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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FOUNDED: 1967
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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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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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
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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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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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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.

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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.

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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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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.

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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.

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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.

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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.

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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.