it blocks waterway traffic and causes lake water to stagnate, making the shoreline a breeding ground for malaria and bilharzia.

"These factors have spelled the end of the lakeside economy—grounding fishermen's boats and depleting fish stocks," says Sanchez. "As the economy continues to dry up, men are vacating villages in search of jobs, often leaving behind women and children who face severe poverty, disease, and malnutrition."

ICRAF's research is helping scientists to better understand the role of the low-lying swampy, valley areas or riparian areas around the lake. When healthy, these areas serve as a filtering system between the rivers that flow down from the hillsides and the lake. When these areas are denuded, water flows right over them—taking with it nutrient-enriched sediments and other pollution.

"Scientists never suspected that the riparian areas played such a key role in preventing pollution and the takeover of the water hyacinth," says Anne-Marie Izac, Director of Research at ICRAF. "They are an essential place to start in restoring the health of the lake and water system. Tree planting in strategic places will help stave off the death of the lake by preventing further sediments runoff."

Satellite technology is able to identify the source of sediments through an "analytical spectrometry method," which indicates each soil type's unique signature or "fingerprint." Spectral signatures are characterized through a color-coding system. The color of the plume—greenish-yellow—indicates that the sediments are made mostly of a soil type, Nitisols, mixed with another soil type, Acrisols. These soils come from gulleys caused by soil and water erosion on agricultural land, on the human and livestock paths through those lands, and in riparian zones where vegetation has been removed.

A new project funded by the Swedish International Development Agency (SIDA), ICRAF, and the Kenyan Ministry of Agriculture will extend the use of satellite imagery to identify other priority watersheds and local hot spots in Kenya and in the other countries bordering Lake Victoria.

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ICRISAT

Seed and Soil: Affordable Options for Small-Scale Farmers

If agriculture is to become more profitable, farmers must raise the stakes—they must invest judiciously in purchased inputs that will raise productivity and output. Commercial farmers have done so. But most small-scale farmers have not done so because they operate in an environment characterized by uncertain rainfall, severe cash shortages, and an aversion to risk, and therefore make decisions about input investment on the basis of criteria different from those of commercial farmers. ICRISAT and its partners are helping to find ways of encouraging input use and technology adoption by paying greater attention to the small-scale farmer's decision-making criteria.

The cornerstone of this approach is the farmer's decision matrix. Rather than simply aiming to maximize yields or profits, researchers are asking how to improve returns on the investments that farmers are willing and able to make. We must provide options that are not only technologically superior but also affordable and practical. These options must lie within the bounds of the decision matrix; only then will farmers invest in new technology. ICRISAT is applying this approach to encourage small-scale farmers to experiment with two key inputs: improved seed and soil fertility.

Better seed, better harvests Traditionally, farmers grow their own seed, saving part of the harvest for the next season's seed. Shortages are met through a combination of gifts, barter, and trade within the community. This system is universally popular because it falls within the bounds of the investment matrix.

ICRISAT research in Niger and Senegal in West Africa, and several countries in Southern and Eastern Africa, has shown that the seed produced is of reasonable quality and that the system works well for traditional landraces and long-established varieties but that it is not very effective in disseminating seed of newly released, improved varieties. Many such varieties are available, but adoption has been limited by lack of seed. ICRISAT economists are working with scientists in Kenya, Malawi, Zambia, Zimbabwe, and the UK's Overseas Development Institute (ODI) to study alternative seed supply systems.

One alternative, typically pursued by NGOs in Africa, is village-level seed production. Seed is produced by farmers in the community and sold to other farmers or through commercial channels. Unfortunately, for various reasons, such schemes are rarely sustainable.

A second alternative—small seed packs—appears to hold promise. ICRISAT worked with a private seed company in Zimbabwe to demonstrate that farmers can be encouraged to buy seed of new varieties if it comes in small, more affordable packs. The seed was sold through a wide network of village retail shops, in packs ranging from 500 grams to 5 kg, instead of the usual 25 or 50 kg. New varieties of six crops (sorghum, pearl millet, pigeonpea, groundnut, beans, and sunflower) were sold at almost full cost—no subsidies. Almost the entire stock was quickly sold, and response from farmers and retailers was so enthusiastic that the scheme is being expanded, first to Mozambique and then to several other countries in Southern Africa. Small seed packs have proved popular because they fall within the investment capacities of farmers (affordable packaging and low risk involved in experimentation) as well as those of rural retailers (small quantities, small investments, and limited risk of unsold stocks).

Experimenting with fertilizer ICRISAT is using the same approach (and lots of computing power) to encourage the use of fertilizer. Its studies in Kenya show that most new fertilizer users buy less than 10 kg; that is all they can afford. But many extension programs completely ignore this investment constraint and instead recommend much higher applications of fertilizer per hectare. Most smallholders are unable to follow these recommendations and use little or no fertilizer. But research shows that they are willing, given the opportunity, to experiment with smaller quantities. ICRISAT aims to encourage such experimentation.

With the aid of computer models many technology options can be tested quickly and cheaply, under various simulated conditions. The results are helping to narrow down thousands of possible options into a smaller number of "best-bet" options.

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JOINED THE CGIAR: 1972

Renewing ICRISAT's Vision and Strategy

By William D. Dar, ICRISAT's new Director General

ICRISAT is convening a broad dialogue to update its vision in a rapidly changing environment, in convergence with the CGIAR's ongoing revisioning and restructuring exercise. ICRISAT's renewed vision is built on the overarching objective of poverty reduction, with a focus on improving the livelihoods of the poorest of the poor. We use the metaphor "science with a human face" to describe our new focus on reducing the suffering of poverty-stricken men, women and children of the rural semi-arid tropics.

This represents a paradigm shift from the approach of the CGIAR and ICRISAT of the past, in which scientific opportunities for commodity improvement to help meet regional and national production targets reigned supreme.

The new vision is ambitious because it requires ICRISAT to address not just biophysical problems but institutional and socioeconomic problems as well. Our work will no longer sit on the shelf, or stop at the farm gate. It has to engage civil society and attack constraints in any part of the system—albeit through partnerships wherever the required capacities lie beyond our own.

This new approach requires the involvement of a many more partners. Consequently, we need to clearly define ICRISAT's role within a large partnership to avoid becoming mired in complexities and confusion. In defining this role, ICRISAT is compelled by its new vision to align itself with its comparative advantages: its internationality, nonprofit motive, and apolitical status.

Putting these comparative advantages into operational terms, we define three key roles for the Institute: bridge, broker, and catalyst. As a *bridge,* ICRISAT takes advantage of its internationality and scientific expertise to foster North-South and South-South exchanges of technology, information, and skills. As a *broker,* ICRISAT takes advantage of its apolitical and nonprofit orientation to engender trust among partners in exchanges of research products that involve tradeoffs (e.g. germplasm, intellectual property, and natural resource endowments). As a *catalyst,* ICRISAT takes advantage of its scientific expertise and global view to convene international partnerships to tackle major research problems that would have been too difficult and costly for any organization to handle alone.

As a bridge, broker, and catalyst, ICRISAT can engage partners to meet the needs of the poor and marginalized rural peoples of the semi-arid tropics (SAT). ICRISAT's work with partners across the research-for-development spectrum does not mean that it will become an extension organization. It means that it will become more adept at partnership, creating opportunities for collective actions resulting in major new impacts that we all agree are important.

Science with a human face, the metaphor that describes ICRISAT's new focus, is about increasing the availability of food for the poor of the semi-arid tropics.

IFPRI

Feeding the World in the Next Millennium

Nearly 75 million people will be added to the world's population every year from now until 2020. During that time, rising incomes in the hands of millions of developing-country people will spur a large increase in global demand for food. To close the large gap between food production and demand projected for 2020:

- The world's farmers must produce 40 percent more rice, wheat, and other grains;
- Developing countries must double their cereal imports; and
- Sixty percent of the developing world's cereal imports will likely have to come from the United States.

To minimize the risk of food shortages, policymakers must begin taking steps immediately, according to *World Food Prospects: Critical Issues for the Early Twenty-First Century,* a 32-page report published by IFPRI.

International trade issues are addressed directly in the report. Per Pinstrup-Andersen, IFPRI's Director General and co-author of the report, warns, "poor countries and poor people risk losing out on the economic benefits of more open global trade. International trade liberalization has to go hand-in-hand with national policy reforms, investments in the agriculture sector, access to developed-country markets, and the elimination of export subsidies in industrialized countries."

In addition, a demand-driven "livestock revolution" is underway, according to the report, and demand for meat is projected to double in the developing world by 2020. In fact, developing countries are likely to have to import eight times more meat in 2020 than they did in 1995. China alone will account for more than 40 percent of this increase in demand for meat products.

The report also examines whether modern biotechnology can help provide food security for all. If focused on solving developing-country problems, biotechnology may help farmers reduce production risks and increase productivity. According to IFPRI's findings, using biotechnology in the developing world could make food grains more nutritious and help combat widespread nutrient deficiencies among the poor, which lead to diseases and premature deaths for millions of women and children every year.

"The bad news is that there will continue to be a lot of hungry people," said Dr. Pinstrup-Andersen. "The good news is that if we choose the appropriate technologies and make the right investments, the world's farmers will be able to satisfy global food needs."

Among the key findings of the report:

- Almost all of the increase in world food demand will take place in developing countries. Developing countries will account for about 85 percent of the increase in the global demand for cereals and meat between 1995 and 2020.
- A developing-country person in 2020 will consume less than half the amount of cereals consumed by a developed-country person and slightly more than one-third of the meat products.
- Between the early 1970s and the mid-1990s, the quantity of meat consumed in the developing world grew almost three times as fast as it did in the developed countries. Demand for meat in the developing world is projected to double between 1995 and 2020.
- Food production is increasing much faster in the developing world than in the developed world. By 2020, the developing world will be producing 59 percent of the world's cereals and 61 percent of the world's meat.
- Cereal production in the developing world will not keep pace with demand, and net cereal imports by developing countries will almost double between 1995 and 2020 to 192 million tons in order to fill the gap between production and demand. Net meat imports by developing countries will increase eightfold during this period to 6.6 million tons.
- About 60 percent of the developing world's net cereal imports in 2020 will come from the United States. Eastern Europe and the former Soviet Union are forecast to emerge as major net exporters, and the European Union and Australia are projected to increase their net exports.
- Food prices will remain steady or fall slightly between 1995 and 2020. The much slower decrease in food prices is due to the slowdown in crop yield increases, and strong growth in demand for meat in developing countries.

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JOINED THE CGIAR: 1980

IITA

The Fight to Save Cassava

Cassava is the paramount staple food security crop in sub-Saharan Africa, and the mainstay of the rural and, increasingly, the urban populations. Peak production in Uganda was 3.5 million tons in 1989, when cassava mosaic diseases (CMD) suddenly started to become so severe that in 10 years cassava production fell by 35–40 percent. The varieties that farmers were growing were highly susceptible to CMD. When they failed and drought struck as well, people starved because they had no food reserves.

By the second half of the 1990s the situation was grave, and the CMD pandemic, as it was called by then, was spreading fast. It swept from Uganda to western Kenya and southward into Tanzania and into Sudan. It has recently been detected in the Republic of Congo.

For more than two decades, IITA and the Office of Foreign Disasters Administration (OFDA) of USAID have been the major investors in the fight against CMD. More than US$9 million has been invested. This sum includes contributions from NGOs such as CARE, Oxfam, and Sasakawa Global 2000 as well as from the Canadian International Development Research Centre (IDRC) and the Government of Uganda. The most recent impact figures indicate a return of more than 150 percent on every dollar spent.

IITA worked on the vector of the cassava mosaic virus, a small whitefly called *Bemesia tabaci,* with funding from the Danish International Development Agency (DANIDA) during 1997–99. IITA scientists and their NARS colleagues in the eastern Africa region monitored the spread of the disease and were able to forecast the areas under threat. Work on the virus itself revealed why the problem was so severe; several strains of the African cassava mosaic virus (ACMV) are involved in the pandemic. Annual cassava losses are estimated at US$60 million in Uganda and at approximately US$100 million in Kenya.

Faced with the prospect of cassava crop failures across the region, an emergency program, which has had remarkable results, was started in 1998. Rapid funding helped as did the commitment and combined effort of IITA and all the national programs. They worked together with NGOs and two regional networks to ensure that farmers not only had access to sufficient planting materials of resistant varieties but also that they were involved in multiplying these varieties. Farmers learned how to process and market their crops. The disease was monitored and mapped and NARS technicians learned how to diagnose the viruses.

IITA has a long-term policy of breeding for resistance. Fortunately, varieties held in trust at Ibadan—some of which had originated in eastern Africa many years ago—were found to be resistant to all the virus strains when tested across the region. Resistant material continues to be needed: each country will require 2 million stems a year. In 1999 alone, various institutes in the region sent out nearly 6,000 bags of stems, enough for more than 2,000 farmers to plant.

Multiplication at other locations meant that materials reached 7,000–8,000 beneficiaries. Six new mosaic-resistant cassava varieties that had been developed by earlier projects were released.

Meanwhile, more than 760 people have been trained in processing and utilization of resistant varieties and 111,625 kgs of high-quality flour have been produced. New market opportunities have been surveyed and additional processing machinery has come to the region where 16 processing sites are operating with NGO support.

Plant health aspects of the campaign went well. Pest and disease constraints have been evaluated at 265 locations, and monitoring and forecasting efforts have been linked across the region. Through the CGIAR's systemwide whitefly Integrated Pest Management (IPM) project, technicians traveled to the United Kingdom to learn new diagnostic protocols. Capacity for diagnosing the virus has been strengthened to include biotechnological techniques to detect both viruses and whiteflies.

More than 15 institutional stakeholders are now involved in the campaign. Its outstanding success is due in no small part to the stakeholders' dedication to ensuring that farmers' crops are saved, that food security is maintained, and that the region becomes self-sufficient in combating and containing the CMD menace.

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE (IITA)
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JOINED THE CGIAR: 1971

ILRI

SAVANNA Strives for Balance in Conservation Areas

Wildlife numbers continue to decline rapidly in the game reserves of East Africa. But scientists from Colorado State University (CSU) and the Nairobi-based ILRI have developed a new tool that could reverse these trends. The tool, a computer-based model that took scientists 15 years to develop, could help save elephants and rhinoceros in East Africa as well as help balance elk and bison populations in the western United States.

SAVANNA is the world's first ecological model that is sufficiently comprehensive to take into account constant changes across large regions while at the same time forecasting the future of an area as small as a 50-yard wide watering hole. It uses hundreds of variables relating to wildlife, plants, livestock, soil, climate, and human activity to make predictions from 5 to 100 years into the future. It forecasts wildlife populations, the health of ecosystems, and human conditions following human and naturally occurring changes in the landscape.

"There is an urgent need to bring the power of this model to bear on the world's greatest conservation treasures," says Hank Fitzhugh, Director General of ILRI. "East Africa is seeing huge increases in population combined with reasonable expectations by people for a better way of life. Conservation areas support the greatest concentration of large mammals left on Earth. But if we can't manage the needs of the people and wildlife on them properly, we will lose them forever."

The authors of the report, *The SAVANNA Model: Providing Solutions for Wildlife Preservation and Human Development in East Africa and the Western United States,* issued jointly by CSU, ILRI, and Future Harvest, document the rapid decline of many species of wildlife. According to the report Kenya's elephant population dropped by 85 percent, to approximately 20,000, between 1975 and 1990; and the country's rhinoceros population fell by 97 percent, to fewer than 500, during the same period.

Land use changes resulting from population growth and poverty, urbanization, increased tourism, and poaching have contributed to these declines, according to the report. The populations of Kenya and Tanzania have tripled since 1960, and urbanization is increasing food demand in the cities. An increasing number of people have taken up both subsistence farming and commercial crop production. Poaching and insufficiently regulated tourism in East Africa are also exerting stress on ecosystems and wildlife.

"Given the increasing food needs of the peoples living around the wildlife areas and in the growing urban centers, more of the fertile lands of East Africa will be tilled," explains Robin Reid, systems ecologist at ILRI, one of the model's developers and co-author of the report. We have some room to plan for the future. For this, SAVANNA is the best tool available."

"SAVANNA's ability to navigate complex systems—including wildlife, livestock, and human—provides concrete information on how change in one area will affect the resources, people, and animals in the others," says Michael Coughenour, senior research scientist at the Natural Resource Ecology Laboratory at CSU, who originally conceived the model and is a co-author of the report. "The model helps us to find a way to save the elephants without driving marginalized people further into poverty."

SAVANNA is focusing on land use issues in areas both inside and around Maasai Mara National Reserve and Amboseli National Park in Kenya, and the Ngorongoro Conservation Area in Tanzania. The same model is being applied in national parks in the United States that have reached their maximum carrying capacity for bison, elk, and wild horses.

According to the report, conservation areas in East Africa carry the greatest large mammal diversity in Africa. But they also coincide with the areas of the greatest human population increase. Armed with data supplied by ILRI scientists and numerous other partners, local NGOs and communities will use SAVANNA to create a long-term, land-use planning program in the Mara ecosystem.

"Most ecological models exclude people, but SAVANNA can help policymakers balance the needs for ecosystem conservation with the needs of people and food security," says Barbara Rose, Future Harvest's executive director.

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE (ILRI)
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FOUNDED: 1995
JOINED THE CGIAR: 1995

Farmers' knowledge will help to improve understanding of the structure of plant genetic diversity.

There are numerous opportunities now to harness the power of synergy between science and public policy.

M. S. Swaminathan, winner of the first World Food Prize

IPGRI

Linking Scientists and Farmers for Agrobiodiversity Conservation

IPGRI's project, "Strengthening the scientific basis of *in situ* conservation of agricultural biodiversity," is forging lasting partnerships between researchers, politicians and farmers in nine countries in order to strengthen the conservation of local crop varieties.

The project seeks to understand genetic diversity conservation at the local level and to frame this knowledge in a coordinated global conservation effort. The information can then be used to support sustainable agriculture and farmer livelihood improvement. The project's goals are to:

- link institutes, disciplines, and stakeholders;
- collect and analyze information about farmers' maintenance of local cultivars; and
- use information to obtain social, economic, ecological and genetic benefits.

This effort is building partnerships in Burkina Faso, Ethiopia, Hungary, Mexico, Morocco, Nepal, Peru, Turkey, and Vietnam. Each country is situated in a region with great diversity of crops of global importance. Each has a national plant genetic resources program and traditional farming communities that maintain plant genetic resources, both of which are particularly important to IPGRI's aim to integrate on-farm conservation practices with national systems.

The partner countries have established teams of experts in the disciplines involved in on-farm conservation. These experts, who include scientists, extension workers, and national and local NGO staff, are being trained in the natural and social sciences and in participatory methods.

A national framework was established to enable participatory collection of information based on farmers' knowledge, as well as empirical data on socioeconomic factors, natural and environmental selection factors, plant population structure, farmer agromorphological selection of traits, seed supply systems and enhancing the benefits of local crop resources for farmers.

Researchers are using the empirical data to confirm and validate the information that is based on a farmer's knowledge of his or her surrounding system and to augment that knowledge. So far, data have been collected in six of the nine partner countries.

These data link farmer decision-making on the selection and maintenance of crop landraces to measures of genetic diversity. The information will help to improve our understanding of the structure of plant genetic diversity and the forces—human and otherwise—that act upon this diversity.

The data can be used to identify the best conservation strategies for particular areas and crops. Analysis of the information will help to identify farming systems practices in which the use of local crop resources improves ecosystem health, and to discover factors limiting the maintenance of local crop diversity on farms. It will also help breeders to improve varieties for marginal environments and to link breeding efforts with farmers' needs.

The project's impact has already been substantial. It has been instrumental in putting in situ conservation onto the national policy planning agendas in Nepal, Burkina Faso, and Morocco. National institutions, local communities, and consumers are becoming sensitized to the value of local crop varieties in the participating countries, while the partners are searching for new market outlets for these varieties.

Agricultural extension workers are being trained on the potential contributions of local crop resources to modern variety packages. And there has been a strong push to increase gender awareness in national *in situ* conservation programs increasing the number of women participating in decisionmaking, training, and data collection.

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FOUNDED: 1974
JOINED THE CGIAR: 1974

IRRI

Improved Management, Increased Productivity

Many poor Asian rice farmers spend large amounts of money on fertilizers. This is despite the fact that they may know little about the nutrients already in the soil or their crops' real needs. In a general sense, one rice paddy is treated much the same as the next.

The reality is that Asia's irrigated rice field varies from farm to farm, so much so that much of the fertilizer so freely used goes to waste. Soil nutrient supplies, fertilizer efficiency, and productivity vary dramatically even within small districts. Consequently, a successful farm can exist alongside farms that are failing.

Use of nitrogenous fertilizer often reflects little or no attention to the amount of nitrogen already existing in the soil and use of potassium, relative to other fertilizers, often does not meet crop requirements. On the basis of these observations and three years of on-farm research in five Asian nations, IRRI, together with its partners from NARS, launched a research project in 1997 to develop a new, more site-specific nutrient management (SSNM) technology for intensive rice systems.

The SSNM system is tailored to the site-specific conditions of any selected area, whether a field, a valley, a district, or a plain. One of the SSNM's major innovations has been the economically sensible selection of season-specific yield targets.

Fertilizer requirements are calculated on the basis of the plant's nutrient requirements considering the soil's indigenous nutrient supply. Simple tools such as a leaf color chart help detect plant nitrogen deficiencies within a season, allowing for the adjustment of nitrogen management.

So far, SSNM has been tested on at least six crops grown on 205 farms in China, India, Indonesia, Thailand, Vietnam, and the Philippines. The results have been encouraging. By applying the same amounts of nitrogen and phosphorus, and slightly more potassium than farmers traditionally have done, SSNM has helped increase yields by as much as 15 percent. Yield increases were as high as 20 percent on about a quarter of the 205 farms.

With SSNM, production in many farmers' fields is now averaging about 5.5 tons per hectare, which translates to an average, increased profit of about US$45 per hectare. It should be noted that this productivity was achieved with currently available varieties and crop management technologies. Hence, it is mainly attributed to balanced plant nutrition and increased recovery efficiency of the applied fertilizer nitrogen. This efficiency is particularly encouraging as high nitrogen losses due to inadequate fertilization strategies can lead to nitrate pollution of water and emissions of nitrous oxide, which are of increasing environmental concern.

The newly developed SSNM concept will be disseminated together with a mechanical fertilizer calculator, a pocket guide for nutrient management, and 'Nutrient Decision Support System' software—all of which are planned for release by the end of 2000. These tools can help farmers develop season- and site-specific fertilization strategies.

In the next few decades, farmers throughout Asia will need to change their management practices and adopt new, more knowledge-intensive technologies to increase productivity and sustain the soil and water resource base. Actual implementation of these new technologies will depend on NARS and on the support of NGOs and private enterprise. IRRI will continue to provide scientific backup, monitor progress, and train extension workers.

INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI)
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FOUNDED: 1960
JOINED THE CGIAR: 1971

ISNAR

Research and Advice on Biotechnology

M. S. Swaminathan, CGIAR elder statesman, respected agronomist, and co-author of a World Bank study on transgenic crops, believes that the challenge of increasing farm productivity in developing countries can be met only by mobilizing frontier science. This, he says, will require blending traditional technologies and ecological prudence with biotechnology, modern information science, and renewable forms of energy production.

Decisions about how best to use biotechnology require careful judgment and experience. Research managers must weigh productivity increases alongside potential environmental risks, research priorities, and potential returns on investment. Recognizing the importance of these decisions, ISNAR established a biotechnology research and advisory program in 1992. Over the past seven years, the intermediary biotechnology service has forged partnerships with advanced research programs in more than 25 developing countries.

Recently, even countries that have not considered becoming directly involved in biotechnology are having to confront the complex issues posed by this new technology. Genetically modified crops arrive daily in ports and markets around the world. Yet only a handful of countries have rules or regulatory agencies that can cope with the new products.

Given the pace of these global developments, developing countries must maintain a degree of self-reliance in analyzing the issues that this new technology raises.

Although, much of the international debate on biotechnology focuses on the formulation of national and international legal frameworks and guidelines, ISNAR's research continues to show that the number one constraint facing most developing countries today with respect to biotechnologies is human resources. Therefore, one of ISNAR's main activities in 1999 was developing the skills of the people in charge of the daily management of biotechnology research.

With support from the Government of Japan, ISNAR developed and conducted a management training course to help practitioners on the front line of biotechnology management develop their skills. Twenty participants from the public and private sectors followed the sessions, which took a hands-on approach to problem solving. Defining priorities and managing biosafety and intellectual property rights were among the topics covered. One participant commented, "Learning from others' experience and sharing knowledge was most beneficial and is already paying off in terms of more effective priority setting and time saving."

About half the course was devoted to biotechnology management, the remaining time was spent on management of information technology. Questions about the management of agricultural biotechnology research were raised, many of which stemmed from real-life situations. Managers were presented with tools to help them think strategically about their research programs. Special emphasis was placed on increasing individuals' effectiveness and on developing leadership qualities.

"The ISNAR management course has helped us to strengthen the link between industry, universities, and research institutions by means of the information we shared during the course," said one participant. Attendees not only increased their knowledge and improved their managerial and leadership skills but also made professional contacts and new friends. Such networking enables them to continue developing their skills.

The management course is now offered annually to participants from Indonesia, India, Malaysia, Thailand, Sri Lanka, the Philippines, and Vietnam. In these countries, biotechnology is growing rapidly. Many managers of agricultural research systems, therefore, urgently need expertise to help them carry out new responsibilities.

ISNAR responds in a number of ways to prevent a growing information gap between industrialized countries and developing countries in biotechnology-related areas. It established the ISNAR Biotechnology Service (IBS), to provide ready access to information on available biotechnologies and expertise. The IBS has an Internet-based information forum that provides an interactive interface for posing and answering questions about agricultural biotechnology.

INTERNATIONAL SERVICE FOR NATIONAL AGRICULTURAL RESEARCH (ISNAR)
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JOINED THE CGIAR: 1980

IWMI

Revealing the Face of Water Scarcity

The scenario that nearly one billion people may not have access to water by the year 2025 is now a generally accepted global challenge. A less-known fact is that IWMI's Global Water Scarcity Study has helped define this problem more precisely, providing a new factual basis for the worldwide policy discussion on water management and its impact on food security.

This research presents a clear picture of the world's water scarcity issues. It projects water supply and demand patterns across 118 countries. Most importantly, it pinpoints countries and entire regions in the developing world where water will no longer be available in 2025 or where water resources will not be developed because of lack of funds, environmental pressures, or other constraints.

IWMI's work picks up where well-known water scarcity research, such as that conducted by the U.N. Commission on Sustainable Development, ends. It considers the importance of the various competing water users—domestic, agricultural, industrial—and the fact that overall demand for water is continually changing and therefore difficult to predict. It also considers the importance of geographical and seasonal water supply variations in some regions.

The strength of the global water scarcity study is that it documents the scope and severity and highlights the causes of the potential water crisis. When completed, the study will supply information to support the policy changes that affected governments must take to address their water-scarcity crises.

The message from the water scarcity study is clear: Unless the countries that will experience water scarcity act today to manage their water resources more productively, they will face a series of difficult decisions when the crisis hits. The inhabitants of these regions will have no choice but to reduce the amount of water they use in agriculture and transfer it to competing users—in the industrial, domestic, or environmental sectors. For the poorest countries, this shift will be catastrophic. Less water in the fields means decreased domestic food production and increased imports of food at world market prices.

The study examines the available economic, demographic, and agricultural data from 118 countries over the 1990–2025 period. It concludes that more than 25 percent of the world's population—or 33 percent of the population in developing countries—lives in regions that will experience severe water scarcity. This research reveals that the groundwater table is falling at an alarming rate in the semiarid regions of the Middle East and in Asia, the home of some of the world's major breadbaskets. These areas will not be able to meet reasonable water needs for domestic, industrial, and environmental purposes. Scarcity of water will create intense competition among different users—competition with political and national security implications.

In the struggle for water, the poorest of the poor—the primary group targeted by IWMI's research—will be left without options. If governments in the affected countries maintain today's "business-as-usual" scenario for water use, by 2025 millions of the world's poorest people will simply see their water disappear as it is diverted for use by wealthier or politically connected users. IWMI predicts that economic scarcity alone will hit some 348 million people across Africa and Asia if current water consumption patterns continue unchecked.

Irrigation holds a special place in the water scarcity debate, as it uses more than 70 percent of the world's total water supply—and up to 90 percent in some developing countries. Any reduction in overall water supply means a reduction in irrigation, which translates into less agricultural production. According to IWMI's research, some policy makers do not view water scarcity as an urgent problem because they think that existing irrigation systems are so inefficient that most, or even all, future water needs could be met simply by increasing the system's efficiency and transferring the water saved to domestic, industrial, and environmental uses. However, the IWMI research shows that the financial and environmental costs of developing water resources are prohibitive. Thus, proportionally more irrigation will be needed to meet future food demands than was needed to meet past food demands.

INTERNATIONAL WATER MANAGEMENT INSTITUTE (IWMI)
WEB: WWW.CGIAR.ORG/IWMI
HEADQUARTERS: COLOMBO, SRI LANKA
DIRECTOR GENERAL: DAVID SECKLER
BOARD CHAIR: KLAAS JAN BEEK
FOUNDED: 1984
JOINED THE CGIAR: 1991

WARDA

New Rice Strains Gain Acceptance

Rice is grown on 74,000 hectares in Senegal and 20,000 hectares in Mauritania. In Senegal, 40 percent of the rice-growing area is irrigated, whereas in Mauritania 100 percent of this area is irrigated. The irrigated sector produces 119,000 tons of rice paddy in Senegal—70 percent of total rice production—and 67,000 tons of rice paddy in Mauritania.

Rice variety Sahel 108 was released along with two other varieties (Sahel 201 and Sahel 202) in Senegal in 1994 and in Mauritania in 1996. The three varieties had been introduced in nurseries distributed by the International Network for Genetic Evaluation of Rice (INGER, then hosted by IITA under the auspices of IRRI) and were selected by WARDA in Senegal and Mauritania. Sahel 108 was an IRRI variety, Sahel 201 came from Sri Lanka, and Sahel 202 from IITA.

The Sahel varieties were released for their improved performance over long-standing cultivars Jaya (medium duration) and I Kong Pao (IKP, short duration), both introduced around 1970. Although Jaya has a high yield potential, it is not tolerant to saline conditions present in the Senegal River delta, and its cycle length prohibits double-cropping. IKP, on the other hand, may be grown in any season, but it has poor grain quality and lower yield potential than Jaya.

Sahel 108 was targeted for the dry season when short-duration performance is important for enabling farmers to double-crop. Sahel 201 and Sahel 202 are of medium-duration performance and therefore are targeted for use in the rainy season. Sahel 201 was introduced for its high yield and moderate tolerance to salinity and Sahel 202 for its high yield and good grain quality.

The Sahels yield approximately 10 percent more rice than the existing varieties in the wet season; Sahel 108 yields about 11 percent more rice than IKP in the dry season. Net revenue gains per hectare are even more impressive. Compared with IKP, Sahel 108 gives rise to 18 percent more net revenue in the wet season. Sahel 201 provides 21 percent and Sahel 202 provides 24 percent more net revenue than Jaya in the same season. Sahel 108 results in net revenues 23 percent higher than those of IKP in the dry season.

More importantly, Sahel 108 matures about 15 days earlier than Jaya during the wet season. This earlier maturation saves 1,000 cubic meters of water per hectare. On the scale of the whole Senegal River (in Senegal), Sahel saves at least 11 million cubic meters of water per year. Assuming an irrigation efficiency of 40 percent, this amounts to 28 million cubic meters of pumped water, or about US$400,000 in saved fuel. In addition, the short cycle opens up new possibilities for double-cropping on a given parcel of land, potentially doubling per-hectare annual output. 10 percent of the cropped area in Senegal is now double-cropped.

Initial estimates of internal rate of return (IRR) are based on conservative adoption estimates (25 percent, 10 percent, and 15 percent for Sahel 108, Sahel 201, and Sahel 202 in the wet season and 40 percent, 5 percent and 5 percent respectively for the same cultivars in the dry season) but are nevertheless high at 118 percent. Sahel 108 already occupies 31 percent of the Senegal River Valley in Senegal in the wet season and 66 percent of the valley in the dry season, so the IRR estimate has already been exceeded. In Mauritania, the three Sahels occupy about 35 percent of the total area under rice production.

WEST AFRICA RICE DEVELOPMENT ASSOCIATION (WARDA)
WEB: WWW.CGIAR.ORG/WARDA
HEADQUARTERS: BOUAKÉ, CÔTE D'IVOIRE
DIRECTOR GENERAL: KANAYO NWANZE
BOARD CHAIR: JUST FAALAND
FOUNDED: 1970
JOINED THE CGIAR: 1975

Synergies in Science

Each CGIAR Center conducts research of the highest quality and applies the results to problems of vital concern in developing countries—feeding the poor, reducing hunger, and managing natural resources wisely. The power of Centers working together was convincingly demonstrated at ICW99 through

- an overview of interCenter collaboration, followed by highlights of collaborative work in integrated gene management;
- illustrative examples of collaboration in several critical areas related to productivity, natural resources management, and institution building;
- a description of systemwide and ecoregional programs; and
- discussion of collaborative approaches to policy issues.

The presentations revealed that the CGIAR Centers have been actively pooling their resources—especially their intellectual resources—in efforts to

- develop effective modes of partnership among themselves and with others in the global agricultural research system;
- improve methods for assessing the impact of their work on poverty alleviation;
- harness high-quality science in the continuing struggle against poverty; and
- maintain the highest possible scientific standards.

Highlights of these presentations, which have been published by the CGIAR in *Synergies in Science: InterCenter Collaboration to Eradicate Hunger and Poverty* are provided below.

Genetic Resources at Work for the Poor

More than 70 percent of the poor in developing countries live in rural, marginally productive areas that are largely untouched by modern technology. They depend for their livelihoods on indigenous genetic resources developed and nurtured over hundreds of years. This genetic diversity is important for increasing productivity and improving the stability of agriculture, forestry, and fisheries. It is the basis of new products—foods, medicines, fibers—and can contribute to the development of production systems that are less dependent on external inputs.

Proper management of genetic resources is fundamental to the CGIAR's mission. Genetic resources are central to the Centers' research on gene management and underpin their work on natural resources management. The Centers maintain—in public trust—the largest collection of agricultural genetic resources in the world (about 600,000 samples). Use of this collection is critical to much of the CGIAR's efforts to eradicate poverty and protect the environment.

Since the Convention on Biological Diversity came into force in 1993, national access legislation has increasingly restricted the movement of genetic resources. In 1994, the CGIAR Centers signed agreements with the United Nations Food and Agriculture Organization (FAO) attesting to their status as trustees, not owners, of genetic resources on behalf of the world community. Shortly thereafter the System-wide Genetic Resources Programme (SGRP) was created to help strengthen and focus the CGIAR's ability to contribute to global genetic resources management efforts, including implementation of the convention. The SGRP joins the genetic resources programs and activities of all CGIAR Centers in partnership to maximize collaboration.

A 1998 review of the SGRP led to the articulation of five areas of focus: policy, public awareness, information, knowledge and technology generation, and capacity building. In the area of policy, the SGRP has developed material transfer and other agreements related to genetic resources exchange. As a result of evaluating each Center's capacity to meet commitments under the in-trust agreements, the SGRP is developing an investment plan to allow Center gene banks to upgrade their standards of operation. In addition, it is working to raise awareness among policymakers and the general public about the loss of genetic resources, their value to development, and the role of CGIAR in their conservation and use.

As noted above, genetic resources are central to the CGIAR's mission to help eradicate poverty. The basis of the System's work on genetic resources is the material that has been developed, selected, nurtured, and conserved by generations of farmers around the world. The work of the SGRP is essential to ensuring that the world's rich natural reservoir of genetic resources serves the interests of the poor in the developing world.

More than 70 percent of the poor in developing countries live in rural, marginally productive areas that are largely untouched by modern technology.

Crop and Livestock Synergies Most farmers in the semi-arid tropics practice mixed crop-livestock farming systems. To be relevant to these farmers, research must explore the interactions of crops and livestock. In the 1980s, the International Livestock Center for Africa (a predecessor of ILRI) and ICRISAT initiated studies at ICRISAT's Sahelian Center in Niger to better understand the role of livestock in mixed farming systems in the semi-arid tropics of West Africa. IFDC, ICRAF, IPGRI, and IITA as well as national agricultural research systems and farmers have joined in these studies, which are now aimed at exploiting crop-livestock synergies in both Africa and Asia. Recent collaborations include the Desert Margins Program in Africa, sustainable management of vertisols (deep black soils) in Ethiopia, the Systemwide Livestock Program led by ILRI, and joint studies based in India on interactions of fodder quality and livestock in Asia.

With the endorsement of the host countries, ICRISAT has given ILRI access to its research station facilities in Niger, in the driest part of the semi-arid tropics, and in India, in the heart of the semi-arid tropics. This access has allowed ICRISAT and ILRI to more easily pursue their multidisciplinary studies. They have investigated nutrient management for crops, feed management for animals, and animal traction issues, along the way addressing technical, economic, institutional, policy, and environmental matters.

In 1997, ILRI began planning its Asia strategy by surveying livestock farming in collaboration with the national agricultural research systems of six countries. More recently it has targeted poverty alleviation in the semi-arid tropics by focusing on fodder and livestock systems. To advance this work, ILRI has proposed that it base its efforts in India, a move welcomed by both ICRISAT and the government of India.

ILRI and ICRISAT are establishing an institutional framework for research on the use of genetic manipulation to improve the digestibility and the feed value of stover, an advance that would greatly assist small farmers. According to a rigorous impact assessment carried out in 1997–98, the net present value of a 1 percent increase in stover digestibility is estimated to be US$42–208 million, depending on adoption rates. The internal rate of return to this research investment was 28 to 43 percent.

Through research on crop-livestock synergies, CGIAR can help poor farmers extract more benefit from their own on-farm resources. Cooperation between the Group and farmers has been most effective when driven by research opportunities, rather than by supply-driven partnerships. Careful analysis is a disciplined starting point for any new collaborative venture; it generates partner and donor confidence that the work is relevant and on track. Participatory planning and execution by national agricultural research systems, farmers, local seed suppliers, and village store owners are crucial to the success of these endeavors.

A Green Revolution for Africa In 1993, the Inland Valley Consortium, comprising four CGIAR Centers, three agricultural research institutes, FAO, programs of 10 West African countries, and NGOs, was established to respond to opportunities and address problems through the Systemwide Ecoregional Program for Inland Valley Development in West and Central Africa. Phase one of the program is developing the

capacity of national agricultural research systems for agroecological characterization, and technology testing and transfer. Inter-Center collaboration on lowland agriculture is crucial because no single Center can provide sufficient expertise to deal with this huge land resource.

The Centers have focused on livestock integration (ILRI), diversification of the crop

portfolio (IITA), and better water management (IWMI). Beyond these crop and livestock improvement and natural resources management efforts, the Centers have provided coordination services, through which national and international members have shared decisionmaking responsibilities, resulting in a strong feeling of ownership among members that has contributed to the success of the consortium. In addition, the Centers have coordinated and regionalized the consortium's research activities. They have strengthened the scientific capacity of consortium members by creating mechanisms for knowledge exchange.

The consortium's characterization of work in key sites and watersheds is nearly complete. National teams have been trained in survey techniques and are now empowered to move into phase two—technology targeting.

Although its objective remains crop intensification and diversification, the consortium moves into phase two with revised priorities. Greater efficiency and coordination, a transparent governance structure, and reduced transaction costs will be ensured by a sound strategic plan. Several of the 16 key work sites will be promoted to benchmark sites through their use in the Ecoregional Program for the Humid and Sub-Humid Tropics of Sub-Saharan Africa (EPHTA), another CGIAR program.

A robust new rice and the untapped potential of the inland valleys are giving rise to a green revolution in Africa.

Stronger Research Capacity through Training and Learning The InterCenter Training Program (INTG) was established in the 1980s. ICRAF, IITA, and WARDA pursued this initiative to advance training in Sub-Saharan Africa. By the mid-1990s, the group focused attention on the role of the national agricultural research systems and the regional associations in training and capacity building.

The aim of INTG is to expand capacity for the conduct of research that will contribute to poverty reduction. Therefore, the INTG pays attention to the people conducting and managing, and the processes underlying good-quality research. It enhances national research and training capacity by building capacity (training of trainers) in African national agricultural research systems, developing training modules to support training, and monitoring and evaluating the training programs that are conducted in Africa. It also seeks to coordinate these activities to avoid duplication of efforts and to mobilize and share resources in training and capacity building.

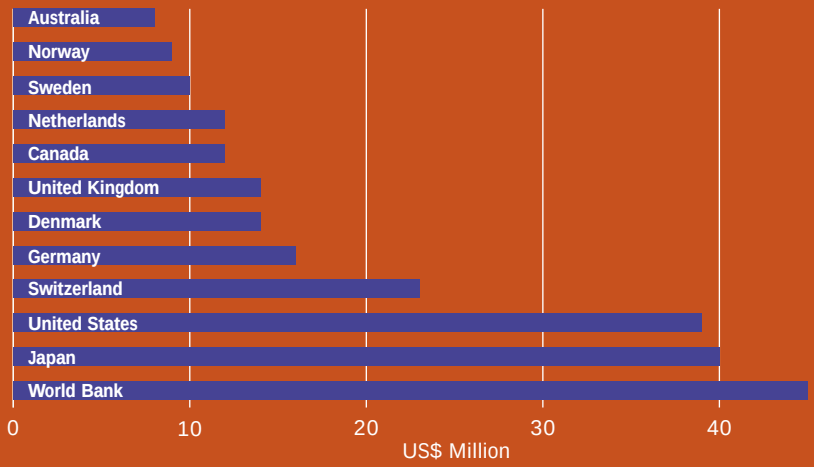
Although INTG membership is global, it has grown most rapidly in Sub-Saharan Africa. Its 45 members include international agricultural research centers, donors, research institutes, and universities worldwide. They collaborate with one another on areas of mutual concern, including participatory research and gender analysis (with CIAT and ICRAF) and development of training modules and materials (with IITA and ICRAF). To improve coordination, INTG has collaborated with ICRISAT to develop specialized databases on training modules and materials produced by international agricultural research centers and national agricultural research systems.

INTG first offered research management training in 1996. In that year, every participant was supported by the Centers. By 1999, about 60 percent of the participants were supported by the national agricultural research systems and regional associations, and women made up 30 percent of course participants.

INTG seeks to produce a multiplier effect in its capacity building. This year the training was delivered by African management training specialists.

Financial Highlights

Top Twelve Contributors to CGIAR in 1999



CGIAR Members support Centers and programs of their choice, and each Center directly receives and spends funds. Thus, the CGIAR financial outcome discussed here is a consolidation of the financial results of the sixteen independent CGIAR Centers. The results are reported in US dollars. CGIAR financial highlights for 1995 to 1999 are shown in the tables. Additional details are provided in the CGIAR 1999 Financial Report, a separate publication available from the CGIAR Secretariat.

Contribution Profile

In 1999, 55 Members made contributions totaling $330 million in support of the CGIAR research agenda. For analytical purposes, these Members can be divided into four distinct groups: industrial countries (21), developing countries (19), foundations (3), and international and regional organizations (12). Industrial countries can be further divided along geographical lines into three subgroups: Europe, North America, and the Pacific Rim. It should be emphasized, however, that because contributions to the CGIAR are voluntary, and each Member has the freedom to decide which Centers to support and at what level, the trends emerging from any of the groupings should not be interpreted as policy decisions by the group concerned.

Total contributions declined from $340 million in 1998 to $330 million in 1999, a decrease of $10 million or 3 percent. The primary reason for the shortfall was the default, due to process mishaps, by the European Commission on its 1999 commitment of $16 million. The Commission remains committed to the CGIAR and steps are currently under way in the Commission to correct the problems in 2000.

Contributions were also adversely affected by the weakness of the Euro against the dollar. This weakness lead to a $6.0 million reduction in contributions during 1999. This reduction was only partially offset by the strength of the Japanese yen which led to a $4.0 million increase.

Contributions from international and regional organizations increased by $4.0 million due to increased contributions from the IFAD, AFDB and ADB. Several developing country Members stepped up their support in 1999. Through these efforts, contributions from developing countries increased by $1.5 million to $14.7 million in 1999.

As shown in Figure 1, contributions from Pacific Rim countries increased by $4 million to $48 million in 1999; and those from developing countries increased by $1.5 million to $14.7 million in 1999. Contributions from international and regional organizations increased by $4 million to $68 million in 1999, and those from non-Members increased by $3 million to $15 million in 1999. Contributions from the European Members decreased by $22 million to $126 million in 1999. Contributions from North American Members remained constant at $52 million.

The support provided by the top twelve contributors to the CGIAR in 1999 funded about three-quarters of the research agenda, the same proportion as in 1998. (This support is illustrated in a bar chart opposite the financials section title page.) Japan and the United States were the largest contributors, after the World Bank. Colombia maintained its position as the largest contributor among the developing countries.

Figure 1. Contributions to CGIAR

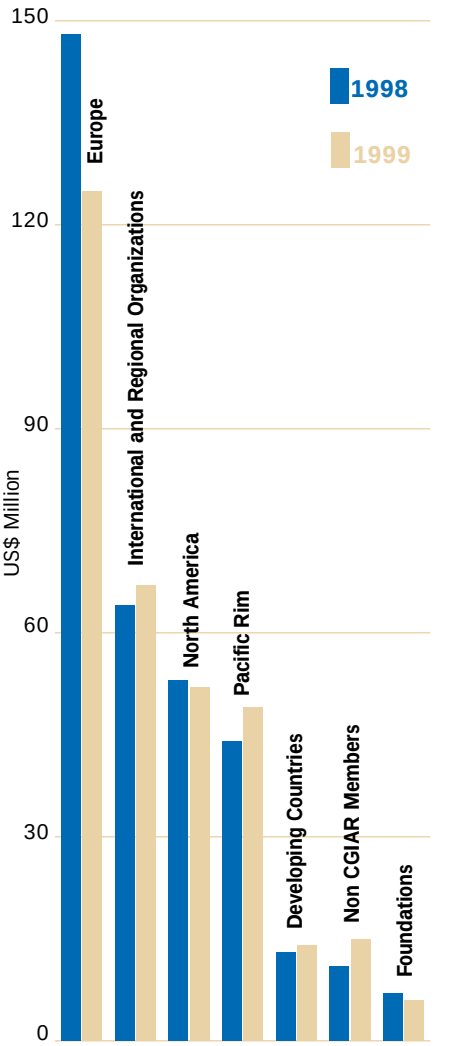
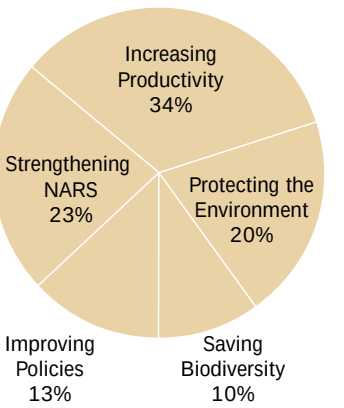


Figure 2. CGIAR Investments by Principal Activity



CGIAR RESEARCH AGENDA FINANCIAL HIGHLIGHTS, 1995–1999 (IN US$ MILLION AND PERCENT)

	1995	1996	1997	1998	1999
Member Contributions (in $ m)	270	304	320	340	**330**
Annual change (%)	14%	13%	5%	6%	**-3%**
Composition of Membership Support (in $ m)					
DAC Countries:					
Europe	107	132	141	148	**126**
Pacific Rim	39	43	40	44	**48**
North America	45	45	51	52	**52**
Developing Countries	5	8	11	13	**15**
Foundations	4	6	6	7	**6**
International and Regional Organizations	68	65	64	64	**68**
Non-CGIAR Donors	1	5	7	12	**15**
No. of Contributing CGIAR Members	41	44	50	54	**55**
CGIAR Contributions as % ODA	0.46%	0.55%	0.67%	0.66%	**0.65%**
Composition of CGIAR Investments by Undertakings (%)					
Increasing Productivity	47%	40%	40%	37%	**34%**
Protecting the Environment	16%	16%	17%	19%	**20%**
Saving Biodiversity	10%	11%	11%	11%	**10%**
Improving Policies	9%	12%	11%	12%	**13%**
Strengthening NARS	18%	21%	21%	21%	**23%**
Center Operating Expenditure (in $ m)	286	325	333	337	**347**
Distribution by Object of Expenditure (%)					
Personnel	55%	53%	51%	50%	**50%**
Supplies/Services	31%	34%	36%	37%	**38%**
Travel	7%	7%	7%	7%	**7%**
Depreciation	7%	6%	6%	6%	**5%**
Allocation by Region (%)					
Sub-Saharan Africa	39%	38%	40%	40%	**42%**
Asia	32%	33%	31%	32%	**32%**
Latin America and the Caribbean (LAC)	17%	17%	17%	18%	**17%**
West Asia and North Africa (WANA)	12%	12%	12%	10%	**9%**

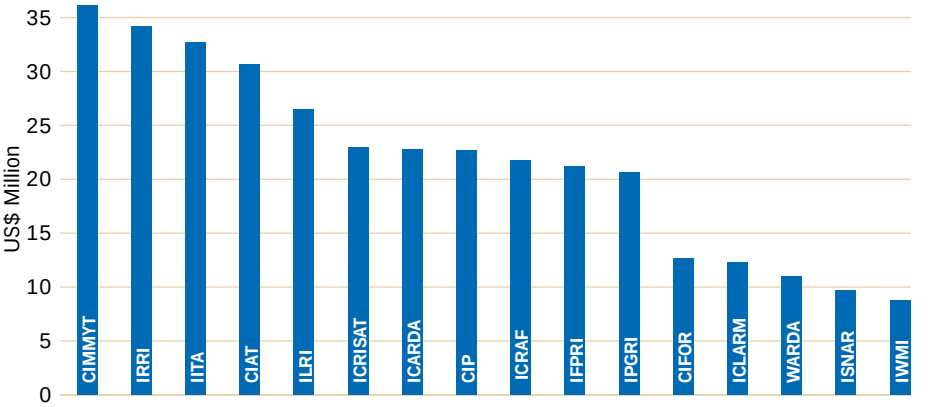
Investment in the CGIAR has been the most effective use of official development assistance, bar none.

THE THIRD CGIAR SYSTEM REVIEW

Disbursement Schedule

The disbursement targets set under the program—50 percent of funds disbursed in January and the balance by mid-year—slipped again in 1999. Only 32 percent of commitments were disbursed in the first half compared with 35 percent in 1998. At the end of the third quarter, 45 percent were disbursed compared to 42 percent in 1998. By the end of 1999, 89 percent of funds had been disbursed, compared with 88 percent in 1998. Eleven percent of funds had yet to be disbursed at the end of 1999.

Figure 3. Funding by Center



Allocation of Agenda Support by the Centers

The allocation of resources in support of the research agenda is reviewed below from four perspectives: by undertaking, by Center, by object of expenditure, and by region.

Investments in Activities Investments in the five principal CGIAR activities—increasing productivity, protecting the environment, saving biodiversity, improving policies, and strengthening NARS—for 1999 are shown in Figure 2 (on page 38). "Increasing productivity" continued as the primary thrust of CGIAR activities. In terms of production sectors, crops remained the primary focus, accounting for 71 percent of investments, followed by livestock with 13 percent, forestry with 12 percent, and fish with 4 percent of investments.

Distribution among Centers Figure 3 shows the distribution of investment in CGIAR Centers in 1999.

Expenditure by Object The trend of reduced personnel spending continued in 1999. Personnel costs amounted to 50 percent of the total costs in 1999, compared with an average of 55 percent in the mid 1990's. The total number of staff remained approximately 8,600 of which 1,100 were internationally recruited. Expenditures by object are indicated in Figure 4.

Allocation by Region The 1999 resource allocation by region is shown in Figure 5. Investment in Sub Saharan Africa increased from 40 percent to 42 percent of total investment. Asia remained at 32 percent. Allocations targeted to Latin America and the Caribbean decreased from 18 percent to 17 percent. Investment in West Asia and North Africa decreased from 10 percent to 9 percent of the total investment. Almost all Centers had activities aimed at sub-Saharan Africa in 1999. Six Centers—IITA, ILRI, CIMMYT, ICRAF, WARDA and ICRISAT—accounted for more than two-thirds of these activities. The pattern was similar in Asia. A majority of the Centers carried out activities in Asia and four Centers—IRRI, ICRISAT, CIMMYT, and ICLARM—accounted for the majority. On the other hand, approximately half of the allocations for WANA continued to be made by ICARDA. CIAT accounted for about one-third of the allocations made in Latin America and the Caribbean.

Figure 4. Expenditures by Object

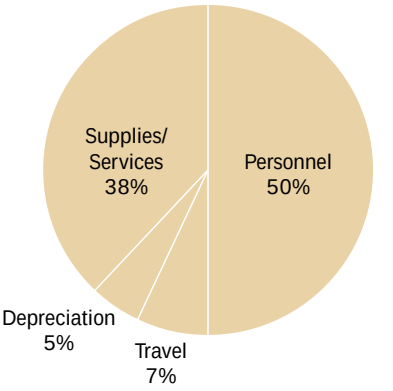
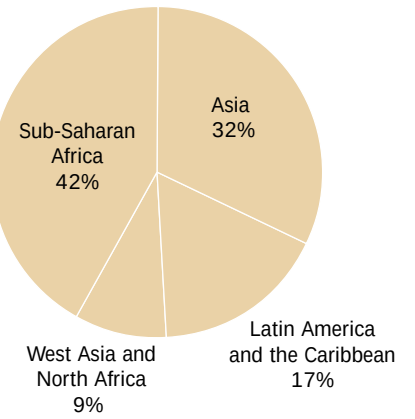


Figure 5. CGIAR Allocations by Developing Region



CGIAR CONTRIBUTIONS TO THE RESEARCH AGENDA BY CENTER, 1972–1999[1] (IN US$ MILLION)

Centers	1972–76	1977–81	1982–86	1987–91	1992–96	1997	1998	1999	Total
CIAT	28.3	65.8	107.0	132.5	138.8	31.7	32.1	**28.7**	564.8
CIFOR					30.5	10.6	11.3	**11.5**	63.9
CIMMYT	33.7	72.6	97.2	130.8	130.2	28.6	30.1	**33.8**	556.9
CIP	10.9	34.8	52.9	83.2	91.4	22.6	22.2	**20.0**	338.0
ICARDA	1.5	47.2	91.5	92.2	92.2	22.3	25.2	**19.5**	391.3
ICLARM					30.3	9.0	10.6	**14.2**	63.5
ICRAF					71.3	21.8	20.4	**20.6**	134.2
ICRISAT	19.8	59.5	103.2	143.1	134.4	26.9	26.5	**21.2**	534.5
IFPRI	1.0	9.9	20.5	41.5	51.3	18.2	20.1	**20.8**	183.3
IITA	37.1	72.4	101.1	107.9	111.3	27.5	29.2	**30.7**	516.8
ILRI[2]	13.6	80.8	107.0	155.2	124.6	25.2	24.6	**26.6**	557.5
IPGRI[3]	1.4	11.4	20.5	33.6	64.2	18.8	21.2	**20.1**	191.2
IRRI	30.2	71.3	104.6	137.5	139.1	28.6	34.8	**32.5**	578.5
ISNAR		3.3	16.8	34.4	36.6	9.9	9.6	**8.2**	118.8
IWMI					36.0	9.5	9.4	**8.8**	63.7
WARDA	1.9	9.4	12.6	28.6	34.6	8.6	10.0	**10.8**	116.3
Subtotal	**179.3**	**538.2**	**834.9**	**1120.5**	**1316.9**	**319.6**	**337.1**	**328.0**	**4973.1**
Reserves/CGIAR Committees			9.1	-16.0	7.0	0.8	2.5	**1.5**	4.9
Total	**179**	**538**	**844**	**1,105**	**1,324**	**320**	**340**	**330**	**4,978**

[1] Figures shown for 1972–1980 are total expenditures (operations/capital) and may be higher or lower than the contributions for that year (due to the accounting convention followed in the 1970s).

[2] Formerly ILCA and ILRAD

[3] Formerly IBPGR and INIBAP

CGIAR CONTRIBUTIONS TO THE RESEARCH AGENDA (1972–1999) (IN US$ MILLIONS)

Members	1972–76	1977–81	1982–86	1987–91	1992–96	1997	1998	1999	Total
Austria			1.0	5.0	7.1	1.8	2.3	**2.3**	19.4
Belgium	3.5	13.7	9.2	14.2	19.9	5.5	6.0	**6.8**	78.4
Denmark	1.7	4.7	5.9	14.4	45.0	19.1	17.7	**14.0**	122.4
European Commission		17.4	28.3	59.0	76.6	23.1	24.9	**6.0**	234.7
Finland			2.1	21.4	3.9	2.1	2.1	**1.5**	33.1
France	1.1	3.1	6.1	18.3	21.4	4.9	5.9	**5.9**	66.7
Germany	13.3	39.1	36.6	54.6	76.2	16.6	16.3	**15.5**	268.2
Ireland		0.4	1.9	1.8	3.0	0.8	1.0	**0.9**	9.8
Italy	0.1	1.9	29.1	39.8	17.6	4.0	3.0	**3.2**	98.8
Luxembourg				0.3	1.0	0.7	0.7	**0.7**	3.4
Netherlands	4.1	11.6	20.5	30.7	55.9	14.5	14.7	**11.6**	163.6
Norway	3.3	9.3	11.4	20.6	28.4	7.2	8.3	**8.9**	97.3
Portugal						0.3	0.3	**0.5**	1.0
Spain		0.5	2.5	2.5	3.9	1.8	1.1	**0.9**	13.2
Sweden	7.2	14.8	16.5	28.0	39.0	7.1	9.3	**10.3**	132.3
Switzerland	1.9	9.5	26.6	46.3	63.6	20.9	22.7	**22.8**	214.3
United Kingdom	9.0	27.5	32.6	55.8	50.8	10.2	11.5	**13.8**	211.3
Subtotal	**45.1**	**153.3**	**230.5**	**412.7**	**513.4**	**140.6**	**147.6**	**125.8**	**1767.7**
Canada	17.3	36.1	48.6	71.0	75.2	12.9	12.3	**12.3**	285.8
United States	41.6	128.1	222.0	217.3	183.5	38.3	40.5	**39.4**	910.5
Subtotal	**58.9**	**164.2**	**270.6**	**288.3**	**258.7**	**51.2**	**52.8**	**51.7**	**1196.3**
Australia	4.0	13.3	20.5	16.7	25.5	6.6	7.8	**8.1**	102.4
Japan	2.5	25.9	54.7	104.9	166.3	33.5	35.3	**39.9**	463.2
New Zealand	0.1	0.1	0.1				0.4	**0.4**	1.3
Subtotal	**6.6**	**39.3**	**75.3**	**121.7**	**191.7**	**40.0**	**43.5**	**48.4**	**566.9**
Bangladesh						0.1	0.1	**0.3**	0.5
Brazil			1.0	0.2	0.0	0.5	0.7	**0.4**	2.7
China			1.5	1.5	2.5	0.5	0.5	**0.7**	7.2
Colombia					4.5	2.6	2.5	**2.7**	12.2
Côte d'Ivoire					0.3	0.2	0.1	**0.1**	0.7
Egypt					1.0	1.1	1.4	**1.4**	4.8
India		0.5	2.5	2.5	4.0	0.8	0.8	**0.7**	11.9
Indonesia					1.2	0.5	0.1	**0.4**	2.3

(CONTINUED)

Over 55 million hectares in developing countries are planted to CGIAR-related wheat varieties each year. The additional output is valued at more than US$1.8 billion per year.

Members (continued)	1972–76	1977–81	1982–86	1987–91	1992–96	1997	1998	1999	Total
Iran	2.0	3.0			1.9	1.5	2.0	**1.8**	12.2
Kenya							0.5	**0.4**	0.9
Korea				0.5	2.6	0.6	0.9	**0.8**	5.3
Mexico		1.4	2.0	0.2	0.6	0.5	0.6	**1.7**	7.0
Nigeria	1.3	5.4	4.2	0.5	0.0	0.1	1.0	**1.6**	14.0
Pakistan						0.5	0.2	**0.0**	0.7
Peru							0.4	**0.3**	0.7
Philippines		0.7	1.6	1.1	1.7	0.4	0.7	**0.3**	6.5
Russian Federation					0.2				0.2
Saudi Arabia	1.0	1.0	3.0						5.0
South Africa						0.5	0.6	**0.5**	1.6
Syria								**0.5**	0.5
Thailand						0.5	0.3	**0.1**	0.9
Subtotal	**4.3**	**11.9**	**15.8**	**6.5**	**20.6**	**10.8**	**13.2**	**14.7**	**97.8**
Ford Foundation	16.8	6.2	4.9	4.6	12.9	3.2	3.1	**2.6**	54.4
Kellogg Foundation	1.3	0.6	1.0		0.4	0.3	0.3	**0.1**	3.9
Rockefeller Foundation	17.1	6.7	3.5	6.3	7.7	2.1	3.4	**3.5**	50.3
Subtotal	**35.2**	**13.5**	**9.4**	**11.0**	**21.0**	**5.6**	**6.8**	**6.2**	**108.6**
ADB	0.3	1.2		1.0	4.0	1.8	3.8	**4.4**	16.1
AFDB		0.1	0.6	5.3	5.6	1.0	0.8	**2.3**	15.8
Arab Fund		1.1	1.4	1.9	5.1	1.0	1.5	**1.9**	14.0
FAO						0.3	0.6	**0.2**	1.0
IDB	11.2	32.2	42.6	48.8	25.8	4.5	2.1	**1.5**	168.6
IDRC	3.9	5.7	6.5	3.4	4.4	2.4	2.4	**3.0**	31.6
IFAD		11.1	24.9	1.9	4.2	3.1	4.0	**6.9**	56.2
OPEC Fund		2.0	9.5	1.2	0.8	0.2	0.2	**0.2**	14.0
UNDP	7.4	21.7	37.0	38.2	38.6	4.5	3.2	**2.1**	152.7
UNEP	0.9	0.5	0.3	0.1	1.2	0.2	0.1	**0.2**	3.5
World Bank	16.1	53.3	116.1	162.8	222.5	45.0	45.0	**45.0**	705.8
Subtotal	**39.9**	**128.9**	**238.9**	**264.5**	**312.3**	**63.9**	**63.7**	**67.7**	**1179.3**
Non-CG Members	0.8	1.1	3.4		6.2	8.2	11.9	**15.0**	**46.7**
Total	**191**	**512**	**844**	**1,105**	**1,324**	**320**	**340**	**330**	**4,963**

Scientific capacity in developing countries has been strengthened substantially. Some 85,000 developing-country scientists have been trained at CGIAR Centers.

Who's Who in the CGIAR in 1999

CGIAR Members

Countries

Australia, Austria, Bangladesh, Belgium, Brazil, Canada, China, Colombia, Côte d'Ivoire, Denmark, Egypt, Finland, France, Germany, India,Indonesia, Iran, Ireland, Italy, Japan,Kenya, Korea, Luxembourg, Mexico,Netherlands, New Zealand, Nigeria,Norway, Pakistan, Peru, Philippines,Portugal, Romania, Russian Federation,South Africa, Spain, Sweden, Switzerland,Syrian Arab Republic, Thailand, Uganda, United Kingdom, United States of America

Foundations

Ford Foundation
Kellogg Foundation
Rockefeller Foundation

International and Regional Organizations

African Development Bank; Arab Fund for Economic and Social Development; Asian Development Bank; Commission of the European Community; Food and Agriculture Organization of the United Nations; Inter-American Development Bank; International Development Research Centre; International Fund for Agricultural Development; OPEC Fund for International Development; United Nations Development Programme; United Nations Environment Programme; World Bank

CGIAR Regional Representatives

Burkina Faso and Ethiopia
Sri Lanka and Fiji
Hungary and Slovenia
Trinidad and Tobago and Paraguay
Sudan and Syrian Arab Republic

The CGIAR

CGIAR Chairman

Ismail Serageldin, *Vice President, Special Programs, The World Bank*

CGIAR Executive Secretary

Alexander von der Osten

Cosponsors and their Representatives

Food and Agriculture Organization of the United Nations (Henri Carsalade); United Nations Development Programme (Roberto L. Lenton); United Nations Environment Programme (Till Darnhofer); The World Bank (Alexander F. McCalla)

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Gilles Saint-Martin, *France*
Ruth Haug, *Norway*
Emmy Simmons, *USA*
Bongiwe Njobe-Mbuli, *South Africa*

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Egypt (Saad Nassar)
European Commission (Uwe Werblow/Nikolaos Christoforides)
Germany (Hans-Jochen De Haas/ Stephan Krall)
IFAD (S. Mathur)
Japan (Hiroaki Isobe/Tetsushi Kondo)
Sweden (Carl-Gustaf Thornström)

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CGIAR 1971–1999

CGIAR Chairmen, 1971–1999

Ismail Serageldin, 1994–
V. Rajagopalan, 1991–1993
Wilfried Thalwitz, 1990–1991
W. David Hopper, 1987–1990
S. Shahid Hussain, 1984–1987
Warren Baum, 1974–1983
Richard H. Demuth, 1971–1974

CGIAR Executive Secretaries, 1972–1999

Alexander von der Osten, 1989–
Curtis Farrar, 1982–1989
Michael Lejeune, 1975–1982
Harold Graves, 1972–1975

TAC Chairs, 1971–1999

Donald Winkelmann, 1994–1999
Alex McCalla, 1988–1994
Guy Camus, 1982–1987
Ralph Cummings, 1977–1982
Sir John Crawford, 1971–1976

TAC Executive Secretaries, 1971–1999

Shellemiah Keya, 1996–
Guido Gryseels, 1995–1996
John Monyo, 1985–1994
Alexander von der Osten, 1982–1985
Philippe Mahler, 1976–1982
Peter Oram, 1971–1976

Notes

[1] William D. Dar, Teresa Fogelberg and John Van Dusen Lewis left the Oversight Committee in 1999.

[2] Jurgen Friedrichsen, Abdelmajid Slama, Takuji Hanatani, R. S. Paroda, and Yasuhiro Mitsui left the Finance Committee in 1999. At ICW99, Canada was elected to Chair the Finance Committee.

[3] Bo Bengtsson, Jurg Benz, Adel El-Beltagy, Norah Olembo, Setijati Sastrapradja and Maria Jose de Oliveira Zimmermann left the GRPC in 1999.

[4] Assia Bensalah Alaoui, Pramod K. Agrawal, Carol Mallette Amaratunga, Bernard P. Auxenfans, Mohamad Adel El-Ghandour, Alejandro Rodriguez-Graue, Susan Crisp-Jungklaus, Dinguri Nick Mwaniki, John M. Preston and Alberto U. Rubinstein left the Private Sector Committee in 1999.

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