CIAT in Perspective 1995-96

Nathan Russell

Perspective in Practice

Sam Fujisaka

Several centuries ago rural people in Africa and Asia began to build their livelihoods around crops brought by traders from tropical America. In recent decades farmers in the Old World have profited from a more systematic influx of seed and practices from the New World. Now, with growing pressure on their land, Africans and Asians need such innovations more urgently than ever before.

The International Center for Tropical Agriculture (CIAT) helps maintain the historical movement of new technology from Latin America to Africa and Asia and among countries within these regions. This work, reflecting CIAT's perspective in practice, is the focus of our annual report for 1995-96.

"For most people what mattered most was not the gold and silver treasure. It was the spread of American food crops to Europe, Asia, and Africa."

***From* Seeds of Change: Five Hundred Years Since Columbus**

A Conversation with Eunice

Grant M. Scobie
Director General

When I joined CIAT in July of 1995, I made a resolution to visit all of the Center's outposted staff during my first year as director general. In this introduction to our annual report, I'd like to describe two especially instructive visits: one to the area around Kakamega in western Kenya and the other to Vietnam's northern province of Bac Thai.

I came away from both places with three overall impressions. First, I was struck by the enthusiasm and dedication of CIAT staff, by the tremendous goodwill they had generated among colleagues in national programs, by their direct contact with problems on the farm, and by their tireless efforts to bring the best of science to bear on these problems. Second, I was pleased to see how closely our work to improve crop productivity is integrated with our efforts to enhance farmers' use of natural resources. And third, I was impressed by the clear vision many farmers have of the challenge we refer to as "sustainability."

A telling incident

Perhaps the most telling incident in my travels was a conversation I had with Eunice Changirwa, a farmer living near Kakamega, where population density is extremely high. While her husband works in construction in Nairobi, she, her mother-in-law, and six children cultivate maize, beans, and bananas on a small plot. After more than 20 years of intensive cropping, Eunice is well aware that soil fertility has declined sharply on her land. She knows that chemical fertilizers can help but cannot afford to apply them.

Plants, like children, become more vulnerable to illness when they are undernourished. By the late 1980s, this was exactly the state of Eunice's bean crop. In the infertile soil of her half-hectare field, severe root rot made production of this staple all but impossible. The only bean plants that yielded well were those few Eunice could fertilize with manure from her single cow. She carried the manure in a basket on her head down to the field.

The story of how Kenyan scientists found solutions to Eunice's problem, with support from CIAT staff, is told elsewhere in this report (see page 14). Though I don't wish to steal their thunder, I will emphasize two aspects of the work. First, the root rot resistant germplasm that Eunice has been testing was brought to this area several years ago from Rwanda, where CIAT introduced it from our Colombian headquarters in the mid-1980s. Second, the introduction of new germplasm and management practices is being coordinated with the efforts of a nongovernment organization to promote the use of organic matter for maintaining soil fertility.

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Kenyan farmer Eunice Changirwa.

A chain reaction

Developments in Vietnam's cassava production illustrate these same points—the importance of long-distance germplasm exchange and of integrating research on crop production with that on resource management—but this time against the background of a very dynamic economy.

In recent years the country has witnessed an amazing set of developments in the use of cassava for industrial purposes. The crop is produced in densely populated upland areas and hauled away in carts for small-scale extraction of starch, which is then sold to food processing and other enterprises. Many of these are small-scale household operations. I visited a toffee factory, for example, where about 20 teenagers were wrapping and packaging the candy in their spare time. This whole chain of events—generating income for producers and creating jobs in processing—would have been impossible without the introduction of improved cassava varieties from Thailand. These in turn resulted from crosses between local and Latin American germplasm. The work in Vietnam is an exciting example of how the international centers can help fuel local economic development.

Cassava producers in northern Vietnam are acutely aware that there is a weak link in the chain—the fragility of the soils in their upland environment. But with the increased income from sales of cassava to industry, they now have a powerful incentive to participate in research aimed at curbing soil erosion (see page 20).

Lines that must be crossed

To better position itself to take advantage of opportunities like these, CIAT has implemented a project approach and is bringing its administrative structure in line with the new style of work. Drawing on a wide range of scientific expertise, the projects offer a more flexible means of integrating research and of organizing joint ventures with partners.

As illustrated here and on the following pages, our Center specializes in finding solutions that cross frontiers. Not just the artificial frontiers that separate nations but the lines between different levels in the hierarchy of agriculture, between individuals and institutions—lines that must be crossed if people like Eunice and her children are to have any hope for a better future.

"I asked one of our scientists what he'd miss most if we didn't have the bean network. He said he'd miss the contact with colleagues in the region."

Joseph Mukiibi, Director General, National Agricultural Research Organisation (NARO), Uganda

"We wish to extend our congratulations to all CIAT and national staff involved for their excellent management of the network in this difficult period."

Willi Graf, East Africa Section, Swiss Agency for Development Cooperation (SDC)

GUY HENRY

Solutions That Cross Frontiers

Sam Fujisaka

Much experience in agriculture suggests that local problems require home-grown solutions. Our own work over the last 25 years indicates that problem-solving power lies in effectively combining the new with the familiar.

To integrate new agricultural technology with local practice, CIAT has woven an intricate fabric of alliances with national institutions worldwide and devised novel methods for involving farmers in research on commodity improvement and natural resource management. The essay that follows describes how we work with them to develop solutions that cross frontiers.

"All these new plants required new techniques which had to be invented, adapted and perfected—sometimes very slowly but in the end with massive momentum."

From* The Structures of Everyday Life, *Fernand Braudel

From Centers of Origin to Marginal Lands

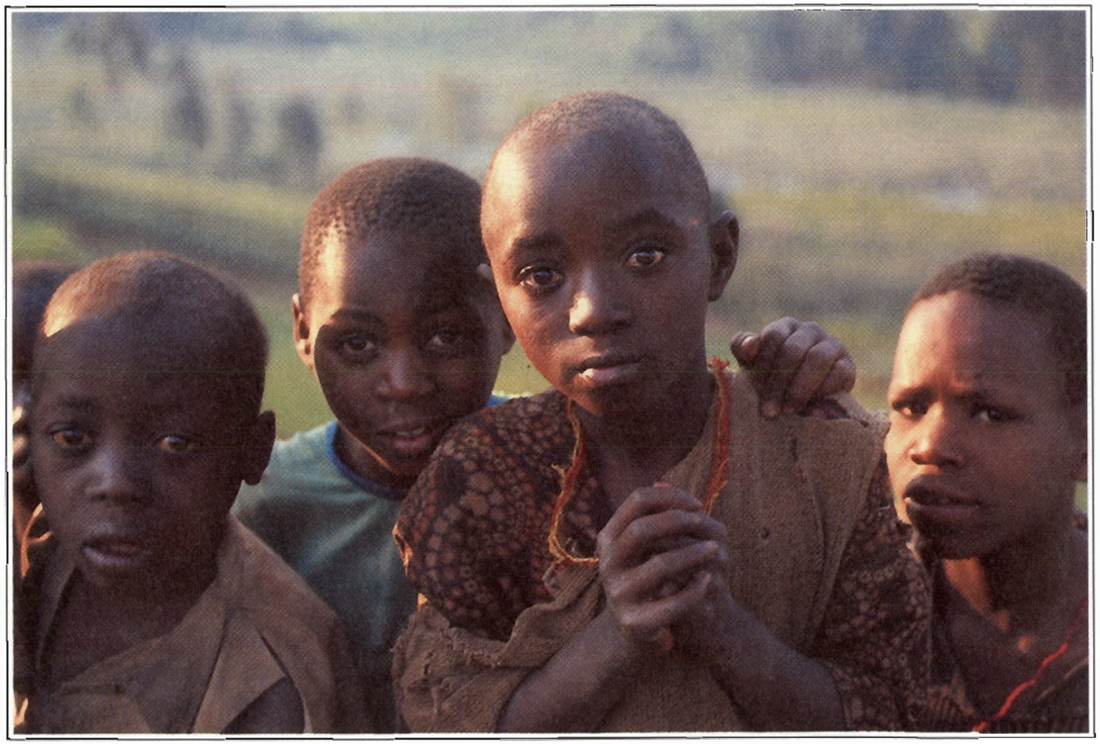
Three decades ago, when famine seemed inevitable throughout much of the world, agricultural scientists averted the coming crisis by developing new, high yielding varieties of wheat and rice. Introducing these crops—along with fertilizers and other technology—into developing countries dramatically boosted global food production and prevented mass starvation in the years to come.

Though few dispute the success of what is now called the Green Revolution, its impact was uneven. For farmers lacking access to agricultural inputs—and for those forced to work marginal, rainfed lands—crop yields have not increased measurably over the past 30 years. Even when they have, poverty prevents many of the world's hungriest people from gaining access to food. In a number of regions—parts of South Asia and virtually all of sub-Saharan Africa—hunger and malnutrition remain critical problems.

Hot spots of food insecurity

A report from the International Food Policy Research Institute (IFPRI) states that 20 percent of the developing world's population—about 800 million people—lack basic food security. While global hunger statistics have dropped since the Green Revolution, "South Asia remains home to about 270 million hungry people, while sub-Saharan Africa has emerged as a major locus of hunger," IFPRI says. "The number of hungry people in Africa has increased by 46 percent since 1970 to 175 million in 1995."

Calling South Asia and sub-Saharan Africa the world's "hot spots of food insecurity," the report also presents evidence for the role poverty and environmental degradation play in hunger and food availability. "Every second person in South Asia and sub-Saharan Africa is absolutely poor," the document states. "More than 75 percent of the poor in sub-Saharan Africa and South Asia are rural people, obtaining livelihoods from agricultural activities or from nonfarm activities that depend on agriculture." IFPRI also reports that two-thirds of all degraded lands are found in Africa and Asia.



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The majority of Rwandan children under age six suffer chronic malnutrition.

Most severe in Africa, where 30 percent of all land is affected, environmental degradation severely compromises agricultural production.

These statistics and others all point to an urgent need for agricultural research—not only to increase food production, but also to generate income for the rural poor and to reduce farming's impact on the environment. The focus must be on crops that are or can be grown by the world's poorest farmers, those who work on marginal lands bypassed so far by improved agricultural technology.

Original answers

Helping such farmers is precisely the goal of our research at CIAT. Although most Center scientists are based at our Latin American headquarters, much of their research is directly relevant to Africa and Asia. Moreover, about a dozen of our staff live and work in those regions. One of their major tasks is to improve crops that evolved and were first domesticated in the Americas—crops like beans, cassava, and some forage legumes, which today feed or support as many Africans and Asians as they do Latin Americans.

Beans are the second most important source of dietary protein in eastern and southern Africa, where a quarter of world bean production is grown. Approximately 300 million Africans rely on cassava as their primary source of calories. Originally a South American crop, half the world's cassava is cultivated in Africa and another third in Asia. In some parts of Asia, the forage plants that sustain livestock, control erosion, and maintain soil fertility, also have New World origins.

In addition to bolstering food security, beans, cassava, and forages generate significant income for farmers. Throughout sub-Saharan Africa, for example, women are mainly responsible for the production, postharvest handling,

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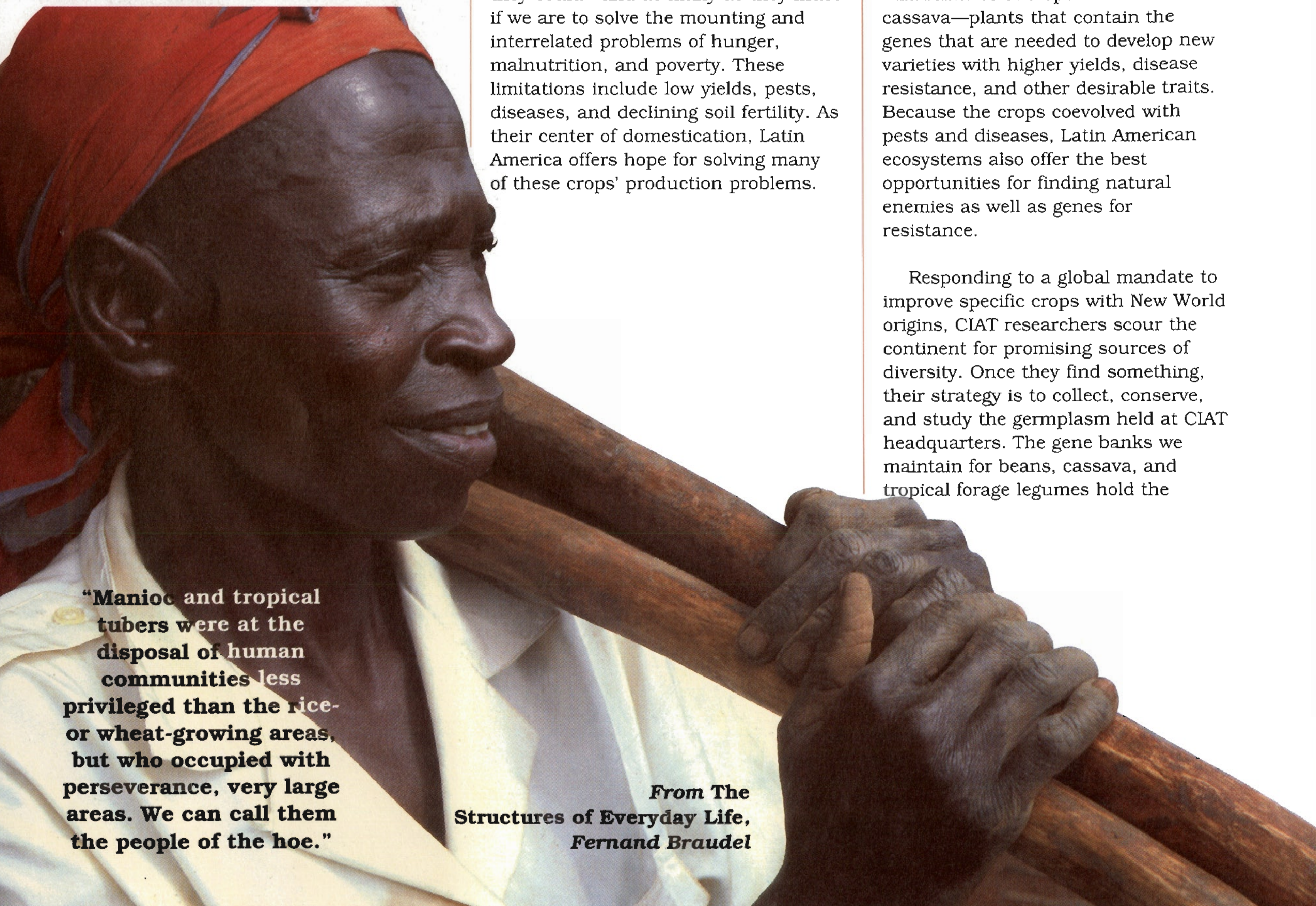
and sale of beans and cassava and therefore receive most of the benefits from new technology.



Important as they are, a number of limiting factors prevent these crops from supporting as many people as they could—and as many as they must if we are to solve the mounting and interrelated problems of hunger, malnutrition, and poverty. These limitations include low yields, pests, diseases, and declining soil fertility. As their center of domestication, Latin America offers hope for solving many of these crops' production problems.

Some of the solutions come in the form of biological diversity. Latin America houses the landraces and wild relatives of crops like beans and cassava—plants that contain the genes that are needed to develop new varieties with higher yields, disease resistance, and other desirable traits. Because the crops coevolved with pests and diseases, Latin American ecosystems also offer the best opportunities for finding natural enemies as well as genes for resistance.

Responding to a global mandate to improve specific crops with New World origins, CIAT researchers scour the continent for promising sources of diversity. Once they find something, their strategy is to collect, conserve, and study the germplasm held at CIAT headquarters. The gene banks we maintain for beans, cassava, and tropical forage legumes hold the

"Manioc and tropical tubers were at the disposal of human communities less privileged than the rice- or wheat-growing areas, but who occupied with perseverance, very large areas. We can call them the people of the hoe."

From* The Structures of Everyday Life, *Fernand Braudel

world's largest and best characterized collections of these crops. While initial screening takes place in Latin America, we transfer the best of what we find to our African and Asian colleagues.

Projecting capacity

CIAT provides more than Latin American germplasm. As detailed on the following pages, we have pioneered approaches—in networking and farmer participatory research—that form critical components of our projects worldwide. Originally developed in Latin America, these methods are adapted to local conditions in cooperation with Asian and African partners.

In recognition of our capacities in key areas, CIAT has been given responsibility for several systemwide programs of the Consultative Group on International Agricultural Research (CGIAR), including a new initiative on farmer participatory research and gender analysis. In 1995 the Center was also designated to coordinate the systemwide Soil, Water, and Nutrient Management (SWNM) Program. It embraces four research consortia, which seek better ways to replenish soil nutrients, optimize soil water use, manage acid soils, and reduce soil erosion. "Through this program," says CIAT soil scientist Richard Thomas, "the Center will be better able to project its capacities in resource management research from Latin America to other regions."

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Nathan Russell

"The greatest test for human society as it confronts the 21st century is how to use the 'power of technology' to meet the demands thrown up by the 'power of population.'"

Paul Kennedy, Professor, Yale University, USA

"The dilemmas in South Asia and Africa are not a product of far-fetched speculation about the distant future; they are a real threat today."

Robert L. Paarlberg, Associate, Harvard Center for International Affairs, USA

The Near-Perfect Food

Domesticated more than 6,000 years ago by indigenous peoples of tropical America, the common bean (*Phaseolus vulgaris*) arrived in Africa in the 16th century, probably carried as food by Portuguese traders. Today beans grow on more than 3 million hectares of the continent, cultivated for subsistence and increasingly as a cash crop by poor farmers—the majority of them women—in eastern, central, and southern Africa. In Rwanda alone, 95 percent of all farmers grow beans, which provide 32 percent of all calories and 65 percent of all protein consumed.

Because of their high protein content—as well as generous amounts of iron, folic acid, complex carbohydrates, and other essentials—nutritionists characterize beans as "a near-perfect food." This quality is especially important for Africa, where protein deficiencies and malnutrition plague millions of poor people—particularly children, whose growth, health, and cognitive development all

suffer as a consequence. For many Africans, beans also provide the least expensive source of calories and protein.

An infusion of diversity

Despite the crop's critical importance, bean production has not kept pace with population growth. According to Julia Kornegay, leader of CIAT's Bean Program, low production stems from a number of biotic and abiotic constraints, including low yielding varieties, pests, diseases, drought, and poor soil fertility. As hunger, poverty, and population growth increase throughout sub-Saharan Africa, bean production must be enhanced—without expanding the amount of land under cultivation or resorting to heavy use of chemical fertilizers and pesticides, which poor farmers cannot afford.

At CIAT we think many answers will come through an infusion of genetic diversity from the New World to the Old. Experts believe that wild ancestors of today's domestic bean evolved in two locations: Mesoamerica (Mexico and Central America) and the Andean region. With more than 28,000 accessions, the gene bank at CIAT represents the largest collection of seeds from both centers of origin as well as from bean-growing regions worldwide. Says CIAT germplasm specialist Stephen Beebe, "Part of our job is to study this collection to see what genes from the Americas may be of use to Africa."

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To make that task easier, Beebe and his colleagues have created what is called a "core collection," a small but representative subset of the gene bank's accessions. Though it is essential to maintain the entire collection, "the sheer number of accessions had become an impediment to detailed characterization of the germplasm," he says. The core collection contains just over 1,500 accessions, 1,420 cultivated beans and the remainder wild relatives.

The scientists have sent the core collection to CIAT staff and other agricultural researchers in Africa (see box, page 12). They also are evaluating the accessions themselves, looking for characteristics that can help sustain Africa's bean production. These traits include tolerance to low soil phosphorus and drought and resistance to specific diseases and pests.

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"Before, I grew just two types of beans, but now I have all these."

Teresa Batuka, Farmer, Uganda

The African bean exchange

Once promising traits are identified, they can be disseminated through collaborative bean research networks, which CIAT helped create, starting in the mid-1980s. Many of their activities are supported by the Canadian International Development Agency (CIDA), Swiss Agency for Development and Cooperation (SDC), US Agency for International Development (USAID), and Overseas Development Administration (ODA) of the UK.

Currently, the networks are located in the continent's central, eastern, and southern regions. Based on models first developed in Latin America, the networks are voluntary associations of national agricultural research systems that work with CIAT scientists. All decisions—including research priorities and allocation of resources—are made democratically. "We depend on the networks as much as they depend on us," says Kornegay.

In recognition of their effectiveness, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) cites the bean networks as models of how to build national research capacity.

A record of success

Another testimony to the networks' success is the fact that national programs have released over 40 new bean varieties in Africa since 1984.

A gene bank turned inside out

Ezekiel Mibako, a farmer near Arusha, Tanzania, doesn't know whether to be happy or sad about his beans. In one field all the plants have "dried up," he says, and will produce nothing. But in another plot, just across a narrow irrigation channel, he points to a healthy crop, whose heavy pods and dark green leaves promise an abundant harvest.

The culprit behind Ezekiel's near disaster, as he demonstrates to a small crowd of friends and neighbors, is the bean stem maggot (BSM). The six resistant varieties he has planted were brought by researchers from the national bean research program. "These are among 16 resistant types that we identified in the bean core collection developed at Center headquarters," says CIAT entomologist Kwazi Ampofo. Most of the 16 were originally collected in Burundi, Malawi, Peru, Tanzania, and Uganda.

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Ezekiel and some of his neighbors are testing the six resistant varieties whose seed types closely match those preferred by consumers in the area.

"The only resistance sources available before," Ampofo says, "had a seed type which these farmers won't accept."

To give them an even wider array of options, Clemence Moshi, plant breeder and leader of the national bean program (as well as coordinator of the bean network of SADC, the Southern Africa Development Community), is crossing the BSM resistant types with all the most commonly grown bean varieties in northern Tanzania, including both local and improved varieties. He will distribute resistant germplasm to other countries in the region where BSM is a major pest. In this way a much-needed solution for one farmer and his neighbors will prove to be a valuable heritage for many more.

Nineteen of these are breeding lines developed at CIAT headquarters, and another 23 were selected in Africa, based on CIAT introductions.

The impact of new bush bean varieties is especially evident in southeastern Uganda and northern Tanzania. The higher yields and disease resistance of the varieties not only strengthen the food security of farm families but better enable them to produce a surplus for the market.

Most of the benefits go to women like Aida Namisano of Nabongo parish in Uganda. She has recently adopted a variety referred to locally as *Namungawo* (meaning "very good tasting"). "It looks like one of our local varieties, but the grains are softer, so they take less time to cook, requiring less firewood," she says. With cash income from the sale of these beans, "I can buy soap, salt, sugar, paraffin, everything," she adds. Other women in the parish remark that the higher yields of *Namungawo* enable them to earn enough cash to cover school fees.

Another clear success story comes from the highland regions of eastern and central Africa, where beans are a critical component of the daily diet. Working through the regional bean networks—and closely with local farmers—CIAT researchers and their national partners have introduced Mexican climbing bean varieties into Rwanda, Zaire, Burundi, Uganda, and Kenya (see box, page 14). Representing an entirely new set of genetic diversity for Africa, these varieties produce higher yields and exhibit greater disease resistance than traditional bush beans. Before civil war broke out in Rwanda—the first nation that adopted the new varieties—farm families were producing an additional 50,000 tons of beans, worth US$12 million a year.

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Declining soil fertility

CIAT scientists and their colleagues in the region are justifiably proud of those achievements. But they are also acutely aware that recent progress will be short-lived unless solutions are found to the fundamental problem of declining soil fertility, particularly in heavily populated regions where farm size is shrinking and cultivation is already very intensive.

"The flexibility and pragmatism of the donors and of scientists from the national programs and CIAT have played a major role in the development of the network."

From a paper prepared by the ASARECA Secretariat

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These primary school children near Arusha, Tanzania, are getting some practical lessons in crop management through a BILFA trial planted on the school grounds.

Part of the answer is to identify bean lines that tolerate infertile soils and use scarce nutrients efficiently. Toward this end scientists across the region are exchanging and testing their most promising germplasm through a project called "Bean Improvement for Low Fertility in Africa" (BILFA).

It is hard to imagine, though, how African farmers will achieve sustainable production without at least modest doses of chemical fertilizers,

The Kakamega bean revival

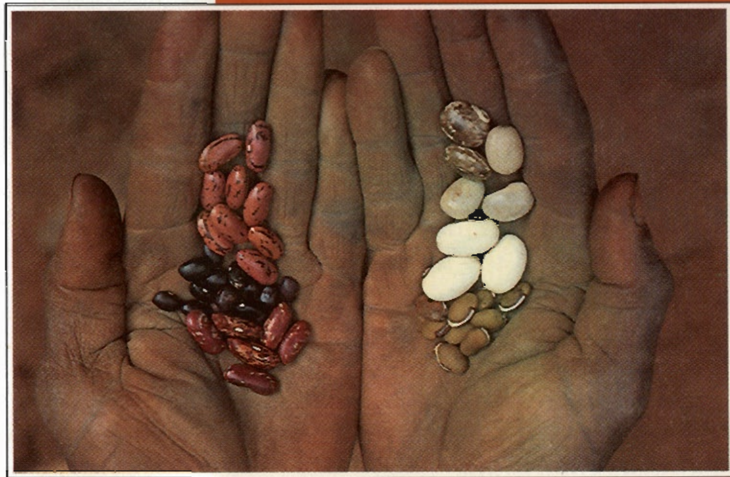
In the early 1990s, Eunice Changirwa and most other farmers near Kakamega in western Kenya practically lost their local bean races, when crops mysteriously began to turn yellow and fail season after season. "I had no choice but to stop growing beans," she says. "Any seed I planted was just wasted, it didn't produce anything."

After that, beans became a rare treat in her household. "Once in a while, I would buy beans in the market from other parts of the country, but they were expensive," she recalls. In the absence of this vital protein source, the family's diet was reduced to a monotonous dependence on maize and banana, their main starchy staples.

But Kenyan bean scientists refused to accept the finality of the farmers' loss. One of them, Reuben Otsyula, a bean breeder with the Kenyan Agricultural Research Institute (KARI), obtained a grant through the Eastern and Central Africa Bean Research Network (ECABREN) to seek solutions. He and colleagues determined that the problem was a complex of diseases referred to collectively as root rot. "Serious outbreaks occur mainly in areas where high population density puts pressure on the land, forcing farmers to cultivate intensively and thus exhaust the soil," explains CIAT scientist John Nderitu. His work is part of the Africa Highlands Initiative coordinated by the International Centre for Research in Agroforestry (ICRAF).

In search of a genetic remedy, Otsyula first screened all the samples in KARI's bean germplasm bank for their reaction to root rot. Under heavy disease pressure, all proved susceptible. Next, Otsyula began to look outside the nation's borders. In 1993 he joined scientists from Uganda and other countries for a "traveling workshop" organized in Rwanda by the CIAT-supported bean network. "I was really impressed with farmers' widespread adoption of root rot resistant climbing beans in highland areas similar to ours in western Kenya," Otsyula says.

complementing the use of green manure crops, such as *Mucuna*. Recent experience in southeastern Uganda suggests that farmers are receptive to the latter practice and highly inventive at finding niches for green manure crops in their complex farming systems. For example, Frederick Alifugani, a small-scale farmer near the village of Ikulwe, is closely studying the effects of several such species and is sharing his experience with neighbors. "When they ask why I'm growing these plants," he says, "I explain the purpose of each one and give them seed to try on their own farms."



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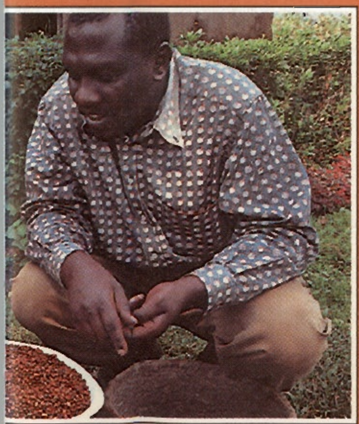
Otsyula arranged to import the 10 best varieties from Rwanda into Kenya. "I began to test them with farmers right away, because root rot isn't a problem in the well-fertilized soils of our experiment station," he explains.



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At about that time, Otsyula attended a field day organized by Patrick Nekesa of the Association for Better Land Husbandry (ABLH). A nongovernment organization supported by ODA, ABLH seeks solutions to the problem of declining soil fertility in Kakamega through its Organic Matter Management Network (OMMN). "Without new opportunities to produce, farmers have no motive to conserve," says Nekesa. "The high yields of these very marketable climbing beans justify the farmers' use of organic material to maintain soil fertility."

At an OMMN meeting, farmers discuss the performance of climbing beans as well as the new, root rot resistant bush varieties with which some have been experimenting. They talk excitedly about the prospect of intercropping beans with maize once again, in addition to growing high yielding climbers on the raised beds where they apply organic matter. With the revival of bean production in Kakamega, farmers are gaining new confidence in the ability of local institutions to help them solve urgent problems.

"The network helps me be a scientist, responsible for every stage of research, from problem identification to project management and reporting of results to colleagues."

Reuben Otsyula, Bean Breeder, KARI, Kenya

A Crop for Hard Times and Modern Times

A staple food throughout the tropics, cassava (*Manihot esculenta*) is largely unknown in the industrialized North. Domesticated in the Americas about 5,000 years ago, cassava, like beans, arrived in Africa with Portuguese traders near the end of the 16th century. Today the crop is a major source of calories for more than 300 million Africans, mostly poor families working marginal, rainfed land. Because its starchy root can be dug up and eaten between 7 months and 3 years after planting—with minimum maintenance in between—cassava has become an important food in times of crisis. During wars or natural disasters, it is often the *only* food available.

In Asia cassava has already outgrown its image as a poor man's crop—although, as in Africa, it remains an important security food in times of crisis. Introduced to Asia by Portuguese traders in the 1700s, the crop today is a major human food only in Indonesia and southern India.

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Elsewhere, it is used mostly as an animal feed and raw material in industry, particularly starch production for a variety of products, including processed food, paper, textiles, pharmaceuticals, and flavoring agents such as monosodium glutamate. Japan alone imports 200,000 metric tons of cassava starch a year.

Matchmakers

A prime attraction of cassava in Africa and Asia is its ability to withstand poor environmental conditions—such as low rainfall and infertile soils—that discourage other crops. It can adapt to a diversity of habitat types, including elevations ranging from sea level to 2,000 meters.

Despite the crop's potential adaptability, however, cassava produces low yields throughout much of Africa partly because of narrow genetic variability. According to former CIAT plant physiologist Marcio Porto, virtually all African cassava is descended from plants collected in coastal Brazil. Adapted to that region's hot, wet climate, these plants may survive, but not thrive, in such African ecosystems as semiarid lowlands and cool highlands.

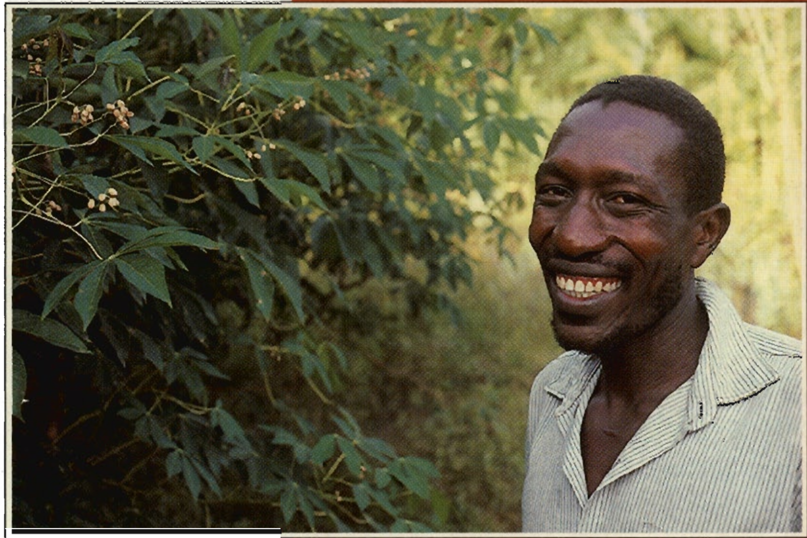
For the past 7 years, CIAT has been collaborating with the Nigeria-based International Institute of Tropical

Agriculture (IITA) to solve this problem by introducing new cassava germplasm—from the crop's Latin American homeland—into its limited African gene pool. Much of the work is done through a partnership with the Brazilian Agricultural Research Enterprise (EMBRAPA), supported by the International Fund for Agricultural Development (IFAD).

At CIAT scientists use a 6,000-accession gene bank to breed and select for different combinations of promising traits, then field test the plants in Latin American ecosystems similar to those of interest in Africa. To identify such environments, they work with experts on geographical information systems (GIS) in CIAT's Land Management Unit, who input data—on temperature and rainfall, for example—from both continents into a GIS program to identify matches.

The best progeny from CIAT and EMBRAPA field trials go to IITA, which grows the plants first in a greenhouse and then in the field to preselect as well as screen the material for diseases. Plants that pass this stage are field tested on experiment stations and then by farmers, who evaluate the results hand-in-hand with scientists.

In many regions of Africa, Latin American germplasm failed miserably because it could not stand up to the African cassava mosaic virus (ACMV), a disease not found in the Americas. "But we got beautiful performance and disease tolerance in semiarid and midaltitude areas," says Porto, who spent 5 years in Nigeria working as the CIAT-IITA liaison and later as an IITA agronomist. "Those are precisely the areas where we need more genetic diversity," he adds. To improve the performance of germplasm from Latin America in ecosystems where ACMV is prevalent, CIAT scientists can cross it with virus-tolerant materials developed by IITA.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Putting cassava on the map

Other traits important to African cassava growers include drought tolerance and high dry matter content. Breeding for these characteristics and for disease resistance will soon become easier, thanks to CIAT's just-completed molecular map of cassava—the first such map ever created outside an industrialized country. Made up of DNA markers that allow researchers to screen hundreds of genotypes a day, the map should increase efficiency and

"Cassava is part of every mouthful that he chews. It is the staple; it bulks out the meal."

From* A Way in the World, *V.S. Naipaul

cut the time it takes to breed a new variety with a specific trait.

Cassava's long growth cycle and the fact that it's an outcrossing plant (with many traits controlled by recessive genes) traditionally has made introducing such traits "a nightmare for the breeder," says geneticist Martin Fregene. A Nigerian, Fregene came to CIAT's Biotechnology Research Unit from IITA to work with geneticist Merideth Bonierbale and the Cassava Program on the Rockefeller Foundation-supported project. Now that an initial version has been completed, the scientists want to use the map to tag genes for traits ranging from cooking quality to virus resistance—jobs that will require 5 years or more, depending upon the number of genes involved.

A matter of time

Other projects on biotechnology research offer potential solutions to these problems as well. One important drawback of cassava in Africa is the crop's high concentration of cyanogens. While traditional processing eventually eliminates these toxic compounds, "women and girls now spend most of their waking hours processing cassava, leaving little time for school or other activities," says Ann Marie Thro, CIAT plant breeder and coordinator of the Cassava Biotechnology Network (CBN), which is funded by the Netherlands' Directorate General for International Cooperation.

One logical approach to solving this problem would have focused on developing new varieties with low cyanogen levels. But according to Thro, African farmers prefer cassava with high cyanogens because these compounds protect the crop from human and animal predators. As a network that works closely with and responds to the needs of farmers, CBN decided to focus on cyanogen breakdown after harvesting. Scientists in advanced laboratories have already cloned some of the genes involved in the process, but developing a repeatable protocol for genetic transformation could take several more years.

Raw material for development

In contrast to the prevalent pattern in Africa, cassava in Asia is processed mainly by large factories. Nonetheless, most of the raw material for these enterprises comes from small-scale farmers. The crop provides an

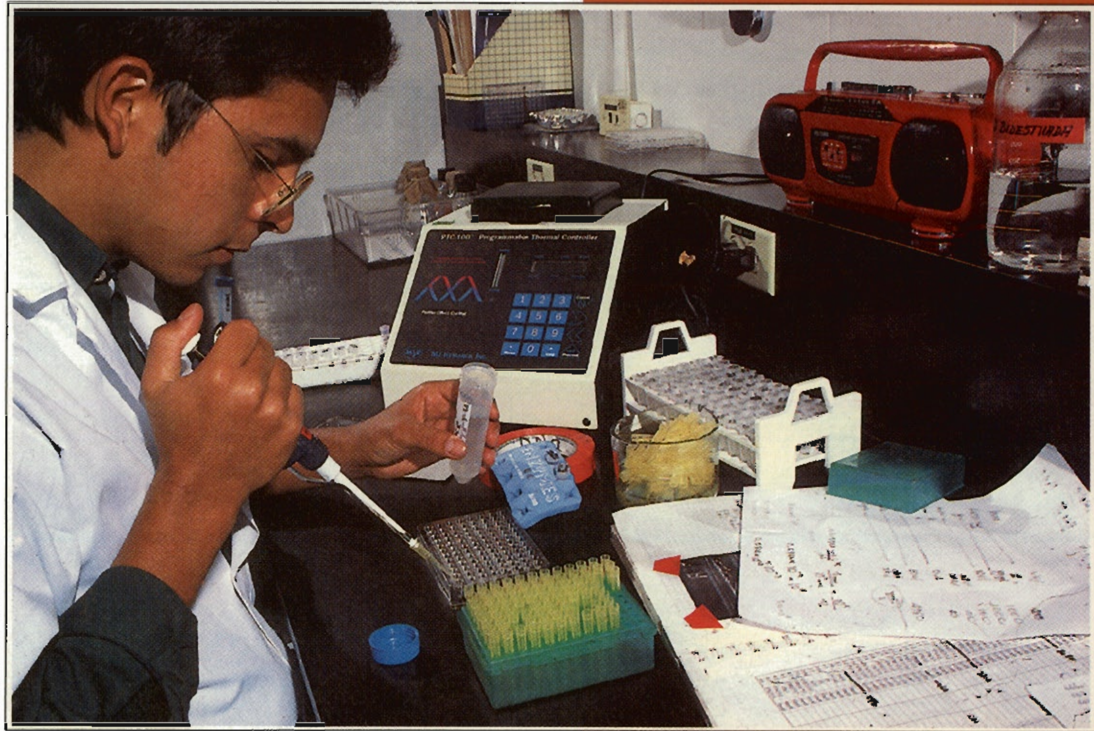
Dominique Dufour

The extraction of water from cassava pulp is the hardest step in the preparation of *gari*, an important cassava product in western and central Africa.

important—and growing—source of income for rural families in Thailand, Indonesia, China, Vietnam, and the Philippines. "Cassava is the principal source of income for farmers on some of Asia's poorest lands," says Kazuo Kawano, CIAT's Bangkok-based cassava breeder. "Nothing else will grow so well in dry or infertile soils."

Working closely with headquarters staff, Kawano and his colleagues in Asian national programs are working to breed, select, and introduce new cassava varieties into the region. Because the crop is used primarily in industry, the scientists target different traits than they do in Africa. "We focus on root yield and starch content and give less attention to cooking quality, nutrition, and cyanide content," says Carlos Iglesias, Colombia-based CIAT plant breeder. Because Asia is also blessed with fewer pests and diseases, "the job of a plant breeder is somewhat less complicated," he adds.

Industry involvement also means that new varieties are disseminated quickly. Improved CIAT germplasm is now grown on about 400,000 hectares in Southeast Asia (see box, page 20). According to Kawano adoption of the new varieties generates "nearly 50 million dollars of additional income a year, much of it going directly to the poorest farming communities."



MAURICIO ANTORVEZA

Cutting environmental costs

In many areas, however, such benefits can come with a high environmental cost. Because cassava is an adaptable plant, growing industrial demand—combined with absorption of prime lands by population growth and other crops—has forced farmers to plant it increasingly on steep slopes.

"Most important are all the connections CBN helped me form with other cassava scientists."

Francisco Campos, Molecular Biologist, Federal University of Ceará, Brazil

The result is severe soil erosion that not only reduces upland soil productivity, but also pollutes rivers, clogs irrigation systems, and fills in rice paddies below. "Soil erosion is a critical problem," says CIAT agronomist Reinhardt Howeler, also based in Thailand. "It has been reported that the river systems of Southeast Asia discharge more than 6 billion tons of sediment yearly—more than three times the sediment load of river systems throughout the entire South American continent."

With funding from Japan's Nippon Foundation, Asian cassava farmers, national researchers, extension agents, and CIAT scientists are working together to help solve the erosion problem. Launched in 1994, the project has enlisted about 130 farmers in China, Indonesia, Thailand, Vietnam, and the Philippines to test and adapt alternative cultural practices along with new cassava varieties.

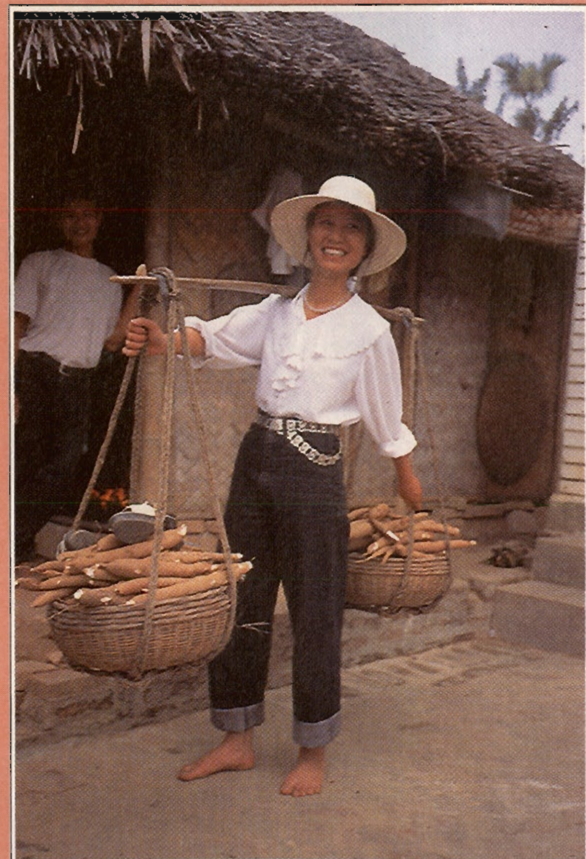
Changing fortunes

Given the relatively low status of cassava in Vietnam, it was an unlikely source of good fortune for Nguyen Hung Cuong and other farmers in the country's southern province of Dong Nai.

Nonetheless, through a combination of factors, including a shift in government policies and developments in the starch industry, improved cassava varieties have placed modest prosperity within his reach. "Before, I was getting about 12 tons of fresh cassava per hectare, but with KM-60 my cassava yield is 25 to 30 tons. With the extra money I earn by selling cassava to the starch factory, I can now send my three children to school."

His simple testimony forms part of a larger picture that conveys the power of new technology to change the lives of individuals and institutions. An economic survey conducted in southern Vietnam during 1995 showed that, just 2 years after its release, KM-60 was already generating benefits valued at US$1 million per year for small-scale farmers. By early 1996 this and another new variety, KM-94, were planted on about 6,500 hectares.

Rapid dissemination of these varieties, explains CIAT cassava breeder Kazuo Kawano, is due in large part to the "indefatigable efforts" of Hoang Kim, director of the Hung Loc Agricultural Research Center. In the early 1990s he established a series of workshops in which farmers, starch factory representatives, and others select clones being tested in advanced yield trials. With proceeds from the sale of cassava stakes for planting, Kim has repaired roads and


GUY HENRY

According to CIAT economist Guy Henry, farmers are evaluating more than erosion control. "They have to look at net income—what they get from cassava and intercrop yields after deducting their additional costs—and compare that figure with the reduction of soil loss." So far, he says, systems that include an intercrop like peanut or contour hedgerows of vetiver grass have been among the most popular, because they reduced erosion while increasing net income.

The project is now expanding to bring in more farmers for the second round of evaluations. Many have heard about the work and volunteered to participate. "Neighbors ask to join the project because they see its value," says Howeler. And when the experiments produce good results, "we don't have to convince anyone to adopt the techniques," he adds. "The farmers convince each other through their own research."

refurbished the center's facilities, transforming it from a "sleepy branch station," says Kawano, into a major center of research activity with strong government support.

Vietnamese farmers and researchers are at last getting a taste of what their Thai counterparts have enjoyed for a long time and on a much larger scale. There the power of new cassava technology is even more in evidence on the country's 1.3 million hectares of cassava. In 1992 the government aimed to substitute five new cassava varieties for the single traditional variety on about 200,000 hectares within 5 years. Through an innovative scheme for variety multiplication, involving research institutes, extension services, farmers, and a private foundation, the country achieved its goal in just 4 years. By 1996 farmers were planting the five improved varieties on an estimated 300,000 hectares.

GUY HENRY

"My good fortune with the new cassava variety began when the head of the experiment station invited me to pick out the varieties I liked best from their harvest."

Nguyen Hung Cuong, Farmer, Vietnam


". . . for they
shall
inherit the
earth."

NATHAN RUSSELL

Sowing a New Tradition

As major tools for erosion control and soil improvement, grasses and legumes have many uses beyond their traditional role as livestock forage. Nitrogen-fixing legumes, for example, significantly enhance soil fertility, increasing the productivity of other crops and allowing farmers to shorten fallow periods. Forage plants also help control weeds, insect pests, and crop diseases. And as livestock feed, they boost meat and milk production, helping to improve nutrition throughout the developing world.

In tropical Asia, livestock are a key component of small-scale farming systems. Not only are the animals a source of protein—meat and milk—but they also provide cash income and draft power: a draft animal allows farmers to prepare 10 times more land than they could by hand.

Unlike the situation in much of Europe, Australia, and the Americas, livestock production is more intensive in Southeast Asia. Rather than allowing their animals to range freely over large areas, farmers must provide them food in "cut and carry" systems. Peter Kerridge, leader of CIAT's Tropical Forages Program, says that "new forages, particularly shrub legumes, offer these farmers an opportunity to increase productivity by complementing the crop residues of low nutritive value often fed to livestock now."

DAVID MOWBRAY

Targeting ecosystems

Using raw material from the gene bank at CIAT, with over 24,000 accessions, members of the tropical forages team have been evaluating and improving forage plant germplasm since the mid-1970s. They began their work in Colombia's savannas, selecting grass and legume species adapted to that region's acid, infertile soils. The new grasses have increased livestock weight gain per unit area of land by a factor of 16; adding legumes has boosted production again twofold.

More recently, the scientists began selecting forage species adapted to other Latin American ecosystems as well as to other parts of the world, particularly Southeast Asia and Africa. Following a strategy similar to that used by cassava researchers, their greatest success has come from Latin American germplasm targeted to similar Asian ecosystems. Although they have identified many promising species, until recently these had little impact at the farm level.

A resource bank for farmers

Now the situation is changing as CIAT introduces new methodologies—along with germplasm—into its Southeast Asian program. In 1995 the Center helped launch the Southeast Asia Forage and Feed Resources Research and Development Network (SEAFRAD), which works to promote forage research through collaboration between scientists in Indonesia, Laos, Malaysia, Thailand, southern China, Vietnam, and the Philippines. We have also introduced farmer participatory research, starting with two training courses, one in the Philippines and the other in Laos, during 1995. In 1996 workshops are scheduled for Indonesia, Thailand, and Vietnam.

The workshops are part of a larger effort, the Forages for Smallholders Project, funded by the Australian Agency for International Development (AusAid) and based at the International Rice Research Institute (IRRI) in the Philippines. Carried out collaboratively by CIAT and Australia's Commonwealth

DAVID MOWBRAY

"I can be an example to other farmers."

Nemisia Purgatorio, Farmer, Philippines

Scientific and Industrial Research Organisation (CSIRO), the 5-year project's goal is to make high quality forages more widely available—to feed livestock, enhance soil fertility, reduce erosion, and provide fencing and other building materials. Though most of the forages come from CSIRO or CIAT, it is the farmers themselves who test and decide which species to adopt.

"We see ourselves as a resource bank, supplying information and germplasm to farmers," says CIAT agronomist Werner Stür. Stür, along with his CSIRO colleague Peter Horne

Novel uses for a tropical American legume

In southern China high population density combined with limited land for livestock grazing has created a demand for good quality forage. It's no wonder, then, that a Chinese scientist visiting CIAT in the 1980s brought back several forage plant accessions to test on Chinese farms. That scientist, Liu Guodao—now an assistant director for the Chinese Academy of Tropical Agricultural Sciences—wrote recently that one of those accessions, *Stylosanthes guianensis* (CIAT 184), "has become the most important forage legume in tropical and subtropical China, covering a total land area of 50,000 hectares."

More remarkable is how *Stylosanthes* is used in China. A legume first collected near CIAT headquarters in Colombia, the plant initially was tested as a commercial forage for tropical American pastures. Ultimately, it failed to meet that potential due to poor persistence under grazing and susceptibility to the disease anthracnose. In China, however, *Stylosanthes* thrived in livestock pastures. But its most important use has turned out to be as a cover crop planted with rubber and fruit trees. A nitrogen-fixing legume—or green manure—*Stylosanthes* takes the place of expensive, chemical fertilizers. It also helps conserve water and controls both soil erosion and weeds.

Luis Fernando Pino

In addition to using it as a green manure, Chinese farmers harvest *Stylosanthes* leaves, dry them in the sun, grind them up, and use them as an ingredient in highly nutritious animal feeds. Such feeds are particularly useful for raising chickens and pigs, which have higher nutritional needs than cattle. Mixtures containing the legume also are fed to ducks, geese, rabbits, and fish.

With its variety of uses, *Stylosanthes* itself has become a cash crop, returning about US$1,400 a hectare when sold as meal for poultry and pig feed. "Starting with a promising plant that had no commercial value at home, the Chinese have come up with a set of entirely novel uses for a tropical American legume," says CIAT plant breeder John Miles.

and other international scientists, work closely with national forage researchers throughout the region. Using participatory research, they go to the farmers, ask them about their needs, then offer a selection of forages suited to the region that may meet those needs. "This is not the sort of research that ends up as columns of figures," says Stür. "We drink tea and talk with each farmer, we walk up and down the hills, and we observe what farmers are actually doing."

Once farmers select forages, the project's next step is to make the desired species more widely available. Whenever possible, farmers are provided an opportunity to multiply their own seeds and cuttings. So far, some of the most successful species have been legumes, like *Stylosanthes guianensis* (CIAT 184), that evolved under harsh conditions in South America (see box). Though the researchers may have predicted the success of certain species, they refrain from imposing strong opinions. "Farmers are always on the lookout for new varieties and technologies," says Stür. "They're also the world's best experts on their own immensely diverse and complicated farming systems."

DAVID MOWBRAY

"Working with farmers is immensely rewarding. We share both our successes and our disppointments."

Werner Stür, Agronomist, CIAT

Luis Fernando Pino

A Fertile Source of Solutions

NATHAN RUSSELL

Tropical America's rich store of agrobiodiversity and other offerings to Africa and Asia have yielded huge benefits for these continents. With its widespread infertile soils and other challenges, the region continues to be a fertile source of effective solutions in agriculture.

In the following sections, we examine selected themes in CIAT's work for tropical America, where new ways to combat poverty and environmental destruction are rapidly emerging. How many of these innovations will find their way across the seas and take root in African and Asian soil?

"Latin America is more influential than ever before in the world of ideas and in the form of practical solutions to overcome current world problems."

David Preston, Senior Lecturer, University of Leeds, UK

New Niches for an Ancient Crop

The common bean is the world's most important food legume, providing protein and carbohydrates for more than 300 million people. But, ironically, the crop has been underutilized during recent years in the Andes, one of its two centers of origin. To help reinvigorate the region's bean production, CIAT and various national institutions launched the Regional Bean Project for the Andean Zone (called PROFRIZA) in the late 1980s, with support from the Swiss Agency for Development and Cooperation (SDC).

The project is not just about reinforcing an ancient heritage, however. Throughout the Andes farmers have created new traditions, involving introduced legumes, such as broad beans, chickpeas, and lentils. "But common bean offers farmers more options than these other species," says CIAT agronomist Oswaldo Voysest. "Depending on the variety, you can cultivate beans from sea level to 3,200 meters, with growth periods that range from 75 to 300 days, enabling the crop to fit a wide array of farming systems." PROFRIZA's research strategies take advantage of this unique flexibility of beans.

In northern Ecuador, for example, farmers in the irrigated valleys are growing red-seeded bush beans for sale across the border with Colombia, while hillside farmers intercrop late maturing climbing beans with traditional maize varieties. For the first group, PROFRIZA scientists have developed high yielding varieties and an integrated pest management (IPM) strategy that enables growers to reduce pesticide use by 60 to 70 percent. For the second group, the project has introduced a red-seeded climbing variety that enables these farmers to break into the export market.

In Santa Cruz, Bolivia, most farmers cultivate soybeans, maize, and rice in the summer season but have few options in the short, dry winter season. With the introduction of rapidly maturing, high yielding bean varieties, these farmers now grow 10,000 hectares of the crop (having started from zero) for export to Brazil. In a nearby upland area, another

NATHAN RUSSELL

Ecuador's bean researchers are working closely with farmers to find alternatives to the alarming "chemical culture" that has arisen in the Andean zone.

group has begun to produce seed for sale to bean farmers in Santa Cruz. "This project has had a snowball effect," says Voysest, "creating entirely new sources of income for farmers across Bolivia."

A Scientific Culture in Farm Communities

In Brazil, the world's second largest cassava producer, the crop is especially important in the country's Northeast. It provides 27 percent of the total caloric intake of the region's population, whose poverty and employment are the highest in the country.

Cassava is beset by a wide range of pests and diseases in the Northeast as well as by scarce rainfall and infertile soils. In search of solutions, the Sustainable Cassava Plant Protection Project (PROFISMA) was launched 2 years ago. Funded by the United Nations Development Programme (UNDP), the project is a joint venture linking CIAT with EMBRAPA's National Center for Research on Cassava and Tropical Fruits (CNPMF) and IITA, which has a parallel effort in West Africa.

Some problems addressed by the project are amenable to classical biological control. For example, to check two devastating arthropod pests in Brazil—cassava green mite and cassava mealybug—researchers have introduced parasitoids and predators from Colombia, Venezuela, and Ecuador and are monitoring the performance of these natural enemies.

Eduardo Figueroa

Biological control agents can usually do their job without farmer involvement. But some problems require solutions that depend on the active participation of growers. For this purpose the project has formed a network of Local Committees for Agricultural Research (COPALs), with support from state research and extension agencies.

"The scientists listen to us, and we listen to them, too. We're good friends."

José Texeira de Jesús, Farmer, Brazil

There are now 20 such committees, each involving 30 to 100 people.

The COPALs' first task was to help diagnose the principal constraints of cassava production in this harsh semiarid environment to provide a basis for setting research priorities. "We were excited to see how enthusiastically the farmers accepted their new role," says CIAT entomologist Steve Lapointe. The diagnostic stage took place in 75 communities and involved 2,565 farmers. "Their opinions and perceptions made us better aware of problems other than the ones we expected to find," says Bernardo Ospina, CIAT agricultural engineer and coordinator of PROFISMA's training effort.

In search of solutions, the committees plan, carry out, and evaluate experiments, with assistance from scientists. "Before, we had plenty of technology, but it wasn't reaching the farmers. Now they realize that they themselves can solve problems," says CNPMF entomologist Ítalo Delalibera. On the foundation of their traditional knowledge and cooperative spirit, farmers are working side-by-side with researchers to build a scientific culture.

LUIS FERNANDO PINO

A rich carpet of *Arachis pintoi* serves as a ground cover in this citrus grove in Colombia. The wild peanut controls weeds, while conserving moisture and fixing nitrogen in the soil.

A Magnificent Legume

Like its relative the domestic peanut (*Arachis hypogaea*), forage *Arachis* is a South American legume that enhances soil fertility by fixing atmospheric nitrogen. When planted with nutrient-poor pasture grasses, it also boosts meat and milk production and persists stubbornly even under intense grazing pressure. Calling it "a magnificent legume," Peter Kerridge, leader of CIAT's Tropical Forages Program, says "*Arachis pintoi* is the only tropical legume I know that does best under overgrazing."

Since the mid-1980s, CIAT researchers have been marshaling strong evidence supporting the advantage of *Arachis* over traditional forage species. In Colombia's *Llanos Orientales* or Eastern Plains, for example, they found that adding the legume to all-grass pastures doubles the weight gain of cattle per hectare. In forest margins of Costa Rica, *Arachis*-grass mixtures produce nearly a ton of beef a hectare—without the addition of nitrogen fertilizer—and increase milk production by up to 25 percent per cow per day.

Despite such compelling statistics—and efforts by national agricultural researchers to introduce *Arachis* varieties selected at CIAT—farmers have been slow to adopt the beneficial legume. Now that is changing: a 1995 survey of Colombian farmers who have tested *Arachis* shows that 70 percent are eager to use it again. Equally significant, more than half are using the multipurpose plant for something other than livestock forage. The other uses of *Arachis* include weed and pest control, soil reclamation, erosion control, and ground cover under tree crops such as banana, coffee, and oil palm.

Now even industry is getting into the act. Nestlé of Colombia—which purchases 200,000 liters of milk daily from the forest margins of southeast Colombia—is funding an *Arachis* promotion project. Working with the region's small farmers, CIAT and national scientists are trying to boost milk production, while reclaiming soils that have been degraded by overgrazing.

The only limit to the spread of *Arachis* now seems to be a shortage of seeds. This bottleneck has turned into a boon for poor farmers in Bolivia's Yapacani region, who—with aid from the Swiss government—have formed a cooperative that grows and sells *Arachis* seeds. This activity has tripled the farmer's income. In addition, they are feeding *Arachis* foliage and flowers to chickens, planting the legume for weed and pest control, and eating its seeds during times of food shortage.

Not Just a Lab Technique

Biotechnology techniques hold much promise for enhancing tropical agriculture—but only if the methodologies are adopted by developing countries themselves. In the Center's first major effort to disseminate one of its own biotechnology tools, CIAT scientists have just completed a successful project to transfer rice

GUILLERMO GUZMÁN

"It was an excellent way to find out how anther culture technology is being applied in other countries."

From an anonymous training course evaluation

anther-culture technology to national programs throughout Latin America.

Supported by the Rockefeller Foundation, the project was a joint effort between CIAT's Rice Program and Biotechnology Research Unit. According to geneticist Zaida Lentini, anther culture was targeted because it makes the process of breeding new rice varieties both faster and less expensive. "In most Latin American countries, it takes 13 to 15 years to develop a new variety," she says. "With anther culture, it may be possible to cut that time in half."

As the pollen-producing part of a plant's stamen, an anther grown in standard tissue-culture medium develops into haploid, nonorganized tissue with half the normal number of chromosomes. During plant formation in rice, this haploid tissue spontaneously doubles its ploidy number and grows into a homozygous diploid plant. Because all its genes are expressed directly, the plant lets breeders know immediately what traits they have.

CIAT's technology transfer began in 1994 with a course and workshop attended by 22 scientists from eight Latin American countries. Each of the 11 participating institutions sent a team of two researchers: a plant breeder and a tissue culture specialist who would continue working together at home. In the year following the course, CIAT scientists visited all the teams to observe their progress. At a final 1995 workshop—held in Argentina, Uruguay, and Brazil—participants summarized their accomplishments and reported on field trials of several new lines they had produced.

While all eight countries have made considerable progress, Lentini cites work in Argentina and Cuba as particularly impressive. Researchers in these countries have produced, respectively, 2,000 and 1,500 new rice lines obtained through anther culture. They also have worked closely with national agricultural breeding programs, an important step, she adds, "because we don't want this to be just a laboratory technique."

Luis Fernando Pino

A new computer model predicts the sustainability of different options in farm management.

Modeling the Future for Decisions Today

Though *sustainability* is a popular buzzword among policy makers, few agree on how to define the term. Fewer still have attempted to quantify or predict it. Working with two University of Florida researchers, Ron Knapp, leader of CIAT's Hillsides Program, has now come up with a computer model that predicts the sustainability of different farming scenarios.

"To many people sustainability is just a vague philosophy," says Knapp. "To us, it's the ability of a farming unit to continue generating enough income to support a family in the future." By feeding different combinations of variables into the model—such as cropping sequences, commodity prices, input costs, and soil erosion—the researchers generate probabilities, ranging from 0 to 1, that the farm will still be in business at a given point in time. Changing the scenario in any way changes the probability value.

To test and refine their model, the scientists worked closely with farmers in Colombia's Cauca department. For this area the model predicts that the most sustainable cropping system is an intensive, 2-year rotation of maize, bean, and cassava, which is further enhanced by adding a high value crop like tomato. Other variables that have major effects on sustainability include land area cultivated, soil erosion, crop prices, and crop price stability.

Some of the model's predictions surprised even farmers, while others seemed obvious and intuitive. Having a tool to do quantitative analyses would put local people in a better position to influence agricultural policy. "Every day, policy makers in government and industry use computer models to make decisions affecting the lives of farmers," says Knapp. "But these models include no measures of sustainability, which is an important variable to the farmer—as well as to the resource base upon which all farming relies."

A Twofold Solution

South America's last agricultural frontier, the savannas, cover 250 million hectares—about a quarter—of the continent's land area. Characterized by acid, infertile soils that degrade easily, savannas nonetheless must be developed to provide food for the world's burgeoning population. The challenge is to find ways of using these lands intensively and at the same time sustainably.

After a 7-year project in Colombia's *Llanos Orientales*, CIAT's Tropical Lowlands Program has found at least one answer. "By combining two different land uses, each of which would be unsustainable alone, we've come up with a system that's both productive and resource friendly," says program leader Raúl Vera. "While we

Luis Fernando Pino

"CIAT's work is indispensable for the sustainable development of Orinoquia."

Manuel H. Aldana, Regional Coordinator, COLCIENCIAS, Meta, Colombia

had a hunch it would work—we even called it our 'best-bet' experiment—we needed several years of data to prove the hypothesis."

The land uses Vera and his team combined were dryland rice and pasture for cattle production. Both were widely grown in the region before, but only as monocultures that rapidly depleted soil nutrients. In the experiment researchers planted a CIAT rice variety—specifically bred to thrive in acid, infertile soils—along with different combinations of grasses and nitrogen-fixing legumes. Such "improved" pastures can support six times as many cows (each gaining about 100 pounds more a year) as pastures of native grasses.

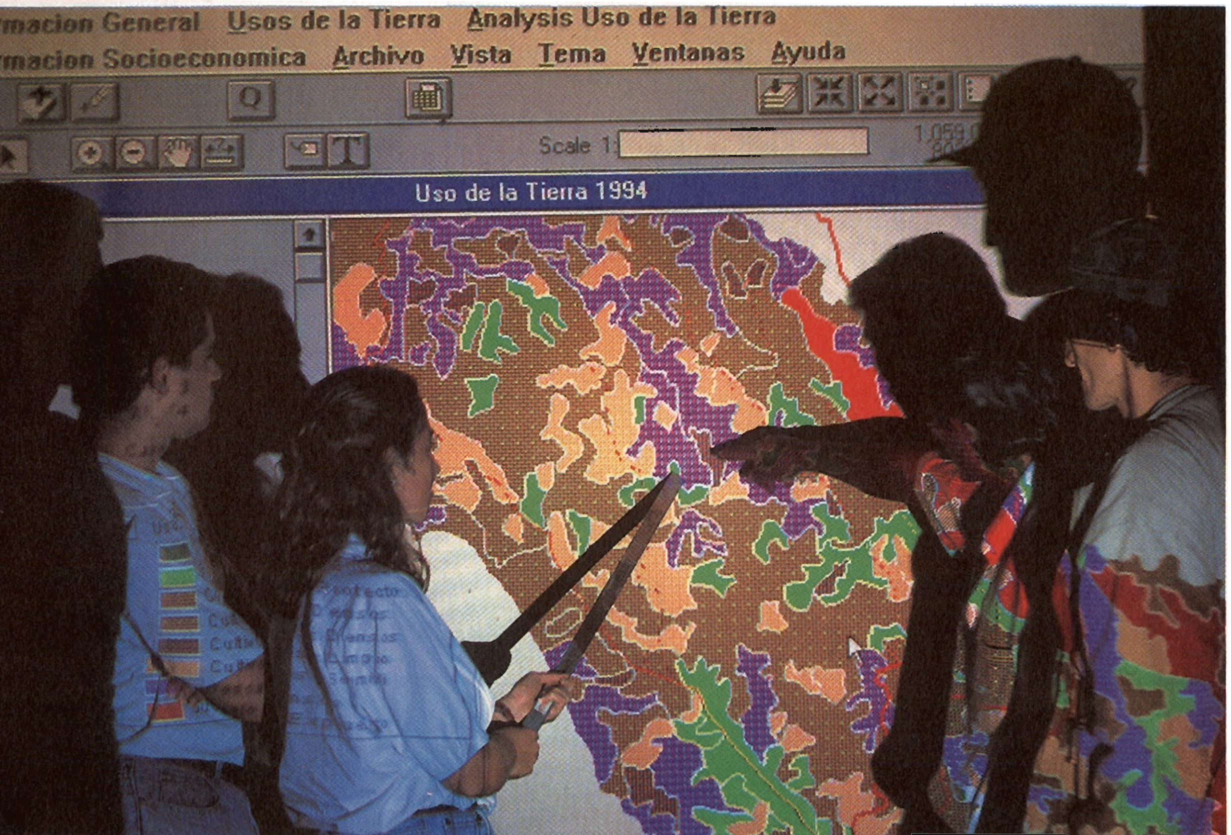
Seven years of continuously rotating rice and cattle shows that both can remain productive. Equally important, several soil quality indicators—including penetrability, earthworm and termite biomass, and microbial nitrogen and phosphorus—support the theory that the mixed system is better for soil than either land use alone.

Now Vera and his colleagues have expanded their long-term experiments to locations throughout the savannas, including the Venezuelan Llanos and Brazilian Cerrados. They are also testing new land-use combinations, including soybeans and maize planted with different combinations of forages. Meanwhile, says Vera, "agricultural researchers throughout the region are working on models inspired by ours." And as word spreads, savanna farmers and ranchers have begun experimenting with their own mixed land-use systems.

Policies That Can See

Developing sound environmental policy in today's complex world requires an enormous amount of technical information. Most decision makers, however, lack the time and training to amass or analyze such data.

Environmental indicators—measurements that distill and simplify technical information—can help them around this difficulty by providing a basis on which to set priorities and gauge progress. In 1995, the United Nations Environment Programme (UNEP) and CIAT's Land Management Unit launched a joint project to establish a set of coherent



Luis Fernando Pino

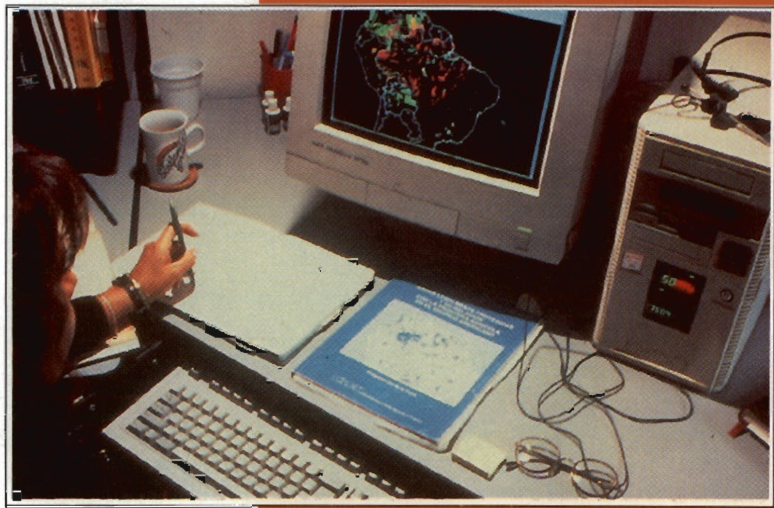
GIS is a powerful tool for presenting complex information in a simpler form.

environmental and sustainability indicators for Latin America and the Caribbean—at local, national, and ecoregional levels.

"Just as blood pressure, temperature, and pulse tell doctors whether their patients are ill, environmental indicators inform decision makers about the health of our planet," says unit leader Gilberto Gallopin. Deforestation rates, for example, reflect land-use changes, while trends in crop yields over time are one important indicator of agricultural sustainability.

Though some Latin American institutions had worked with indicators before, there was no effort to integrate or make them consistent before the UNEP-CIAT collaboration. In the project's first year, representatives of national and international organizations working in the region met to find out what groups already were working with indicators, to analyze each country's capability to devise and use these measurements, and to reach consensus on the framework in which indicators should be used for specific purposes. Today this work continues through a regional network.

Gallopin's team, meanwhile, has moved on to a new phase of the project: mapping environmental indicators with GIS, tools that allow researchers to overlay, compare, and analyze many layers of data describing a given geographic location. As with indicators themselves, the goal of the mapping exercise is to provide policy makers more information, so they can make better decisions.



MAURICIO ANTORVEZA

"By itself a list of deforestation statistics doesn't tell you much," says CIAT environmental scientist Manuel Winograd. "But if you see exactly *where* that deforestation is—and combine the data in one image with population density, economic activities, habitat type, and other information—you get a better understanding of what's going on. That understanding in turn should lead to better priority setting and more effective conservation policies." Toward this end CIAT is forging new links with institutions such as Colombia's National Planning Department and Brazil's Ministry of the Environment, Water Resources, and the Amazon.

"Given the important work going on at CIAT, we are interested in establishing cooperation between our institutions."

Haroldo Mattos de Lemos, Secretary for Coordination of Environmental Affairs, Ministry of the Environment, Water Resources, and the Amazon, Brazil

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Fernando Angel, Molecular Biologist (Senior Research Fellow)
Luis Destefano, Molecular Biologist (Postdoctoral Fellow)*
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Genetic Resources Unit

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Pest and Disease Management Unit

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Elizabeth Alvarez, Plant Pathologist (Research Fellow)
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Costa Rica

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Gilberto Gallopín, Ecologist and Unit Head
William Bell, GIS Specialist
Samuel Fujisaka, Agricultural Anthropologist
Glenn Hyman, Agricultural Geographer (Postdoctoral Fellow)
Peter Jones, Agricultural Geographer
Eric Veneklaas, Tropical Ecologist (Research Fellow)
Manuel Winograd, Environmental Scientist and Coordinator of the CIAT-UNEP Project

Scientific Publications

CIAT scientists published about 30 articles in refereed journals during 1995. A complete listing of staff publications for the year is available upon request from the Center's Information and Documentation Unit.

Impact Assessment Unit

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Rubén Darío Estrada, Agricultural Economist (Research Fellow)
Guy Henry, Agricultural Economist
Joyotee Smith, Agricultural Economist

Support Units

Maria Cristina Amézquita de Quiñonez, Biometrician (Associate Scientist)**
Elizabeth Goldberg, Head, Information and Documentation Unit
Thomas Hargrove, Head, Communications Unit (on sabbatical)
Nathan Russell, Interim Head, Communications Unit
Vicente Zapata, Head, Development of National Training Capacity (Research Fellow)

Finance and Administration

Jesús Cuéllar, Executive Officer
Alfonso Díaz, Superintendent, Field Operations
Juan Antonio Garafulic, Financial Controller

General Administrative Staff

Camilo Alvarez, Head, Purchasing
Fabiola Amariles, Head, International Staff Administration
Alfredo Caldas, Coordinator, Training and Conferences
Walter Correa, Coordinator, Research Services
Luz Stella Daza, Internal Auditor
Alberto Estrada, Head, Information Management and Network Services**
Sibel González, Head, Protection and Institutional Security
Germán Gutiérrez, Head, Maintenance Services
Emil Pacini, Head, Budget**
Fernando Posada, Manager, CIAT Miami Office
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Germán Vargas, Head, Human Resources
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Carlos Garcés, Irrigation Specialist and Head, Andean Project, IIMI
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Yoshimitsu Saito, Ecologist (Tropical Forages Program), JIRCAS
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David Williams, Biologist and Interim Regional Director, IPGRI
Stanley Wood, Technical Coordinator, LAC Research Priority Setting Project, IFPRI/CIAT (Impact Assessment Unit)

Acronyms and Abbreviations

ABLH Association for Better Land Husbandry, UK
ACMV African cassava mosaic virus
ASARECA Association for Strengthening Agricultural Research in Eastern and Central Africa
AusAid Australian Agency for International Development
BILFA Bean Improvement for Low Fertility in Africa
BRAIN Bio-Oriented Technology Research Advancement Institute, Japan
BSM Bean stem maggot
CATIE Centro Agronómico Tropical de Investigación y Enseñanza (Center for Research and Training in Tropical Agriculture), Costa Rica
CBN Cassava Biotechnology Network
CGIAR Consultative Group on International Agricultural Research
CIDA Canadian International Development Agency
CIMMYT Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center), Mexico
CIRAD Centre de coopération internationale en recherche agronomique pour le développement (Center for International Cooperation in Agricultural Research for Development), France
CNPMF Centro Nacional de Pesquisa de Mandioca e Fruticultura (National Center for Research on Cassava and Tropical Fruits), Brazil

COLCIENCIAS Instituto Colombiano para el Desarrollo de la Ciencia y la Tecnología (Colombian Institute for the Development of Science and Technology)

COPAL Comitês de Pesquisa Agrícola Local (Local Committees for Agricultural Research), Brazil

CORPOICA Corporación Colombiana de Investigación Agropecuaria (Colombian Corporation for Agricultural Research)

CPAC Centro de Pesquisa Agropecuária dos Cerrados (Center for Agricultural Research in the Cerrados), Brazil

CPAF Centro de Pesquisa Agroforestal do Acre (Center for Agroforestry in Acre), Brazil

CSIRO Commonwealth Scientific and Industrial Research Organisation, Australia

ECABREN Eastern and Central Africa Bean Research Network

EMBRAPA Empresa Brasileira de Pesquisa Agropecuária (Brazilian Agricultural Research Enterprise)

FLAR Fondo Latinoamericano de Arroz de Riego (Fund for Latin American Irrigated Rice)

GIS Geographical information systems

ICRAF International Centre for Research in Agroforestry, Kenya

IFAD International Fund for Agricultural Development

IFDC International Fertilizer Development Center, USA

IFPRI International Food Policy Research Institute, USA

IICA Instituto Interamericano de Cooperación para la Agricultura (Inter-American Institute for Cooperation in Agriculture), Costa Rica

IIMI International Irrigation Management Institute, Sri Lanka

IITA International Institute of Tropical Agriculture, Nigeria

IPGRI International Plant Genetic Resources Institute, Italy

IRRI International Rice Research Institute, Philippines

JIRCAS Japan International Research Center for Agricultural Sciences

KARI Kenyan Agricultural Research Institute

LAC Latin America and the Caribbean

NARO National Agricultural Research Organisation, Uganda

ODA Overseas Development Administration, UK

OMMN Organic Matter Management Network, Kenya

ORSTOM Institut français de recherche scientifique pour le développement en coopération (French Institute of Scientific Research for Cooperative Development)

PROFISMA Projeto Proteção Fitossanitária Sustentável da Cultura da Mandioca no Nordeste do Brasil e África (Sustainable Cassava Plant Protection Project), Brazil

PROFRIZA Proyecto Regional de Frijol para la Zona Andina (Regional Bean Project for the Andean Zone)

SADC Southern Africa Development Community

SDC Swiss Agency for Development and Cooperation

SEAFRAD Southeast Asia Forage and Feed Resources Research and Development Network

SWNM Soil, Water, and Nutrient Management Program

UNDP United Nations Development Programme

UNEP United Nations Environment Programme

USAID US Agency for International Development

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NATHAN RUSSELL

The Power of Perspective

Frederick Alifugani's small farm in southeastern Uganda provides a livelihood but also serves as a laboratory. In addition to growing new crop varieties, he experiments with several shrub and herbaceous legumes that help maintain soil fertility, reduce erosion, and control pests.

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NATHAN RUSSELL

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