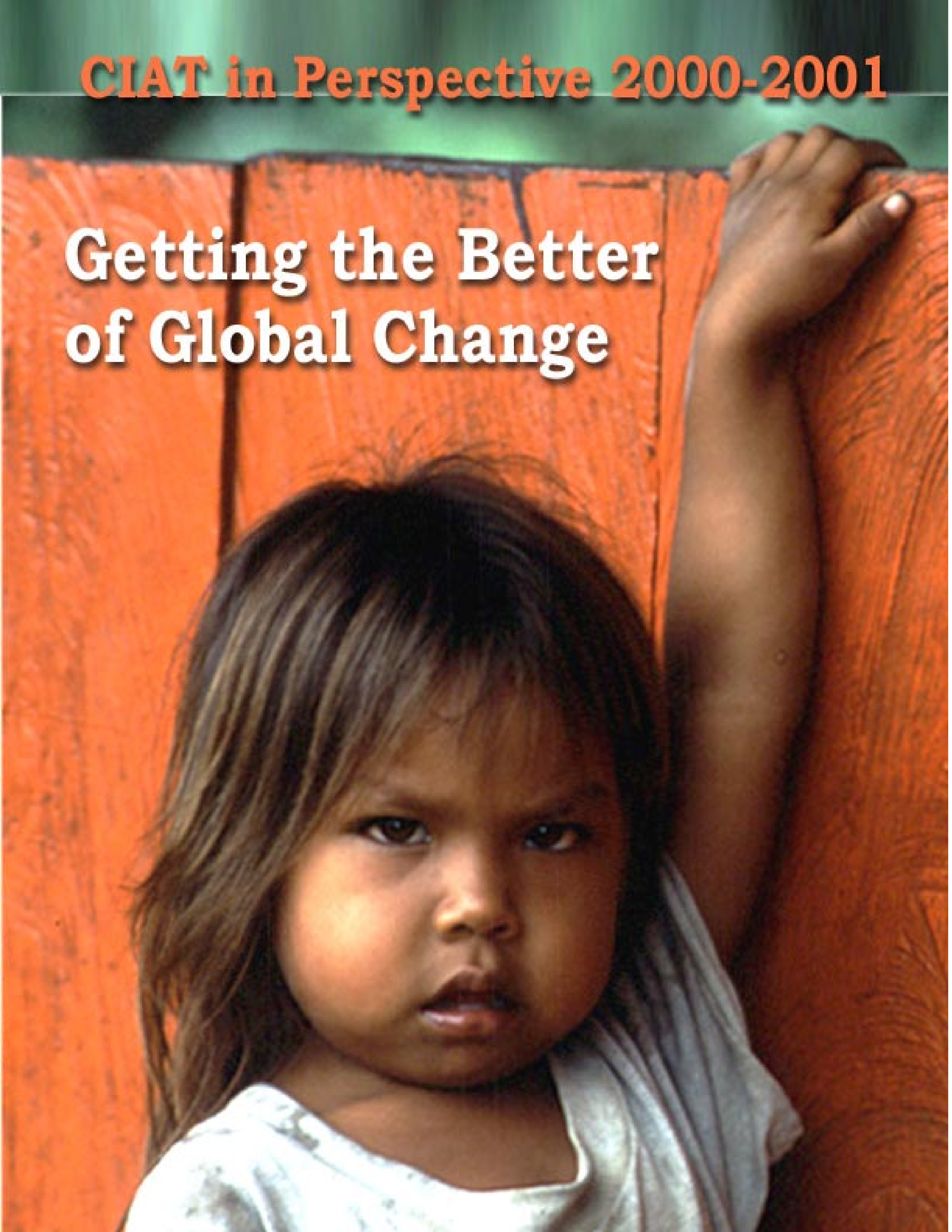
CIAT in Perspective 2000-2001

Getting the Better of Global Change



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Nurturing a farm family in Uganda's Mbale District.

Perspective in Practice

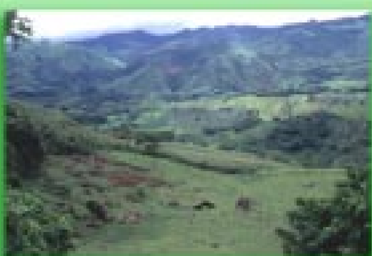
Family farms are the backbone of most developing country economies. For billions of people, agriculture represents daily survival and the best hope for a better tomorrow. Food production remains the most important use of the world's natural resources. But a billion people, mostly farmers in tropical countries, live in extreme poverty.

Global forces are at work that will have far-reaching effects on their livelihoods. In some cases global change will offer farm families new opportunities to escape poverty, while in others it could tighten poverty's grip on their lives. CIAT's vision for the future—the heart of its strategic plan for the next decade—is that these men, women, and children will turn deprivation into sustainable rural livelihoods. As our annual report for 2000-2001 illustrates, Center scientists can speed this transformation through research that contributes to competitive agriculture, healthy agroecosystems, and rural innovation.

Joined by his children, a farmer at San Dionisio in Nicaragua's Matagalpa Department shows visitors a bean and maize variety trial, established by the local agricultural research committee to which he belongs.

Toward a Global Research System

Director General's Message



Hillside agriculture in Nicaragua's Matagalpa Department.

Noodles made with cassava starch in southern Vietnam.

A community experimental farm at San Dionisio in Nicaragua.

Over the past year or so, we at CIAT have crafted a new strategy to pursue our goal of fighting poverty in the tropics while protecting natural resources. At the core of this strategy is a vision of sustainable rural livelihoods, grounded in competitive small-scale agriculture, healthy tropical agroecosystems, and community-based innovation.

Our strategic vision emerged from an analysis not only of what CIAT has achieved during more than 30 years of research but also of the rapid changes sweeping our world. It recognizes that globalization presents an uncertain mix of opportunities and threats. It takes the view that high-quality science is a powerful tool for bringing globalization's benefits to the rural poor of the tropics, while minimizing the risks.

The emerging vocabulary of globalization includes terms like biodiversity and biopiracy, food security and water scarcity, global warming and disaster mitigation, free trade and cultural diversity, genetically modified organisms and biosafety. CIAT's R&D efforts are clearly relevant to these and other international public concerns. And we intend to keep it that way.

A tighter ship plying global waters

The Consultative Group on International Agricultural Research (CGIAR), which backs CIAT and 15 other Future Harvest centers, is now well advanced in a detailed reassessment of how the centers can work together more effectively in the future. It's particularly intent on addressing issues of global reach, like those framed in conventions on biodiversity, desertification, and climate change.

Part of the CGIAR plan, approved in May 2001 at Durban, South Africa, is to harmonize research programming across centers and to streamline management structures. This will allow the Future Harvest centers to function as a more integrated global system—to run a tighter ship, so to speak. As CIAT's director general, I'm committed to ensuring the Center contributes fully and positively to the CGIAR's reform plan. Our long-term capacity to conduct socially and environmentally progressive research for development depends on the health and unity of all of the Future Harvest centers.

Within several years, a sizable share of CGIAR funding is expected to go to a small number of "global challenge programs." These will link Future Harvest centers with each other, and with other sources of expertise, in research on world-scale problems. Proposed topics include the impact of climate change on small-scale agriculture and the critical role of water resources in food and environmental security.

Elevating the game

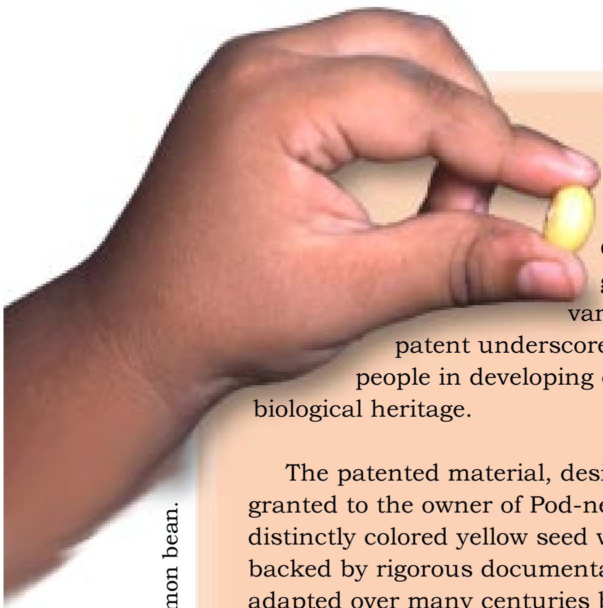
As CGIAR Chairman Ian Johnson recently said, it's time to "elevate the game." This means increasing the impact and visibility of CGIAR research by connecting it with the highest levels of international dialog, policy, and action. The shift of emphasis will involve major tradeoffs among research priorities as well as new ways of doing business—among scientists, center managers, and national partners.

The exact trajectory of CGIAR changes will not be known for some time. Nevertheless, I believe CIAT's new strategic plan for 2001-2010 is consistent with the CGIAR's commitment to efficiency and global relevance. The quest for sustainable rural livelihoods takes research beyond the goal of merely increasing the volume of agricultural production and monetary income to include the development of social capital, enhancement of human well-being, and protection of the planet's natural resources.

One step CIAT recently took in an effort to elevate the game was to formally challenge a US patent granted on a "new" variety of bean that was claimed to have a distinctive yellow color (see box). The plant material covered by the patent is nothing other than a popular type of bean grown and eaten for centuries by Latin Americans. The patent application, I believe, was legally, morally, and scientifically unfounded.

We hope our move, the first-ever challenge of a plant patent by a Future Harvest center, will set a global precedent. Concerted action is needed to protect the rights and livelihoods of developing country farmers. At the same time, we need to maintain the ability of research centers like CIAT to freely produce and distribute public goods for the benefit of all.

Joachim Voss
Director General, CIAT



Peruvian landrace of common bean.

Yellow beans and patent injustice

CIAT recently launched a formal challenge to a 1999 US patent that grants a businessman from Colorado intellectual property rights over a variety of common bean with yellow seeds. Our decision to challenge the patent underscores our concern over the continuing vulnerability of the livelihoods of rural people in developing countries and the need to protect traditional agricultural knowledge and biological heritage.

The patented material, designated Enola, was produced from seed obtained in Mexico. The patent, granted to the owner of Pod-ners L.L.C., claims Enola is a "new field bean variety that produces distinctly colored yellow seed which remains relatively unchanged by season." CIAT's counterclaim, backed by rigorous documentation, is that the material in question is based on traditional cultivars adapted over many centuries by Andean and Mexican farmers. It is believed that the gene controlling the color of the seed is of Peruvian origin.

Patent number 5,894,079 grants the owner of Pod-ners a monopoly within the USA over common beans exhibiting the shade of yellow noted in the patent application. It thus denies Mexican producers the right to freely market one of their most valuable and hard-won renewable resources—traditional crop cultivars that also serve as food staples. The patent also seriously limits work carried out by US plant breeders with all classes of yellow beans.

The Enola patent issue was pushed into the international limelight in 2000 largely through the efforts of the Action Group on Erosion, Technology and Concentration (ETC Group), until recently known the Rural Advancement Foundation International (RAFI).

In its challenge to the Enola patent, CIAT argues that the protected bean variety is "substantially identical" to at least six yellow bean samples found in the Center's seed bank. Under an agreement with the UN Food and Agriculture Organization (FAO), the contents of this collection are considered international public goods and may not be patented by anyone.

Recently, the case became more complex when the patent holder filed additional claims based on information contained in his original application. The US Patent Office will now conduct a joint review of CIAT's challenge and the patent holder's additional claims. If the patent is upheld, then the issue could end up being appealed to a US court. Such a legal battle would be costly and best handled as a joint effort of the Future Harvest centers, according to Voss. "But we'll cross that bridge when we come to it."

Nurturing Rural Livelihoods in the Tropics

CIAT's Strategic Plan for 2001-2010

Economic development over the past century, driven largely by science and technology, has significantly cut the proportion of the global population that is poor. Nevertheless, one-fifth of the world's people are still absolutely poor, living on one US dollar a day or less. Among the most destructive effects of this persistent poverty is hunger, suffered by some 800 million people, mostly women and children.

The world's hot spots of poverty are and will continue to be tropical countries, especially in Africa and Asia. Rural communities that depend on small-scale agriculture and food processing for survival are the most disadvantaged. They are also the people most vulnerable to the ill effects of environmental degradation. And for lack of political and economic power, they risk further marginalization by the growing forces of globalization.

CIAT believes that improving the livelihoods of small farmers through high-quality science is an effective and direct way to address the needs of the tropical world's rural people, while supplying cheaper food for the urban poor. The notion of sustainable rural livelihoods is at the core of CIAT's strategic vision for 2001-2010.

As a research center specializing in people-centered solutions for tropical agriculture, CIAT will use partnership-based research to help its rural clients get to three intermediate destinations along their path to sustainable rural livelihoods: (1) competitive agriculture, (2) agroecosystem health, and (3) collective rural innovation based on the accumulation of social capital.

Our scientific portfolio

To promote these conditions, CIAT will integrate its past research experience with recent scientific advances in genomics, agroecology, and informatics. Scientific competence will be cultivated in five core areas:

- Agrobiodiversity and genetics
- Ecology and management of pests and diseases
- Soil ecology and improvement
- Spatial analysis
- Socioeconomic analysis

Together, these areas of research will form an enduring institutional framework, conducive to transdisciplinary research on agricultural productivity, environmental protection, and community capacity to plan, execute, and monitor innovations. At the same time, this mix of competencies will give CIAT sufficient scientific flexibility to respond to an evolving research agenda, including issues of global reach, such as climate change.

Implementing the research agenda

CIAT will implement its 10-year strategy through medium-term plans. Each will cover a 3-year period and respond to emerging trends, problems, and opportunities. Several policies and principles will guide the setting of our research agendas:

- Research priorities for each region should be harmonized with those of partner groups, such as national research programs, farmer associations, and community development organizations.

- Center scientists should maintain close contact with advanced institutes to identify and acquire relevant new scientific tools, methods, and knowledge.

- Proposed research topics should be directly relevant to the Center's vision of sustainable rural livelihoods and its overall mission of alleviating poverty and hunger and protecting natural resources.

- When activities fall outside the Center's core scientific competencies, research partnerships should be formed to secure the necessary expertise.

- Stakeholders' commitment to invest in research or otherwise contribute resources should serve as a key indicator of the feasibility of proposed work.

Regional coordinators will help ensure that global and regional research agendas are harmonized and that scientific outputs complement regional development efforts. The actual research will be carried out by project-based multidisciplinary teams. CIAT will make special efforts to obtain funding from nontraditional sources and to actively disseminate Center products, such as technology and information, to potential users and investors.

Orientation of future research

CIAT's research program fits into a global context, namely, the work of the Future Harvest centers supported by the CGIAR. Some of CIAT's outputs, such as conserved agrobiodiversity, are essentially global public goods. Work in this and other areas, however, will continue to be planned in such a way that it complements regional research agendas.

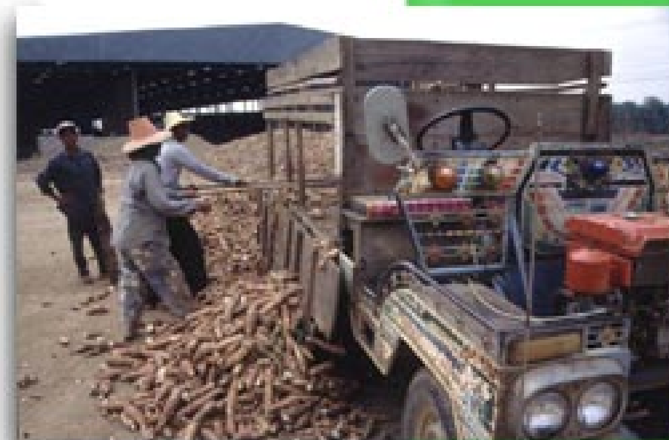
Several research topics are highly relevant to sustainable rural livelihoods in all three regions in which CIAT works, namely, Latin America and the Caribbean, Africa, and Asia. These include the genetic conservation and improvement of cassava and tropical forages, as well as natural resource management, farmer participatory research methods, and agroenterprise development.

In the case of natural resource research, soil management and enhancement methods, such as the use of green manures, will receive special attention. In addition, CIAT will continue to participate in global efforts to combat whiteflies and to develop geographic information systems for land management and planning at various physical scales.

Research will also continue on common beans, an important source of daily protein for millions of small farmers in Latin America and Africa. Emphasis will be put on development of highly productive climbing beans, improved drought tolerance, and higher iron content for improved human health. CIAT's strategy for rice research will, as in the past, focus exclusively on Latin America. It will aim to make producers more competitive, improve rice's disease resistance, and broaden the rice gene pool.

Hillside agroecosystems, particularly in Latin America but also in the uplands of Asia and the midaltitude areas of eastern, central, and southern Africa, will receive special attention. This work will build on the orientation of CIAT's previous strategic plan.

In Latin America, some emphasis will also be given to research on tropical fruits and on crops, natural resource management, and land use in the Amazon and savanna agroecosystems.



Delivering cassava roots to a drying plant in Thailand's eastern Sra Kaew Province.

On the way home after cassava harvest near Mitú, Vaupés Department, in the Colombian Amazon.

Trying out an improved farm implement at Worka village in Ethiopia's Oromo Region.

Harvest for Peace
Harvest for Earth
Harvest for Growth
Harvest for Health
Harvest for People

FUTURE HARVEST

Future Harvest is a nonprofit organization dedicated to raising public awareness of the close links between agriculture and other global issues like peace, economic growth, environmental renewal, human health, and the size of the world population. It's sponsored by the 16 food and environmental centers, including CIAT, that are funded through the CGIAR.

Future Harvest sees itself as a "wake-up call" to a brewing global crisis. Military conflict, water and land shortages, loss of biodiversity and soil fertility, the spread of human disease, climate change, poverty, and stagnating crop yields already threaten the world's ability to adequately and equitably feed itself. Moreover, during the next half century, the global population is expected to grow by some 73 million people annually. This addition of more than 3.6 billion people will intensify pressure on already stressed food-producing ecosystems and on social and political structures, especially in developing countries.

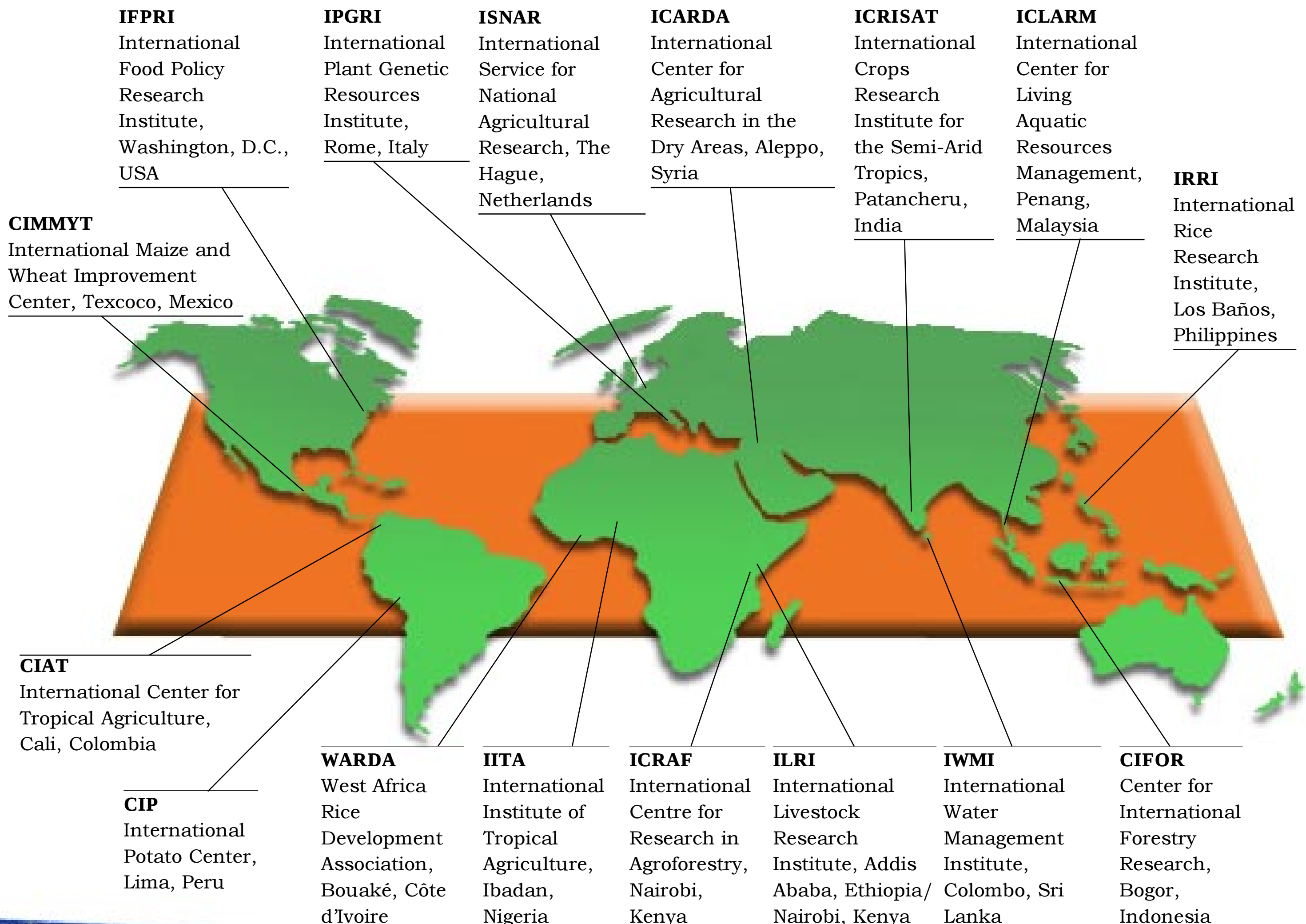
Future Harvest believes agriculture itself, based on good science, holds solutions to some of these compelling problems of global reach. International R&D provide technology and information vital to helping poor farmers boost food production, while protecting the natural resource base. In turn, these improvements lead to better human health and nutrition, alleviate poverty, enhance the environment, and stimulate rural economic progress. Equally important, they create a social and political milieu conducive to peace and therefore to further improvements in the quality of life.

The organization draws on respected experts, many of them high-profile, to serve as public advocates for the massive international research effort needed to ensure the world can feed itself sustainably in the future. Its ambassadors include Archbishop Desmond Tutu of South Africa, former Costa Rican president and Nobel Peace Prize laureate Oscar Arias, Queen Noor of Jordan, and former US president Jimmy Carter. In connection with its public awareness, educational, and advocacy roles, Future Harvest commissions studies that explore the relationship between agriculture and key global issues. Since the organization was set up in 1998, such studies have examined the role of agricultural research in reducing conflict, protecting biodiversity, and mitigating the effects of natural disasters. Similar studies are planned on the topics of human health and child welfare in the context of agriculture.

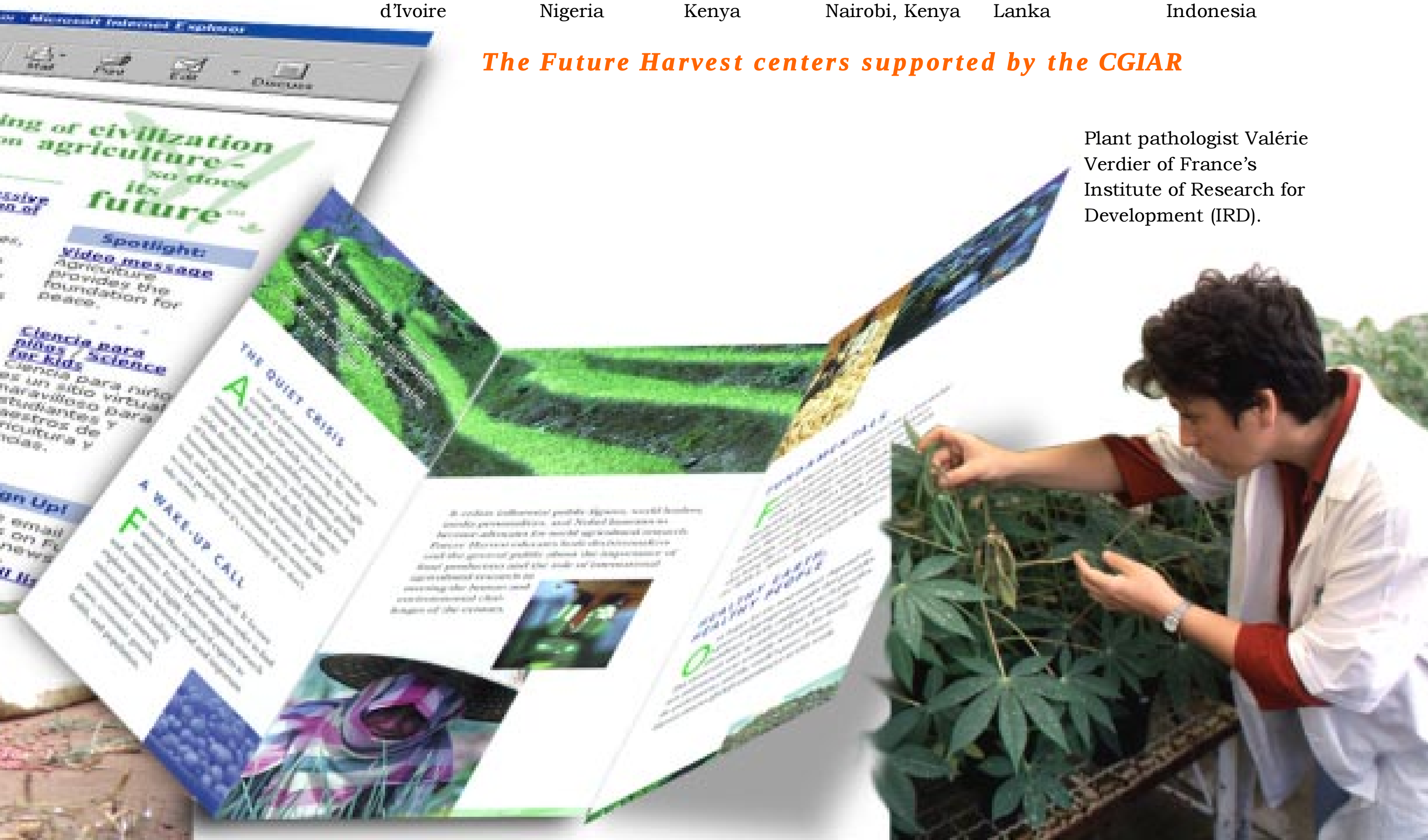
Future Harvest promotes a hopeful vision of the future—a "green and prosperous earth that provides abundance, health, and peace to its peoples." It cautions, however, that this "can only be realized if we devote attention and resources to scientific research for food, the environment, and the world's poor."

www.futureharvest.org

Gathering improved bean seed in Mbale District, Uganda.



The Future Harvest centers supported by the CGIAR



Plant pathologist Valérie Verdier of France's Institute of Research for Development (IRD).

Evaluation of hybrid Brachiaria grass at the Papaloapan Experiment Station of Mexico's National Institute for Forestry, Agriculture, and Livestock Research (INIFAP).

Getting the Better of Global Change

Global forces of change, whether of deliberate human design or merely the unexpected effects of past behavior, present difficult challenges. Both the emerging global economy and atmospheric warming, for example, will have a penetrating impact on world agriculture. We need to meet these threats and opportunities with visionary interventions, both technological and policy-based, that enable rural people to get the better of global change.

In the following pages, *CIAT in Perspective* presents three areas of research that respond to global challenges. The first centers on a model for predicting the effects of climate change on agriculture later this century. The second involves a global campaign to fight another growing threat to world agriculture and agroecosystem health—the spread of whiteflies. Finally, we profile the commercial “germination” of a hybrid pasture grass bred by CIAT and now being marketed to small meat-and-dairy farmers. The hybrid is expected to make tropical producers more competitive in today’s global economy, while slowing the buildup of greenhouse gases.

Farmers adopting new hybrid Brachiaria grass in Mexico’s Veracruz State have seen dramatic improvement in milk production.

Risky Farming in a Hotter World

Scientists devise a new method to predict the effects of global climate change

Scientists at CIAT and the International Livestock Research Institute (ILRI) have devised a new method for predicting how global climate change will affect tropical farming 50 years or more from now. Preliminary analysis of a large study area in southeastern Africa suggests a general reduction of maize yields and pasture production by 2055. It also predicts higher risk for farmers, many of whom are poor people cultivating small plots of marginal land. Certain small areas, however, may actually benefit from climate change.

A key advantage of this innovation in agricultural analysis, which combines three types of computer modeling, is that future crop growth and production risk can be simulated for any site in tropical Africa, Latin America, and Asia. The minimum geographical data needed to run the composite model, for a specific cropping scenario, is the location's latitude and longitude. The method helps bridge an enormous gap between two geographical levels of inquiry: the landscape scale at which meteorologists predict climate change and the farm scale at which agronomists and crop physiologists examine plant behavior.

"The study has achieved, perhaps for the first time, an integration from process-level plant-growth models to global climate models: the full gamut of the scaling problem," write authors Peter Jones of CIAT and Philip Thornton of ILRI in a recent scientific paper.

Tough choices

Growing crops is never a sure bet for any farmer. But global warming will make production risks even harder to assess and respond to in future. As our atmosphere warms due to high levels of greenhouse gases like carbon dioxide and methane, farmers as well as researchers and public officials will be faced with tough choices. The new CIAT-ILRI composite modeling technique gives these agricultural decision makers a rational basis for designing measures to cope with complex changes in farming environments.

Climate change raises many questions for agriculture. If the risk of growing maize becomes unacceptably high to small farmers in Zimbabwe, for example, what other crops or production systems might be viable alternatives? Or, what

According to CIAT/ILRI predictions, farmers in southeastern Africa can expect a general reduction in maize yields as a result of global climate change. The maps at right depict a sharp decline in the probability of maize yielding more than 1.5 tons per hectare, with white areas indicating high probability and darker areas low probability.

traits should plant breeders start building into food crops to address future changes in the quantity and variability of rainfall? And what about the prospect of large numbers of rural people migrating to better growing areas or to cities? Governments and development agencies need reliable information on the likely impact of climate change, not only at the farm level but also across regions. Otherwise, they will not be able to prevent social disruption and conflict due to growing competition for scarce productive land.

"People have been asking me for 10 years whether we can estimate the effects of climate change on agriculture," says Jones, an agricultural geographer who specializes in analyzing and manipulating climate data to make it more useful to scientists. "Global warming is going to change farming a lot. If we let it creep up on us, it will be too late for anyone to do anything about it. So we have to know certain impacts well in advance. Plant scientists, for instance, need to decide whether it's more important to breed crops for tolerance to water stress, for heat tolerance, or for shorter growing seasons. There may even be areas where certain crops will no longer grow."

Jones and Thornton have been working together on climate data applications for many years. With the help of other colleagues, they designed and recently packaged a computer tool, MarkSim, which generates the site-specific daily weather data needed to run computerized crop models. Comprehensive testing of MarkSim for diverse sites has shown it to be very reliable.

Crop models simulate how specific varieties of plants will grow under different soil, weather, and farm management conditions. They provide today's farmers and researchers with critical information about the yields they can expect and the level of weather-related production risk in a given growing environment. But a serious hurdle to applying crop models has been the scarcity of relevant and detailed weather data for the precise locations researchers want to analyze. MarkSim, now available on CD-ROM from CIAT, goes a long way to solving that problem. And because MarkSim meets a common international data standard known as DSSAT-ICASA, its weather files can be used to feed a wide range of crop models.

Leaping over time and geography

But Jones and Thornton also have something bigger in mind. They recently hit on an elegantly simple but potent tactic for broadening the application of MarkSim. With global climate change models finally starting to agree with each other, they reckoned, it might be feasible to predict the effects of global warming on future crop production.

The researchers selected a relatively new general circulation model of global climate called HadCM2, developed by the Hadley Centre in the UK. This allowed them to generate monthly temperature and rainfall values for an area of southeastern Africa for the period 2040-2070. Each geographic unit, or cell, in the HadCM2 grid represents an area of roughly 116,000 square kilometers, depending on how close the cell is to the equator. Jones and Thornton then adjusted ("interpolated") the HadCM2 results to fit the geographic grid used by MarkSim, which has a much higher resolution.

Next, the interpolated HadCM2 results were fed into MarkSim, which generated 30 years' worth of daily weather files for more than 1,000 locations. In turn, these files, along with soil and crop data, were plugged into two crop models. The researchers were thus able to simulate future crop production at specific sites in the African study area and compare the results with simulated data for 1960-1990. In effect, MarkSim served as a data link between different physical scales of analysis—global for climate change and local for crop modeling—as well as a bridge between two distinct time frames, the late-20th century and the mid-21st century.

"We were startled by the results," recalls Jones, referring to their initial work that demonstrated the modeling systems could actually be meshed. Their preliminary crop study focused on maize and pastures. The overall study "window" included all of Zimbabwe and Malawi; much of Tanzania, Mozambique, and Zambia; and parts of Botswana and the Republic of Congo. HadCM2 conservatively estimates that average temperatures in this tropical zone will rise 2.5 to 3 degrees Centigrade over the next 50 years or so, with slight increases in rainfall.

The maize modeled in the study is a popular Kenyan variety, Katumani Composite B, developed about 25 years ago. For simulating future production of the variety, the researchers used a well-known crop model called CERES-Maize, developed by a scientist at Texas A&M University. For pastures they drew on a water model, WATBAL, which estimates potential growing days for a pasture.

People on the move

The study findings indicate that some marginal lowland areas may become even less suitable for maize production, while highland areas might benefit due to higher night temperatures and rainfall. Overall, though, a comparison of simulations for 1960-1990 and for 2040-2070 suggests a reduction in mean yields. Predicted declines in both maize and pasture productivity relate in part to the fact that future increases in rainfall will probably be offset by greater moisture evaporation brought on by higher temperatures.

The potential impact on rural communities, says Jones, was not lost on three African research directors with whom he and his colleagues shared the results. "One of them said to me, 'there's going to be a lot of people moving around'."

With improvements now being made to MarkSim, it will be soon be possible to do futuristic analysis of all the staple crops on which the Future Harvest centers conduct research. The challenge now is for decision makers to begin incorporating such information into their agricultural R&D planning so that farmers can cope with the harsher weather on the distant horizon.

Global Science versus the Whitefly

Rapid response to a crop emergency saves lives in eastern Africa

An international team is systematically piecing together a complex biological puzzle that affects the entire tropical world: outbreaks of whiteflies and the role these tiny insects play in spreading devastating crop diseases. The whitefly problem has intensified over the past 12 years, directly threatening the livelihoods of millions of small producers and in some cases their very lives.

The sheer number of viruses and host crops involved in disease transmission illustrates why this menace is so daunting. Worldwide, at least 12 of the more than 1,200 known species of whitefly cause economically important damage. The most destructive is the sweet potato whitefly, *Bemisia tabaci.* Found across the tropics, this species transmits at least 90 disease-causing viruses. And it reproduces on more than 500 kinds of plants. Commercially valuable crops affected by whiteflies include cassava, sweet potatoes, beans, tomatoes, peppers, potatoes, eggplant, squash, and melons. In some instances whiteflies destroy the entire crop.

Conquering complexity

"Everyone knew something needed to be done, but the complexity of these problems has been overwhelming," says CIAT entomologist Pamela Anderson, who coordinates the global Whitefly Integrated Pest Management (IPM) Project under the Systemwide IPM Programme of the CGIAR. "We were

Nymphs and adults of the whitefly species *Bemisia tabaci.*

isolated, and communication was poor. Different research groups were duplicating efforts. And each group was using its own methodologies, which meant we couldn't compare results."

But the Whitefly IPM Project, launched in 1997, has changed all that. It pulls together experts from national programs in 30 countries; advanced research laboratories in Australia, Germany, New Zealand, the UK, and the USA; and five international research centers: CIAT, the International Institute of Tropical Agriculture (IITA), the International Potato Center (CIP), the Asian Vegetable Research and Development Center (AVRDC), and the International Centre of Insect Physiology and Ecology (ICIPE). Their aim is to reduce pesticide use while improving food security and farmers' incomes in Africa, Asia, and Latin America.

Initial project funding came from Danish International Development Assistance (Danida). As the work expanded to include new countries and topics, other donors joined the partnership. They include the Australian Centre for International Agricultural Research (ACIAR), the US Agency for International Development (USAID), the New Zealand Ministry of Foreign Affairs and Trade, the US Department of Agriculture (USDA-ARS), and the UK's Department for International Development (DFID).

Crisis response in Africa

At the project's outset, the focus was on building an international whitefly research network and a common knowledge pool. But, as Anderson says, researchers discovered early on that the team had "an incredible capacity for rapid response to emergencies." That field-level capacity was clearly demonstrated in East Africa's Lake Victoria region.

Around 1990 a new and highly virulent form of cassava mosaic disease (CMD), transmitted by whiteflies, began to wipe out cassava crops in Uganda. CMD has been known in this region of Africa for almost a century, but crop losses from it were historically low. Scientists now know that the new CMD resulted from two geminiviruses combining into a potent strain.

"When we started growing cassava in 1988, the incidence of mosaic was low," says Ugandan farmer Harriet Lubwama. "On half a hectare, we would get about 10 to 20 infected plants. But the following year, 1989, the number increased, until 1990 it became so terrible that virtually all the plants were infected."

From a high of 3.5 million tons in 1989, the country's cassava production plummeted to 2.25 million tons in 1996. In Kenya, the next country to be hit by the scourge, production in Western Province was cut by more than two-thirds between 1995 and 1998. Though reliable data are scarce, Uganda's losses from CMD have been estimated at US$60 million a year between 1992 and 1997. Similar losses are now being suffered in neighboring countries.

But the crisis was much more than an economic blow. "When other crops failed in periods of rain shortage or floods, farmers were not able to offset caloric losses with their traditional food bank crop—cassava," states a May 2000 communiqué from the US embassy in Kampala. "As a result, general nutrition was suffered and people died."

Uganda's National Agricultural Research Organisation (NARO) quickly realized the need for help in tackling the problem. First on the scene was a DFID-funded project, which enabled NARO and UK-based scientists to determine how the epidemic

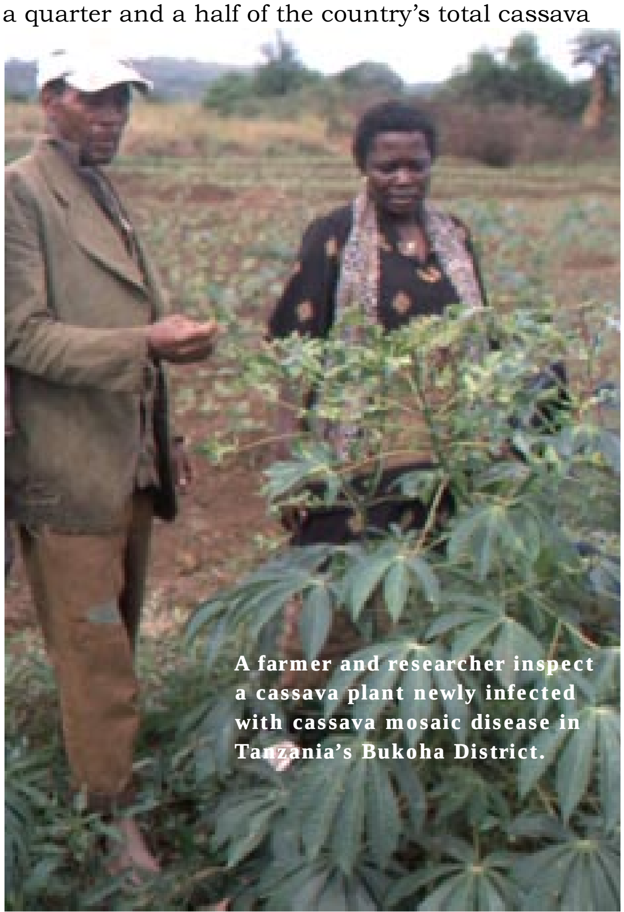
A researcher monitors whiteflies on cassava. In the background varieties resistant to the whitefly-transmitted cassava mosaic disease are being multiplied in Tanzania's Mwanza Region for massive distribution to farmers.

was spreading. To offer farmers a solution, researchers identified and distributed CMD-resistant cassava varieties in affected regions, with support primarily from the Gatsby Charitable Foundation, USAID, and the Ugandan government. These varieties had been developed through years of painstaking research by cassava breeders at IITA in Nigeria.

The Whitefly Project team soon saw the need to develop a regional strategy for tackling the epidemic. By 1998 it was spreading southwards, in a pincer-like advance, down both the eastern (Kenyan) and western (Tanzanian) shores of Lake Victoria. In an emergency program led by IITA and funded by USAID, scientists tracked the epidemic and identified newly affected and immediately threatened zones. Both in affected zones and at strategic sites ahead of the epidemic "front," they rapidly multiplied CMD-resistant varieties.

Two partners in the Whitefly IPM project—the Lake Zone Agricultural Research and Development Institute of Tanzania and the Kenya Agricultural Research Institute—each spearheaded efforts to solve the problem in their respective countries. They also joined forces with IITA, NARO, and others working on cassava to establish a regional network that could monitor progress and plan future strategies to control the CMD pandemic and thus strengthen regional food security.

In Uganda the results were spectacular. Between a quarter and a half of the country's total cassava area is now planted with new CMD-resistant varieties, and national cassava production has been restored. An IITA impact study estimated the internal rate of return on USAID's investment in cassava R&D for Uganda to be an impressive 167 percent.



A farmer and researcher inspect a cassava plant newly infected with cassava mosaic disease in Tanzania's Bukoha District.

The multipartner Whitefly IPM team is now repeating these achievements in neighboring Kenya and Tanzania. With thousands of hectares already planted to new cassava, success seems to be assured.

Ground-breaking work

Whitefly Project teams have organized themselves to examine three critical ways in which whiteflies threaten tropical agriculture: as virus carriers in mixed cropping systems, as virus carriers and direct pests in cassava-growing areas, and as direct pests in tropical highland farming.

Results from this work are already being used to design environmentally friendly pest control methods. For example, researchers have identified possible tactics for managing the whitefly *Trialeurodes vaporariorum* on highland bean and tomato crops in South America. Options include manipulating cropping dates, replacing broad-spectrum insecticides with more selective ones, and recruiting a natural insect enemy of the whitefly, the parasitoid *Amitus*. Researchers will test these and other techniques with the help of farmers and extensionists.

Project teams have also made good headway in determining the distribution and importance of various whitefly species. The results to date contain several surprises. It was previously thought, for example, that *Bemisia* whiteflies occurred only at elevations below 1,000 meters and *Trialeurodes* only above that level. But CIAT, Colombian, and Ecuadorian researchers recently proved there are mixed populations of these two groups at midaltitudes. "This is critical information for designing IPM packages for farmers," says Anderson.

One promising line of investigation is the natural resistance to whiteflies that CIAT, in earlier ground-breaking work, has identified in certain lines of cassava. Scientists are now using molecular markers to tag the genes responsible for this unique source of resistance as an aid to cassava breeders. The goal is to combine, or pyramid, whitefly resistance with viral resistance—in both African and South American cassava.

Sustainable Livestock Production for Mexico and Beyond

New tropical forages help small farmers compete in the global marketplace

Southeastern Mexico is in the midst of a rural revolution, and CIAT is helping supply the ammunition. But the upheaval isn't about politics. And it doesn't involve masked militants marching on Mexico City. Rather, its foot soldiers are traveling agricultural technicians, often seen wearing white baseball caps emblazoned with a green butterfly and armed with nothing more than a few bags of grass seed. Their campaign is nevertheless aimed at empowering poor rural communities—and making a reasonable profit in the process.

This "quiet" revolution is about environmentally and economically sound production of milk and meat, based on highly productive tropical forages. The latest addition to this genetic arsenal is the world's first commercial hybrid of Brachiaria grass, CIAT 36061. The hybrid is now being marketed under the varietal name Mulato by a dynamic young Mexican company called Papalotla, which means "butterfly" in the indigenous language Nahuatl.

Completing the R&D loop

Based on three species of African origin, Mulato and other new Brachiaria hybrids resulted from more than a decade of plant breeding by CIAT scientists, whose work on tropical forages is supported principally by the Colombian and Japanese governments. Mulato was first released in 2000 by Papalotla for demonstration purposes, but the firm is now moving ahead with full-scale seed production and marketing in Mexico. Distribution is also expected to start soon in other countries. Under an agreement with CIAT, Papalotla has exclusive world rights to produce and sell Mulato seed. CIAT will receive funds to support Brachiaria breeding plus a small royalty on sales.

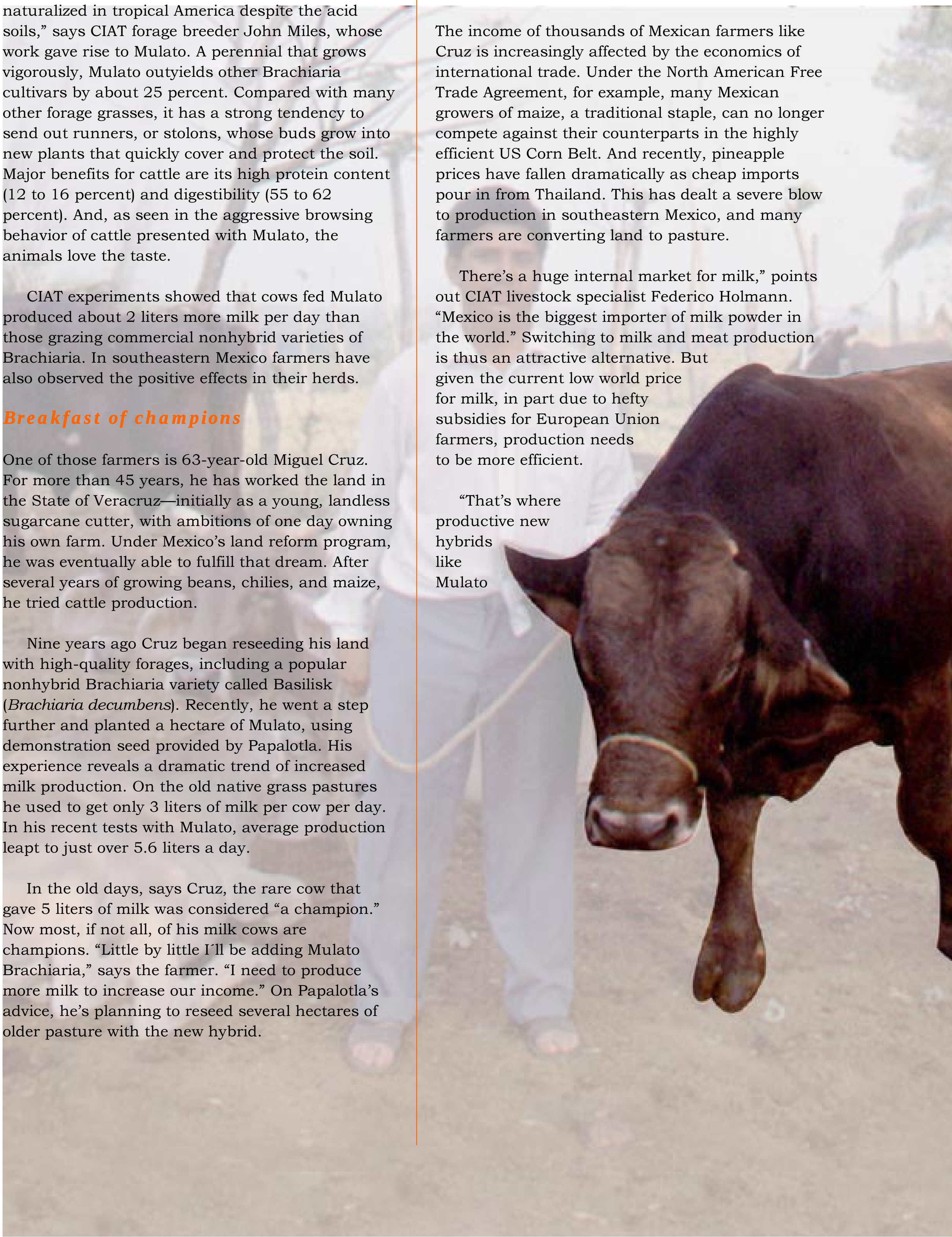
Papalotla is just one player in a network of research, production, and marketing. It works with Nestlé Mexico, a major buyer and processor of fresh milk, and is in regular contact with researchers at CIAT and Mexico's National Institute for Forestry, Agriculture, and Livestock Research (INIFAP). Papalotla supplies farmers with forage seed and technical advice throughout the pasture and cattle production cycle. For its part Nestlé buys the milk from participating farmer groups and provides credit to cover the costs of cooling tanks installed at rural collection points around the country. Papalotla makes its profit from 20 seed payments by each farmer, deducted from milk revenues.

The multipartner arrangement thus completes the research-to-development cycle. In addition, the financial risk to farmers is low, since credit repayment schedules are directly linked to milk production.

Out of Africa

Of the 100 or so species of Brachiaria grass found in the tropics, about two-thirds are from Africa. Several species are thought to have made their way to Latin America via the hay bedding used on slave ships. Once in the New World, Brachiaria grass adapted, thrived, and spread quickly.

Mexican livestock producer Miguel Cruz (right) discusses the performance of Mulato, a new hybrid variety of Brachiaria grass, with Anilú López and Alejandro Bravo of Papalotla Seeds.



"It's amazing how Brachiaria has been naturalized in tropical America despite the acid soils," says CIAT forage breeder John Miles, whose work gave rise to Mulato. A perennial that grows vigorously, Mulato outyields other Brachiaria cultivars by about 25 percent. Compared with many other forage grasses, it has a strong tendency to send out runners, or stolons, whose buds grow into new plants that quickly cover and protect the soil. Major benefits for cattle are its high protein content (12 to 16 percent) and digestibility (55 to 62 percent). And, as seen in the aggressive browsing behavior of cattle presented with Mulato, the animals love the taste.

CIAT experiments showed that cows fed Mulato produced about 2 liters more milk per day than those grazing commercial nonhybrid varieties of Brachiaria. In southeastern Mexico farmers have also observed the positive effects in their herds.

Breakfast of champions

One of those farmers is 63-year-old Miguel Cruz. For more than 45 years, he has worked the land in the State of Veracruz—initially as a young, landless sugarcane cutter, with ambitions of one day owning his own farm. Under Mexico's land reform program, he was eventually able to fulfill that dream. After several years of growing beans, chilies, and maize, he tried cattle production.

Nine years ago Cruz began reseeding his land with high-quality forages, including a popular nonhybrid Brachiaria variety called Basilisk (*Brachiaria decumbens*). Recently, he went a step further and planted a hectare of Mulato, using demonstration seed provided by Papalotla. His experience reveals a dramatic trend of increased milk production. On the old native grass pastures he used to get only 3 liters of milk per cow per day. In his recent tests with Mulato, average production leapt to just over 5.6 liters a day.

In the old days, says Cruz, the rare cow that gave 5 liters of milk was considered "a champion." Now most, if not all, of his milk cows are champions. "Little by little I´ll be adding Mulato Brachiaria," says the farmer. "I need to produce more milk to increase our income." On Papalotla's advice, he's planning to reseed several hectares of older pasture with the new hybrid.

Thriving in the global marketplace

The income of thousands of Mexican farmers like Cruz is increasingly affected by the economics of international trade. Under the North American Free Trade Agreement, for example, many Mexican growers of maize, a traditional staple, can no longer compete against their counterparts in the highly efficient US Corn Belt. And recently, pineapple prices have fallen dramatically as cheap imports pour in from Thailand. This has dealt a severe blow to production in southeastern Mexico, and many farmers are converting land to pasture.

There's a huge internal market for milk," points out CIAT livestock specialist Federico Holmann. "Mexico is the biggest importer of milk powder in the world." Switching to milk and meat production is thus an attractive alternative. But given the current low world price for milk, in part due to hefty subsidies for European Union farmers, production needs to be more efficient.

"That's where productive new hybrids like Mulato can help," says Holmann. "They offer small livestock producers, in Mexico and elsewhere in the tropics, a chance to not only survive but also thrive in today's highly competitive, global marketplace."

Healthier agroecosystems

Although rice, wheat, and maize are the world's premier food crops for people, that distinction belies the pervasiveness of cattle and other livestock in the landscape. Livestock occupy 3.4 billion hectares of grazing land, and animal feed is produced on about one-quarter of crop land. All told, more than two-thirds of our planet's agricultural land area is devoted to animal production.

Food economists have long been predicting that global demand for animal products will skyrocket in the 21st century. Current trends suggest the developing world's annual demand for meat, for example, will grow from the current 206 million tons to 275 million tons, and perhaps more than 300 million tons, by 2020.

How can farmers meet this growing demand, while protecting the environment? The use of hybrid Brachiaria grasses like Mulato and tropical forage legumes offers tropical livestock producers a promising avenue for boosting production, with long-term improvements in agroecosystem health. This is why CIAT researchers refer to tropical forages as a "multipurpose genetic resource." They are key ingredients of the biological capital farmers need to build sustainable rural livelihoods.

Mexican livestock producers in Veracruz State.

First, the growth habits of these African grasses, adapted over centuries to the presence of large grazing mammals, make for thick vegetative cover. The plants resist trampling and heavy grazing, suppress weeds, and help retain soil moisture and fertility. In contrast, pasture lands covered by native grasses, which still account for 60 to 70 percent of Latin American cattle production, evolved without heavy grazing pressure. In many areas, especially Brazil, they have become severely degraded due to attacks by spittlebug, a major pasture pest.

"The new grasses provide a powerful biological tool for pasture rehabilitation," says Carlos Lascano, manager of CIAT's project on tropical forages, "especially when combined with fertility-enhancing legumes."

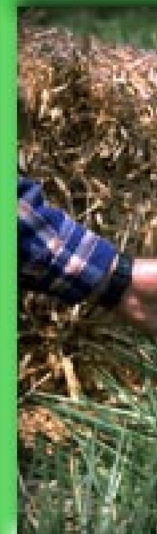
A second factor is the potential for improved Brachiaria grasses to slow global warming—an environmental service of benefit to all people. The robust root systems of these grasses allow for significant buildup of organic matter deep in the soil, compared with native Latin American grasses. This effect is enhanced by the addition of legumes, such as *Arachis pintoi*, a wild member of the peanut family. In effect, Brachiaria grasses, including the new hybrids, are powerful "carbon sinks." They capture and sequester vast amounts of carbon dioxide that otherwise would be recycled to the atmosphere.

Third, and perhaps most important, the higher yields of these forage grasses, along with resistance to spittlebug, tolerance to acid soils, and good protein content and digestibility, allow for agricultural intensification, even on lands of low fertility. The resulting increases in production and production efficiency by both small and large farmers should translate into lower consumer prices for milk and meat products. At the same time, they should free up more favorable growing environments for food crops and reduce current pressures to extend production into adjacent forest.

With improved forages, says Papalotla's Eduardo Stern, "You need less land to produce more. So the pressure on the jungle is alleviated. These alternatives will eventually let people produce sustainably in an open world economy and competitively with industrialized countries."

The Road to Research Impact

Improved cassava under evaluation in Thailand.



Hybrid Brachiaria grass at a Papalotla seed production site in Chiapas State, Mexico.

Impact assessment helps institutions like CIAT see where they've been, where they're going, and what's happening in the surrounding environment. Agricultural research often covers long time frames and uncharted scientific territory. Cultivating 360-degree vision is therefore essential to good planning. This section gives an update on selected efforts to evaluate the actual and potential impact of our research.

New varieties leave a big footprint on world agriculture

A recent study of the impact of CIAT's crop improvement research, covering the past three decades, estimates the cumulative global benefits of Center-related varieties at just under US$8.7 billion (1990 dollars).

CIAT economists Nancy Johnson and Douglas Pachico examined the Center's four mandated crops: rice, beans, cassava, and tropical forages. For their analysis they defined "CIAT-related varieties" as genetic material from the Center's germplasm bank, crosses made by CIAT, and crosses made by national research programs using CIAT parents or grandparents. Theirs was one of a series of studies being conducted on commodity research impacts by the Future Harvest centers.

The retrospective study notes that CIAT has contributed to the development and release of over 700 improved varieties of these crops. About 50 countries have benefited from the germplasm. Globally, the largest benefits came from increased rice production ($5.5 billion), followed by forages ($1.4 billion), beans ($1.3 billion), and cassava ($514 million).

The land area sown to CIAT-related varieties also tells much of this research success story. In Thailand, for example, more than half the cassava-growing area was planted to CIAT-related varieties as of 1997. And in Latin America, CIAT-related bean varieties accounted for 49 percent of the area planted to beans in 1998. Brazil had nearly 1.7 million hectares in 1997, making up 50 percent of its total bean area.

CIAT-related rice varieties are also a major feature of Latin America's rural landscape. In 1997 they occupied 94 percent of Brazil's rice fields, or a little more than 1.4 million hectares. The figures for Argentina, Colombia, Costa Rica, Ecuador, Peru, and Venezuela—also big rice producers—were likewise high, in each case more than 70 percent of the planted area.

The proportion of pasture land covered by CIAT-related forages is still rather small. This is partly because elite materials were distributed and adopted somewhat later than improved rice, beans, and cassava. Nonetheless, the absolute area of improved pastures in Latin America is impressive. In Brazil alone over 5 million hectares are estimated to be sown to CIAT-related forage cultivars.

Agropastoral systems for the savannas: Looking to the future

A second CIAT study during 2000 looked ahead, projecting the potential economic benefits of disseminating agropastoral technology in the South American savannas.

In recent years farmers have become concerned about the need to counteract widespread pasture degradation and declining rice yields. One set of solutions promoted by CIAT is to integrate cropping with cattle production based on better forage grasses and fertility-boosting legumes. In fact, a trend in this direction is already under way in this vast ecosystem, which covers 243 million hectares in Brazil, Venezuela, Colombia, and Bolivia.

Improved beans in Yoro Department, Honduras.

The CIAT cost-benefit analysis concludes that a rotational system of rice production and improved pastures would generate substantially greater economic benefits than rice monocropping or straight cattle production on either improved or native pastures. According to CIAT economist Albert Gierend, who conducted the study, such an agropastoral system would, over 30 years, provide total estimated benefits of just under $40 billion to the four savanna countries. At the same time, soil structure and fertility will improve, thus providing an important environmental bonus to this final frontier of agricultural expansion in South America.

Calculating the benefits of germplasm royalties

Developing countries increasingly are demanding compensation for providing much of the raw genetic material used in modern plant breeding: farmer-bred crop varieties and their wild relatives. The Rio Convention on Biodiversity is one international mechanism that recognizes the legitimacy of such claims by declaring that plant genetic resources are the property of the country of origin.

A recent CIAT study projected the financial costs and benefits of introducing a global system of royalty payments on sales of crop seed. Common beans were used as the example in this modeling exercise. The income and payments were calculated so as to permit comparisons between regions of the world and between selected Latin American countries—to see who would win and who would lose.

At the Jiménez family farm in Mexico's Quintana Roo State.

The study, by economist Douglas Pachico who leads CIAT's Impact Assessment Unit, makes two key assumptions. First, the royalty is set at a liberal 10 percent of the seed price. Second, royalties are divided among countries according to the genetic contribution each country makes to the global bean gene pool from which commercial varieties are bred and then marketed as seed.

The projections show, as expected, that the royalty scheme would favor poorer southern countries as a whole. The block of richer northern countries would have net payments to make. Based on current levels of global bean production, developing countries would pay out about $49 million in royalties and take in about $53 million, for a net gain of $4 million. Europe and North America (excluding Mexico) would take in less than $2 million and pay royalties of close to $6 million, for a net loss of about $4 million.

But the study also shows that among individual countries and regions, there would be large imbalances. For example, Peru and Mexico, which possess many bean landraces and wild ancestors, would each have an annual net income of over $13 million from the scheme. In contrast, Brazil, a major bean-growing country but not a source of bean genetic diversity, would have a net annual bill of $17.5 million. Sub-Saharan Africa, also a major bean producing region, would have net payments of $12 million, more than Europe and North America combined. Asia and the Caribbean would also be net payers for bean germplasm.

The study concludes that, despite national and regional disparities, a royalty system based on germplasm ownership "could be in the common interest if it serves to provide improved incentives for the conservation of genetic diversity." And insofar as such a system might also encourage further exchange, development, and use of germplasm, it would have the benefit of boosting bean productivity. Pachico estimates the financial windfall from additional production to be between 6 and 27 times greater than the anticipated royalty payments. "It would, in principle, be worthwhile for gene-poor, low-income countries to pay for access to genes. But most developing countries have far more to gain from increasing bean productivity than from a royalty system for bean germplasm."

Near Mitú, Vaupés Department, in the Colombian Amazon.

Research and Development Highlights

Saving wild peanuts

In a novel application of a CIAT computer tool called FloraMap, researchers have mapped out how future climate change will likely affect the distribution of wild peanuts in their region of greatest genetic diversity, South America. The resulting scenarios paint a precarious future for most of the 18 species analyzed.

The findings have major implications for efforts to protect wild peanuts in natural habitats and, by extension, for the future availability of wild genes for breeding programs. Wild peanuts possess significant disease resistance and other useful traits that breeders could transfer to their more susceptible cultivated cousins.

When it comes to migration to new ecological niches, wild peanuts (comprising 68 known species in the genus *Arachis*) are exceedingly slow. In contrast with plants whose seeds are scattered by wind, rain, and birds, the propagation of wild peanuts takes them no more than about 1 meter per year. The main reason is that their fruit grows underground. This rather sedentary reproductive behavior makes them highly vulnerable to climate change. If they cannot adapt by moving, then they face extinction.

The research team, composed of scientists from CIAT and the International Plant Genetic Resources Institute (IPGRI), obtained temperature and rainfall information for South America, generated by a climate change model called HADGCM. These data—estimates for the period 1961-1990 and predictions for 2041-2070—were mapped onto the smaller-scale grid used by FloraMap. The geographic coordinates of the sites where specimens of the 18 wild species have been previously collected were then input into FloraMap. This allowed the projected distributions for the two time periods, past and future, to be mapped and compared.

A key pattern the team was looking for was distribution overlaps, climatic zones where wild peanut species potentially grew in the late 20th century and would likely continue to survive in the mid-21st century. For three of the 18 species, overlaps were significant, suggesting their chances of survival are high. In four cases the model predicted significant reductions in and

Fruit of the cultivated peanut (*Arachis hypogaea*) with that of the wild peanut species *A. williamsii*. Both samples are from Bolivia, where the peanut is believed to have its center of origin.

fragmentation of distribution. The really disturbing finding was that for each of the remaining 11 species, there was no overlap. Without human intervention these species are likely to die out.

Apart from climate change, wild peanut habitats are also threatened by human encroachment and industrial development. For example, in southeastern Bolivia, thought to be the center of origin of the cultivated peanut, construction of a gas pipeline through a wilderness area will probably be accompanied by an influx of pioneer farmers and livestock. Cattle in particular pose a major risk, since they have a strong preference for wild peanuts and tend to eradicate them through grazing.

When David Williams, a wild peanut expert with IPGRI, learned of the pipeline project, he and colleagues began planning a rescue expedition to collect wild species with Bolivian scientists. "Finding the wild species that originally parented the domesticated peanut, *A. hypogaea*, would be a major breakthrough for crop improvement," says Williams. "The wild progenitors could serve as genetic bridges for transferring disease resistance from other wild species to the domesticated *A. hypogaea* by means of conventional breeding. This would enable peanut farmers to cut costs, increase yields, and better protect the environment by reducing pesticide applications," he notes.

But unfortunately, a complex controversy recently erupted in Bolivia over compensation for environmental damage due to pipeline construction. Local groups, hearing news of the planned peanut collection mission, perceived it to be yet another assault on the environment rather than the protective measure it was conceived to be. In the hot political atmosphere, the international team has been unable to obtain a collecting permit.

Even so, a Bolivian NGO, Fundación Amigos de la Naturaleza (Friends of Nature Foundation), is using the modeling results to plan conservation of the wild relatives of peanut as well as of other crops. In addition, these results should provide Bolivian decision makers with compelling new evidence of the importance of conserving globally important plant genetic resources.

Fortifying beans and cassava

After several decades of success in boosting crop yields, plant breeders around the world are now targeting their skills on a major and growing international health threat: micronutrient deficiencies in the human diet. At CIAT researchers are investigating the iron and zinc content of common beans and beta-carotene (the precursor of vitamin A) in cassava. Fortifying these two crops with essential micronutrients through breeding is seen as a powerful way to improve the health of vast numbers of poor people at low cost.

The work at CIAT is part of a collaborative study, funded by Danish International Development Assistance (Danida) and involving four Future Harvest centers, that examines the potential for plant breeding to overcome micronutrient deficiencies. Based on the promising results so far, researchers are planning an expanded initiative that will include another four centers. The new

CIAT and IPGRI scientists predict that global climate change will dramatically reduce the species richness of wild peanuts in South America, their region of greatest genetic diversity.

project will bring together specialists in plant breeding, genomics, human nutrition, and food policy to develop new varieties that help combat micronutrient deficiencies among the poorest people in the tropics. CIAT will coordinate the plant breeding across seven centers, while the International Food Policy Research Institute (IFPRI) will coordinate work on nutrition and policy.

High iron and zinc in beans

"Nutrient deficiencies drain the health, stamina, intelligence, and productive capacities of poor people," says CIAT bean breeder Steve Beebe. For example, iron-deficiency anemia affects nearly 2 billion people worldwide. In young children it impairs physical and cognitive development and immune response to disease. And in pregnant women, it's linked to higher risk of illness and death as well as to major health threats to their fetuses and newborns.

Beebe and colleagues have analyzed CIAT's core bean collection—more than 1,000 samples covering various classes of common beans. The aim is to get a better idea of the genetic basis and variability of micronutrient content. Findings show the quantity of iron differs markedly within and among bean types, with an average of 55 parts per million (ppm). Zinc follows a similar pattern, averaging 35 ppm.

Results of preliminary experiments reveal several patterns and characteristics that favor success for a bean breeding strategy and point researchers in the right direction:

- It appears that concentrations of iron, zinc, and other minerals in beans are genetically correlated. So, selecting for high iron content, for example, would automatically provide the added benefit of bean seeds with more zinc.

- Beans selected for high mineral micronutrient content can be expected to retain that trait across different growing environments. This bodes well for new fortified varieties having geographically wide impact.

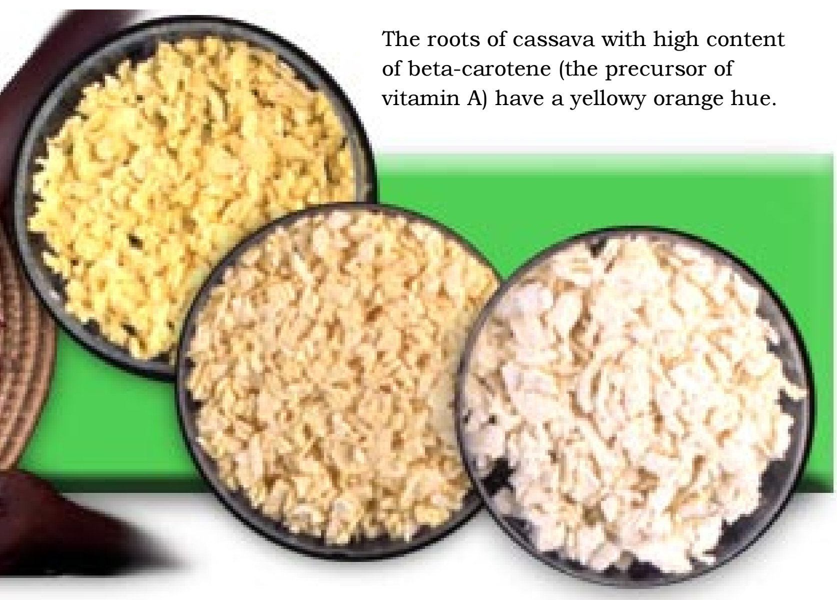
- Mineral content is unlikely to conflict with consumer preference traits like grain size and color. Since micronutrient fortification would be invisible, bean eaters would not have an obvious reason to shun new varieties.

The bottom line, says Beebe, is that there appears to be enough genetic variability in common beans to allow breeders to improve their iron content by up to 80 percent and their zinc by up to 40 percent. The challenge now is to incorporate the necessary genes into the bean types that interest farmers without losing valuable traits like high yield and drought tolerance. To this end CIAT bean scientists are now identifying molecular markers linked to the half dozen or so genes responsible for high mineral content. Molecular marker technology will also help speed up selection of superior plants.

Carotene-rich cassava

Worldwide, between 140 million and 250 million children under 5 suffer from vitamin A deficiency. Like iron deficiency, this tends to weaken the immune system. And in severe cases it causes irreversible blindness.

Sorting bean seed at a market in Kampala, Uganda.



The roots of cassava with high content of beta-carotene (the precursor of vitamin A) have a yellowy orange hue.

The leaves and, to a lesser extent, the roots of some cassava varieties contain significant concentrations of beta-carotene (vitamin A) and ascorbic acid (vitamin C). Recent CIAT studies suggest that high beta-carotene concentrations also slow the deterioration of roots after harvest. This means better storability and greater food security.

The double benefit of root beta-carotene, combined with the fact that root processing before consumption tends to make its vitamin C unstable, has led CIAT to concentrate on enhancing root beta-carotene. A major consumer-related problem to resolve, though, is that carotene-rich roots tend to be yellow or yellowy orange. While in some parts of Africa people like this hue of cassava, the general preference in most countries is for white roots.

Hernán Ceballos, manager of CIAT's cassava project, notes that several strategies are being pursued simultaneously to enhance the vitamin A content of cassava for regions where the crop is important and vitamin A deficiency is severe.

First, yellow cassava varieties from Latin America are being crossed with African varieties resistant to cassava mosaic disease, a major threat in Africa. The resulting germplasm can then be distributed in areas where yellow roots are preferred. The research is being done jointly with the Nigeria-based International Institute of Tropical Agriculture (IITA).

Second, researchers are trying to break the genetic linkage between root yellowness and high beta-carotene content. This involves crossing white and yellow cassava varieties and then selecting progeny that are less yellow but have good beta-carotene content.

The third and longer term strategy involves genetic transformation—"cut and paste," as Ceballos calls it. CIAT scientists will use molecular markers to pinpoint the few genes that act together to produce good root beta-carotene. These genes will then be cloned, biologically packaged, and transferred to current varieties that appeal to farmers and consumers. "With this strategy," notes Ceballos, "we'll improve the nutritive value of already successful varieties, thus bypassing many of the steps involved in lengthy conventional breeding."

Biosafety: Progressing with caution

As the operator of a major agricultural biotechnology program, CIAT observes the highest standards of biosafety. Strict enforcement prevents experimental genetically modified organisms (GMOs) from accidentally entering the natural environment of Colombia, our host country.

Today, there is much public debate—and confusion—over GMOs, namely organisms that have had foreign genes inserted into their DNA through genetic engineering. A key concern is that genetically modified plants may interbreed with the same or similar species or wild relatives —a process known as geneflow—thereby transferring foreign genes and disrupting the ecosystem. Geneflow, a naturally occurring process, has been an important part of crop evolution. So, the concern is not about geneflow itself but about the possible consequences of introducing genes that are not present in the genome of a given species.

CIAT has been experimenting with transgenic methods since the early 1990s. It sees the technology as one way to overcome inherent difficulties in conventional breeding of crops grown by poor farmers. "We look for the most practical and safe method to improve crops," says Aart van Schoonhoven, CIAT's director of genetic resources research. Transgenics, he says, is just one of several options for accelerating the diffusion of high-quality germplasm to farmers.

CIAT's Biosafety Committee has been operating since 1991 in close collaboration with the Colombian government. On the one hand,

Testing of lines resistant to the rice *hoja blanca* virus in biosecure plots at CIAT headquarters in Colombia.

representatives of two public Colombian scientific agencies are members of the committee, thus ensuring national perspectives in our biosafety work. On the other hand, CIAT has provided advice to the government on the formulation of national biosafety regulations for GMOs. And it recently organized biosafety training for Colombian and Latin American researchers and seminars for journalists.

The Center also conducts research on biosafety issues. In 2000, Germany's Federal Ministry of Cooperation and Economic Development (BMZ) approved a collaborative project to evaluate potential geneflow in two crops, beans and rice.

Gene-transfer work at CIAT has moved ahead steadily over the past decade, with research on rice being the most advanced. In many ways transgenic rice serves as a model for the Center's biosafety work, not only in the area of enforcement, but also in biosafety research, training, and information.

The most advanced experimental transgenic rice was developed with Rockefeller Foundation support in the late 1990s. It's resistant to the highly destructive rice *hoja blanca* virus (RHBV), a major problem in Latin American rice fields. The foreign gene comes from the virus itself. Developing durable resistance to this disease has been a key aim of the research.

Once the transgenic rice was developed under safe laboratory conditions and, more recently, tested in controlled glasshouses, the next step was to conduct outdoor field trials. In 2000, CIAT received approval from Colombia's National Biosafety Commission to do so. Formal registration with the agency now also allows us to generate and import transgenic plants for further germplasm development. The transgenic rice has since graduated from the confines of the glasshouse to a biosecure outdoor plot at our main experiment station. Precautions in the field trial are numerous and mutually reinforcing, thus minimizing the risk of geneflow.

Biotechnology by and for farmers

A low-cost system for growing disease-free cassava planting material in rural areas promises to boost production of this important crop in Latin America and beyond. Besides putting more money in the pockets of small-scale farmers, the technology offers rural communities a chance to launch a new type of lucrative and beneficial rural agroenterprise.

The technology's centerpiece is a farmer-operated tissue culture laboratory in which inexpensive local equipment and materials substitute for high-cost components typically found in a conventional biotechnology laboratory. Preliminary results show that the cost of setting up such a rural laboratory is about 5 percent that for a conventional facility.

"The main idea is to stop the cycle of disease transmission in cassava production while increasing farmers' income," says CIAT biologist/biochemist Roosevelt Escobar. The technology was designed and initially tested by Escobar and colleagues with a group of nine women farmers in Colombia's Cauca Department. A national NGO, the Agricultural Research and Development Foundation (FIDAR), also plays a central role in the project, coordinating farmer participation and providing business management training.

Start-up funding for farmer involvement in the micropropagation research was provided by the Participatory Research and Gender Analysis (PRGA) Program. Coordinated by CIAT, this is a global, multi-institutional initiative of the CGIAR.

The laboratory procedure begins with disease-free cassava—*in vitro* plantlets—supplied by CIAT. Transforming the plantlets into stem cuttings, called stakes, for sale to local farmers comprises several steps involving rigorous attention to cleanliness. For example, tissues are prepared in a sterile enclosure whose cost is about one-tenth that of a high-quality flow chamber used by professional agricultural laboratories.

The cuttings are cultured in sterilized glass bottles with a growth medium prepared with off-the-shelf products from local shops. These are much cheaper than the custom chemical products used in a scientific laboratory. For example, baby food jars substitute for laboratory test tubes and spring water for bottled water. This do-it-yourself method of preparing culture medium costs about one-quarter as much as conventional medium. And, surprisingly, it results in plant propagation rates similar to or better than those in CIAT's laboratory.

"At first we were afraid we wouldn't be able carry out the laboratory work," says farmer Doris Castillo. "The equipment seemed sophisticated. But now it comes as naturally to us as sowing seed."

After 4 to 6 weeks of *in vitro* growth in a simple bamboo-framed greenhouse covered in plastic, the new cassava plantlets are ready to be redissected and cultured in another round of micropropagation. Once a large enough quantity of plantlets has been generated from the original CIAT germplasm, they're grown in pots with soil to promote root growth. Eventually they're transferred to an outdoor nursery where they grow into full-sized plants, ready for cutting into disease-free stakes that farmers can plant in their fields.

Escobar is hopeful that this still-evolving tissue culture technology can also be successfully applied to other crops like plantain, blackberries, and orchids.

Unmasking a major cassava disease

In joint work by CIAT and France's Institute of Research for Development (IRD), researchers have made considerable progress in identifying individual strains, and three distinct groups of strains, of the bacterium responsible for cassava bacterial blight (CBB). Called *Xam*, short for *Xanthomonas axonopodis* pv. *manihotis*,

Colombian farmer Doris Castillo prepares new cassava plantlets for micropropagation, while Nohemí Larrahondo displays a plant in the nursery. They and seven other women operate a rural tissue culture laboratory in Colombia's Cauca Department.

this highly variable organism can result in cassava root losses ranging from 20 to 100 percent. Given the importance of cassava as a staple food and income earner in Latin America and Africa, the disease poses a serious threat to food security.

Cassava stem cuttings called stakes, planted each cropping season by farmers, are the main repository of CBB. If infected, they allow the disease to persist from year to year and to spread between fields. And transport of contaminated stakes between growing regions spreads the disease even further afield. Latin America, the center of origin of cassava, is also the region with the greatest diversity of *Xam* strains. CBB is also a problem in Africa now, having been accidentally introduced there in the 1970s from Latin America.

The CIAT-based studies began in 1995 and built on earlier research by IRD in Africa. The recent findings are based on analysis of numerous *Xam* samples collected from Colombia, Venezuela, and Brazil. (Similar work is being done under a European Union-funded project in Benin and Togo.)

The results have allowed the CIAT-based team to design a set of laboratory and field methods for detecting the disease in cassava stems and seeds. This is a major step in preventing its spread. Diagnostic techniques, including visual inspection procedures, have been compiled into a manual for national and other users, available in Spanish and English.

Laboratory methods are based on polymerase chain reaction (PCR) as well as two older techniques, dot-blot hybridization and ELISA (enzyme-linked immunosorbent assay). As key tools for certifying that cassava stakes and seed are disease-free, they promote safer exchange of germplasm within and between countries and help prevent the spread of *Xam* strains to uninfected areas.

“I’d like to see all the products we developed made available to national research programs and farmer groups,” says Valérie Verdier, an IRD plant pathologist and coauthor of the manual, which also includes disease-prevention advice for growers. She expects high demand in cassava-producing countries.

Just as important as their role in disease control, the recent advances in CBB characterization and diagnostics aid selection and breeding of CBB-resistant germplasm. “Now we have a better picture of the resistance of the cassava material available in CIAT’s core collection,” says Verdier. Scientists are also using the Center’s molecular genetic map of cassava to identify regions of the cassava genome responsible for CBB resistance. To date they’ve identified 19 molecular markers, paving the way for marker-assisted selection and breeding of resistant materials.

In collaboration with CIAT, France’s Institute of Research for Development (IRD) has developed new techniques for detecting cassava bacterial blight, a major disease of the crop in Africa and Latin America.

People power in the Amazon

Indigenous women in the Colombian Amazon have teamed up with CIAT researchers to combat a grave impediment to cassava production: root rots. These fungal diseases turn otherwise edible cassava roots into foul-smelling mush. Every year they destroy 20 percent of the world's cassava crop and, in badly infested areas, the figure can be as high as 70 percent.

Enhancing host plant resistance is widely seen as the best way to manage root rots. This requires intensive germplasm selection to identify cassava lines that resist the fungus and have other desirable traits. The fact that the disease-causing fungus *Phytophthora* is a highly diverse organism, consisting of many species and many strains within those species, complicates the work.

Participatory research in nine communities around Mitú in southeastern Colombia's Vaupés Department complements CIAT's laboratory and field experiments. In a diagnostic survey in 1997, local farmers clearly identified root rots as the key constraint of cassava production. Center researchers then consulted with the women to design comparative cassava-growing experiments. These were conducted by participants in their *chagras*—small forest plots that are slashed and burned and then planted to cassava and other crops like pineapple, plantain, maize, yam, and sugarcane. The participatory research was funded by Colombia's World Bank-supported National Program for the Transfer of Agricultural Technology (PRONATTA).

"We wanted to know the farmers' preferences for growing cassava, so we could give them exactly what they wanted," says CIAT plant pathologist Elizabeth Alvarez. "The women are so happy and proud to be selecting varieties themselves."

Based on long experience cultivating cassava in the forest, the farmers laid out their own criteria for good crop growth as well as preferred traits at harvest time. The participants then cultivated a mix of traditional and improved materials on four plots in different communities and compared their performance.

The women shared results among themselves and with other farmers in the region, with help from local development agencies. An important outcome of this work is a handbook on diagnosing cassava production problems and evaluating options, especially germplasm. It makes extensive use of drawings, since farmers in the region speak different dialects of the local language, Tukano, and many cannot read or write. In addition, a collection of indigenous cassava varieties has been assembled and conserved locally. This will help maintain the biodiversity needed for good crop health and food security.

While building farmers' capacity to evaluate and select suitable resistant varieties is important, better soil management is also needed, says CIAT agronomist Germán Llano. Population growth around isolated towns in the Amazon is intensifying pressure on the forest. Under shifting cultivation fallow periods and crop rotation have been reduced in recent years. The resulting declines in soil fertility, combined with high soil humidity, provide a perfect environment for proliferation of root rot fungi. CIAT scientists recently continued their participatory experiments, this time to evaluate the effects of soil enhancement on the yield of local cassava varieties.

Cassava harvest near Mitú, Vaupés Department, in the Colombian Amazon.

Integrated agroenterprise projects

The temperate zones will forever envy the tropical world its treasure house of plant diversity—exotic fruits, aromatic herbs, medicinal plants, delicate flowers, and food staples like cassava and arrowroot, also used for industrial purposes.

Despite the biological wealth at their doorsteps, tropical farmers have all too often encountered failure in publicly sponsored attempts to add value to existing crops or launch new ones. The architects of these projects were sometimes far too concerned with the production side of the equation. Scant attention was paid to the real needs of industrial and individual consumers and to the support services vital to sustaining small businesses.

CIAT's agroenterprise specialists—with support from the UK's Department for International Development (DFID) and Canada's International Development Research Centre (IDRC)—have designed a new participatory method for creating viable business opportunities for small tropical producers. It's based on analysis of strengths and weaknesses in the overall marketing chain, followed by design and execution of integrated agroenterprise projects. Under preparation as a CIAT training manual, the method stresses competitiveness, job creation, higher value added, and the involvement of many contributors to the marketing chain. It has been tested in hillside communities of Honduras and Colombia and in the forest margins of Peru.

In Pucallpa, Peru, the Center is working with a local consortium of development agencies and community groups—the Consortium for Sustainable Development of the Ucayali Region (CODESU)—to promote production and marketing of cocona (*Solanum sessiliflorum*), a tropical fruit. This forest species has enormous market appeal as fresh produce, juice, jam, and ice cream flavoring, as well as an ingredient in liquor and spicy sauces.

In designing an integrated agroenterprise project for cocona, local participants examined production, processing, and marketing factors. As the fruit is still a minor commodity, there are many bottlenecks to deal with. For example, lack of investment capital and weak organization at all stages of the marketing chain were seen as major impediments.

Nevertheless, market analysis indicates that, if various bottlenecks can be eliminated, a bonanza awaits local farmers. Consumer demand for cocona is expected to explode in the coming years. If the projections are right, production will need to reach 3,125 tons a year, more than six times its current level.

"The participatory mode—getting the actors together to exchange ideas and information—is a strong motivator," says Rupert Best, manager of CIAT's Agroenterprise Development Project. Over the past year, CODESU has been promoting its agroenterprise project among potential service providers and participants. An association of cocona producers is on the drawing board, and its promoters have interested local investors in building a pilot processing plant.

In Colombia's Cauca Department, similar agroenterprise development activities are taking place—for dairy products, medicinal plants, and cassava starch. And in two Honduran communities, local farmers and other participants in the food marketing chain are concentrating on coffee and maize. Lessons from these pilot projects have allowed CIAT to solidify its methodology for developing integrated agroenterprise projects. Now the Center is broadening dissemination of the methodology through a training course for eastern and southern Africa.

Results of farmer participatory analysis of the coffee market chain in Yoro Department, Honduras. This kind of analysis yields information that can help farmers become more competitive.

Soil scientists and farmers find a common language

CIAT and three partner organizations have developed a new decision-support tool, in the form of a training guide, for identifying local indicators of soil quality in eastern Africa. Based on earlier work in Latin America, the guide is helping farmer groups and researchers develop a common language for jointly combating one of the gravest threats to food security in the African highlands: soil degradation.

The traits that tropical farmers typically look for when evaluating soil are quite different from those that researchers examine. Farmers have a long tradition of relying on indicators like soil color and smell, native plants, and surface salt crusts. Soil scientists, in contrast, measure factors such as biological activity, organic matter content, plant-available nutrients, and pH. While both groups are searching for essentially the same insights into soil quality, differences in their methods, vocabulary, and training are a major obstacle to communication and joint problem solving.

The new English-language guide for eastern Africa—together with its Spanish counterpart, which has been used in Colombia, the Dominican Republic, Honduras, Nicaragua, Peru, and Venezuela—provides a solution. The guide explains how to elicit, organize, and rank farmer perspectives and integrate them with those of soil scientists so that both groups benefit.

"Farmers and technicians can use the resulting indicators to monitor and evaluate the impact of technologies designed to improve the soil," says CIAT soil scientist Edmundo Barrios. As a result, researchers gain valuable farmer feedback on the performance of new technologies, expressed in language that everyone understands.

Scientists estimate that two-thirds of Africa's crop land is degraded. Most degradation is subtle and incremental, occurring over a period of years. So it may go unnoticed until it's too late for countermeasures. Both farmers and public officials responsible for natural resource policies need reliable indicators of soil quality for early problem diagnosis.

The African training guide is the result of multiagency collaboration that began in 2000 in Uganda. CIAT's partners are the African Highlands Initiative (AHI), coordinated by the International Centre for Research in Agroforestry (ICRAF); the CGIAR's systemwide Soil, Water, and Nutrient Management (SWNM) Program; and the Tropical Soil Biology and Fertility (TSBF) Programme, based in Kenya.

After an initial train-the-trainer event in Uganda, several African trainees stayed on to work with CIAT staff and colleagues to adapt the guide to eastern Africa. The resulting version draws heavily on African examples of soil-quality indicators, particularly the presence of certain types of weeds. "It's interesting that you find plants of the same genus but different species occupying similar niches in Africa and Latin America and that farmers use these to identify similar soil conditions," observes Barrios.

The African guide was tested at a second training course, held in Tanzania in March 2001. Graduates of the Ugandan course served as instructors for personnel invited from NGOs, universities, and other institutions in Ethiopia, Kenya, Uganda, and Tanzania. Moreover, a new initiative is under way with Uganda's National Agricultural Research Organisation (NARO) for adapting other decision-support tools available from CIAT to conditions in eastern Africa.

A course on participatory analysis of soil quality indicators in Tanzania. CIAT and three partner organizations have adapted a training guide, originally developed for such courses in Latin America, for widespread use in eastern Africa.

Local action plans for natural resource management

In recent years CIAT and collaborating agencies have jointly designed nine decision-support tools, in the form of training guides, to help tropical hillside farmers manage their natural resources collectively and sustainably. The soil-indicators guide described in the preceding section is one such tool. But it's one thing to train small groups of people and quite another to ensure that the acquired skills are applied to real problems and that the results are fed back into the overall learning process.

"Training is not the end goal," says CIAT trainer Vicente Zapata. "The experience has to be incorporated into the bloodstream of participating institutions. We encourage them to adapt our decision tools to their daily work and needs." Action plans, designed and monitored by the organizations whose personnel receive training in the use of CIAT tools, are the key to success, according to Zapata. They provide a direct link between training and development outcomes in rural communities.

There are many tasks in natural resource management (NRM) that small farming communities may wish to take on. These include agroenterprise development, protection of forests and watercourses, and the prevention of soil erosion. But before communities can begin specific projects, there is much groundwork to do. Once basic food security has been strengthened, they may then wish to set up organizational partnerships and build a common knowledge base about local geography, land uses, and social needs. The CIAT tools cover all these steps and more.

In developing and testing its NRM tools and training guides, CIAT has worked at various reference sites, organized around well-defined watersheds, explains José Ignacio Sanz, who manages the CIAT project Community Management of Hillside Resources. The reference sites are located in Honduras, Nicaragua, and Colombia, and CIAT's work there has been strongly supported by the Canadian, Danish, and Swiss governments.

Training courses, however, have been held for groups in other countries as well. So far, 15 courses on various tools have been offered to about 400 people in seven countries of Latin America and eastern Africa. Based on the training, says Sanz, "participating organizations have drawn up about 35 concrete plans for translating their new skills into collective action for improved natural resource management."

Sandra Madrid, the executive director of a community-based NGO in southwestern Colombia's Valle del Cauca Department, is the key architect of local action plans for eight small communities in the municipality of Bolívar. Different decision-support tools were applied in different communities, depending on local needs.

"CIAT has given us the tools needed to gain a clear vision of what we can do to solve local environmental and social problems," says Madrid. In the water-short community of Ricaurte, for example, residents used CIAT's participatory resource-mapping tool to identify eroded areas in need of reforestation.

In another village, Aguas Lindas, the same CIAT tool helped residents document illegal tree cutting. Once the issue had been raised publicly, the community rallied. The forest damage was videotaped and shown to government authorities. The logging immediately stopped. As Madrid notes, the very act of getting local people directly involved in mapping the surrounding landscape, triggered joint action to solve a problem hitherto ignored.

Farmers at Bolívar in Colombia's Valle del Cauca Department conduct participatory mapping and monitoring of natural resources. The results provided the basis for an action plan to protect endangered resources through collective action.

The Amazonian ecosystem and human health

From the standpoint of human health and wealth, the Peruvian Amazon is something of an enigma. This vast landscape of lush tropical forests, rivers, and valleys possesses a huge share of the Neotropics' biodiversity and other natural resources. Yet, its inhabitants, many of them new arrivals engaged in shifting agriculture, are extremely poor and afflicted by chronic or seasonal illnesses.

An international, transdisciplinary team of researchers and development agents led by CIAT is working to pinpoint the reasons for this apparent contradiction. Its aim is to ensure that future interventions to improve human well-being take into account factors so far played down by both research and public policy. These include sociocultural differences, local biodiversity, natural seasonal rhythms affecting food availability, people's livelihood strategies, and their own perceptions of problems and goals. In short, the team takes a holistic "ecosystem" approach to human health and development.

Eight rural communities in the Ucayali Region of central-eastern Peru participate in the project, which is funded by IDRC. Other contributors include Peruvian health and fisheries ministries; indigenous and women's groups; research groups from Peru, Canada, and the UK; and PATH-Canada, a nongovernment health organization. Through household and community surveys, the scientists have compiled a large database on the health of local women, men, and children. This information is being correlated with local resource-use patterns, ecosystem characteristics, and other information.

Recent health surveys reveal disturbing levels of anemia and parasitic infections. For example, the incidence of moderate anemia among children ranged from 69 to 88 percent of those tested. In one community all 146 children examined were moderately to severely anemic. Vitamin A deficiency is also widespread, and malaria, dengue fever, and persistent diarrhea are on the rise.

Seasonal flooding, during which rivers may rise by as much as 10 meters, has been recognized as a powerful influence on health. It physically isolates communities, periodically making transport to health services and markets extremely difficult. It also undermines drinking water quality and affects cropping patterns, human migration, and seasonal distribution of fish, game, and wild edible plants.

The project team is now working with the study communities to design local action plans. These center on practical measures like nutrition education, testing for diseases, water purification, small-scale food production, and better hygiene and sanitation.

The researchers have also noted the motivational power of participatory methods. "The impact of having mothers, fathers, and children view their own parasites through a microscope far surpassed the information value of stool and sample analysis," says a recent IDRC project brief. "Parasites were no longer an abstract concept discussed only by Ministry of Health professionals; they became real aspects of villagers' daily experience with poor water quality and diarrhea. In each community villagers were immediately mobilized and sought solutions to reduce water contamination and parasite transmission."

Working with women's focus groups to gain a better understanding of local diets in the Peruvian Amazon.

Participatory methods prove their worth

Less than 3 years after Hurricane Mitch devastated agriculture in Honduras and Nicaragua, rural people in both countries are again living the nightmare of food and seed scarcity. This time, though, the threat comes from a severe and widespread drought. The Honduran Secretariat of Agriculture and Livestock recently reported that in 57 municipalities more than 75 percent of the bean, maize, and rice harvests had been lost.

Mitch prompted a deluge of emergency aid, including a successful seed relief effort organized by four Future Harvest centers, under CIAT coordination, and funded by the US Agency for International Development (USAID) and Canadian International Development Agency (CIDA). But the new crisis has elicited a different response. Now, the Honduran government and the Red Cross are seeking help in applying measures that can reduce agriculture's vulnerability to natural disasters.

In responding to this call, explains CIAT soil scientist Miguel Ayarza, who coordinates the Center's work in Central America, "we'll draw on a growing repertory of participatory approaches. These tools offer one of our best hopes for making hillside land and communities more resilient in the face of periodic crises."

Some of the evidence supporting this claim has come from CIAT's experience with disaster relief after Mitch. For example, in areas of Honduras and Nicaragua where local agricultural research committees, or CIALs, had been established with support from the W.K. Kellogg Foundation, these farmer groups proved highly effective in targeting seed relief.

Some CIALs have evolved into small agroenterprises that specialize in producing and marketing high-quality crop seed. According to seed specialist Guillermo Giraldo, who coordinated the Future Harvest centers' emergency seed relief effort after Mitch, networks of small farmer-run enterprises could provide the foundation for a national, community-based seed system that guarantees adequate seed supplies in good times and bad.

Another participatory approach that rose to the challenge of Hurricane Mitch is a community watershed management association called *Campos Verdes* (Green Fields). Consisting of representatives from the 16 communities that make up the municipality of San Dionisio in Nicaragua, explains CIAT scientist Jorge Alonso Beltrán, *Campos Verdes* expresses farmers' needs, conveys feedback to research and development organizations, and mounts projects in response to local demand.

In the months following Mitch, explains Paulina Aguilar, a member of the association's governing board, "*Campos Verdes* organized two projects to deal with the hurricane's impacts on our community." One involved multiplication and distribution of improved seed, while the other was designed to give the community a good overall grasp of the state of the local environment and to identify areas that are particularly vulnerable to continued degradation.

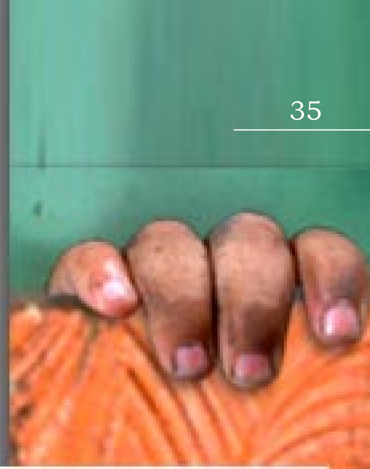
Under particularly trying circumstances, the CIALs, *Campos Verdes*, and other participatory tools have proven their worth as engines of grass roots rural innovation. If applied more widely, they could enable thousands of vulnerable people in vulnerable places to cope better with natural disasters as well as more subtle changes in the local landscape and economy.

Honduran farmer Nelson Palma, leader of a local agricultural research committee, discusses new bean varieties with CIAT agronomist Juan Bosco in Yoro Department.

Solutions That Cross Frontiers

An Overview of CIAT

The International Center for Tropical Agriculture (CIAT) is a not-for-profit, nongovernment organization that conducts socially and environmentally progressive research aimed at reducing hunger and poverty and preserving natural resources in developing countries. CIAT is one of 16 food and environmental research centers working toward these goals around the world in partnership with farmers, scientists, and policy makers. Known as the Future Harvest centers, they are funded mainly by the 58 countries, private foundations, and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).



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- Australian Agency for International Development (AusAid)
- Australian Centre for International Agricultural Research (ACIAR)

Belgium
- General Administration for Cooperation in Development (AGCD)

Brazil
- Brazilian Agricultural Research Enterprise (Embrapa)

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Our mission

To reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resource management.

Our project portfolio

CIAT's research is conducted through the projects listed below. These provide the elements for integrating research within the Center and for organizing cooperation with our partners.

Institutional Links

Participatory Research Approaches
Partnerships for Agricultural Research and Development
The Impact of Agricultural Research

Crop Improvement

Improved Beans for Africa and Latin America
Regional Bean Networks in Africa
Improved Cassava for the Developing World
Rice Improvement for Latin America and the Caribbean
Multipurpose Tropical Grasses and Legumes

Agrobiodiversity

Conserving Plant Genetic Resources of the Neotropics
Using Agrobiodiversity Through Biotechnology

Pests and Diseases

Integrated Pest and Disease Management

Soils and Systems

Overcoming Soil Degradation
Rural Agroenterprise Development
Sustainable Systems for Smallholders

Land Management

Community Management of Hillside Resources
Land Use in Latin America

Crop and agroecosystem focus

Within the CGIAR, CIAT has a mandate to conduct international research on four commodities that are vital for the poor: beans, cassava, tropical forages, and rice. Our work on the first three has a global reach, while that on rice targets Latin America and the Caribbean region. Increasingly, the Center also helps national programs and farmer groups find solutions to production problems encountered with other crops, such as tropical fruits, by applying research capacities developed through work on the mandate commodities.

In Latin America our integrated research on crops and natural resource management is organized largely on the basis of three agroecosystems: hillsides, forest margins, and savannas. CIAT scientists also work to improve crops and natural resource management in midaltitude areas of eastern, central, and southern Africa and in upland areas of Southeast Asia.

Partnerships

CIAT builds ties with other institutions through research partnerships based on projects. Our expanding circle of partners includes other Future Harvest centers, national research institutes, universities, NGOs, and the private sector. We work with them under a variety of innovative arrangements, such as consortia and networks, at the local, regional, and global levels. Through strategic alliances with advanced institutes, we bring valuable scientific expertise to bear on the central challenges of tropical agriculture.

As a service to its partners, the Center provides varied offerings in training and conferences and specialized services in information and documentation, communications, and information systems.

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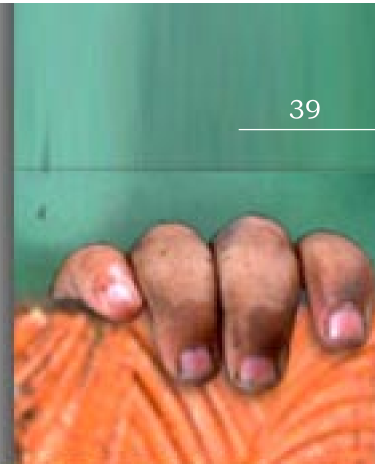

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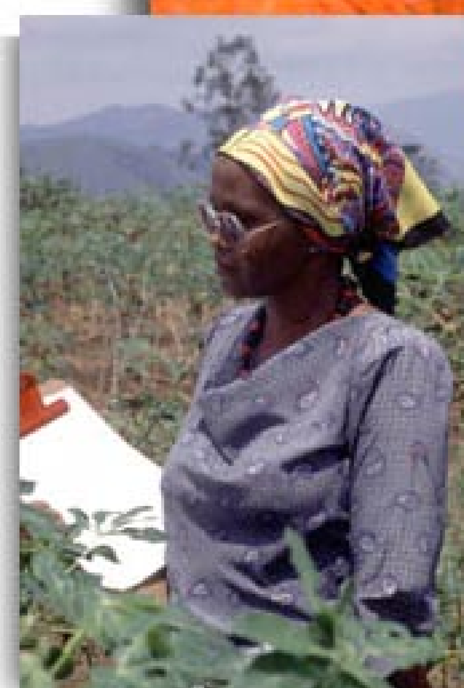

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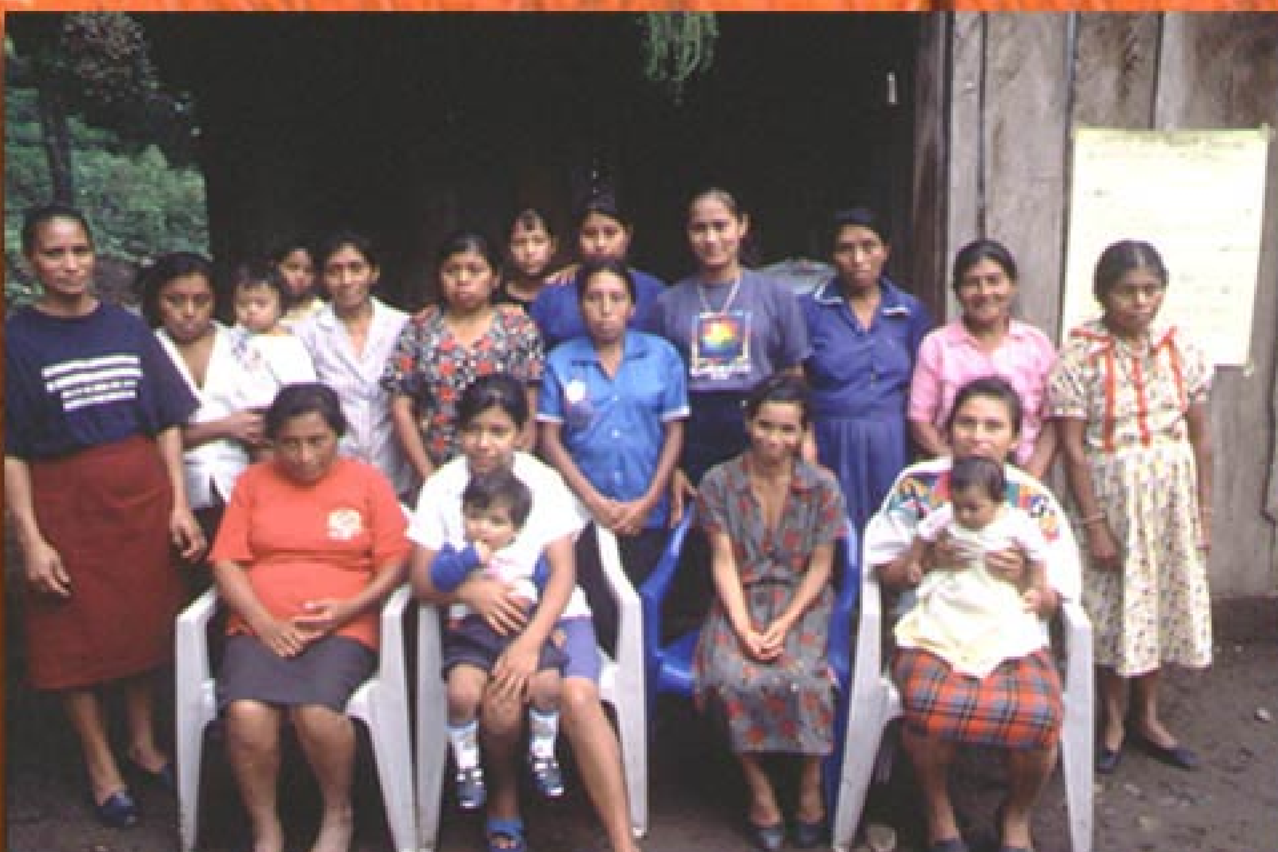

Members of a local agricultural research committee meet with neighbors at San Dionisio in Nicaragua's Matagalpa Department.

The Power of Perspective

Despite the demands of a busy harvest season, 15 women from the hillside community of Wibuse in Nicaragua's Matagalpa Department still found time recently to gather at the home of Bertha Adilia Jarquín. Their main interest was in sampling various food preparations made from the soybeans that Bertha and other members of a local agricultural research committee have been testing.

The committee has already selected and multiplied seed of improved maize and bean varieties. So, now they're searching for new opportunities to bolster local food security, raise incomes, and protect natural resources.

Life has always been hard for these women. But a string of natural disasters—Hurricane Mitch 3 years ago and more recently a severe drought—has made it more difficult still. Nonetheless, they seem determined to get the best of these ills by gaining new knowledge and organizing their community for change.

Nicaraguan farmer and community leader Bertha Adilia Jarquín.

Solutions That Cross Frontiers

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CGIAR

FUTURE HARVEST

The International Center for Tropical Agriculture (CIAT) is a not-for-profit, nongovernment organization that conducts socially and environmentally progressive research aimed at reducing hunger and poverty and preserving natural resources in developing countries.

CIAT is one of 16 food and environmental research centers working toward these goals around the world in partnership with farmers, scientists, and policy makers. Known as the Future Harvest centers, they are funded mainly by the 58 countries, private foundations, and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

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