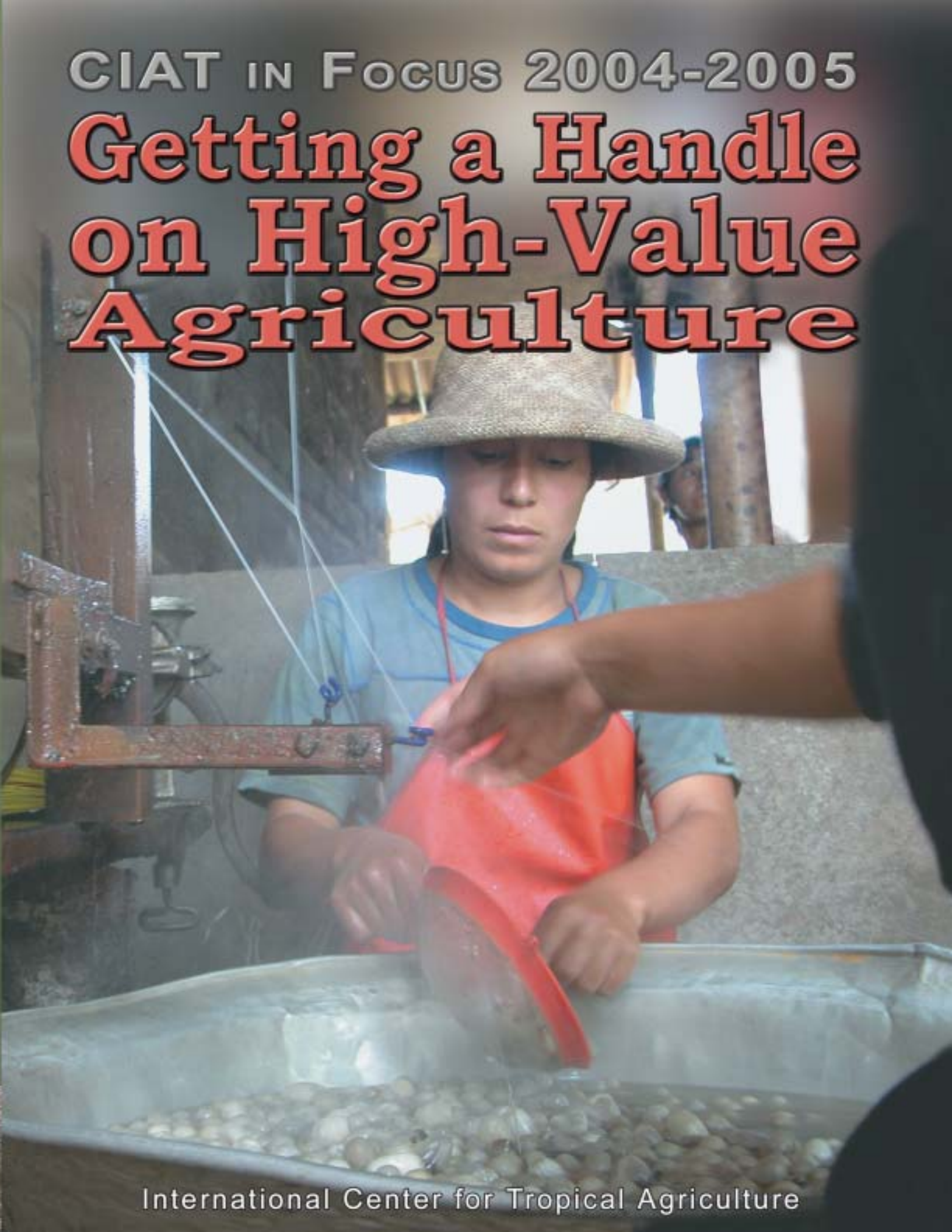
CIAT IN FOCUS 2004-2005

Getting a Handle on High-Value Agriculture



International Center for Tropical Agriculture

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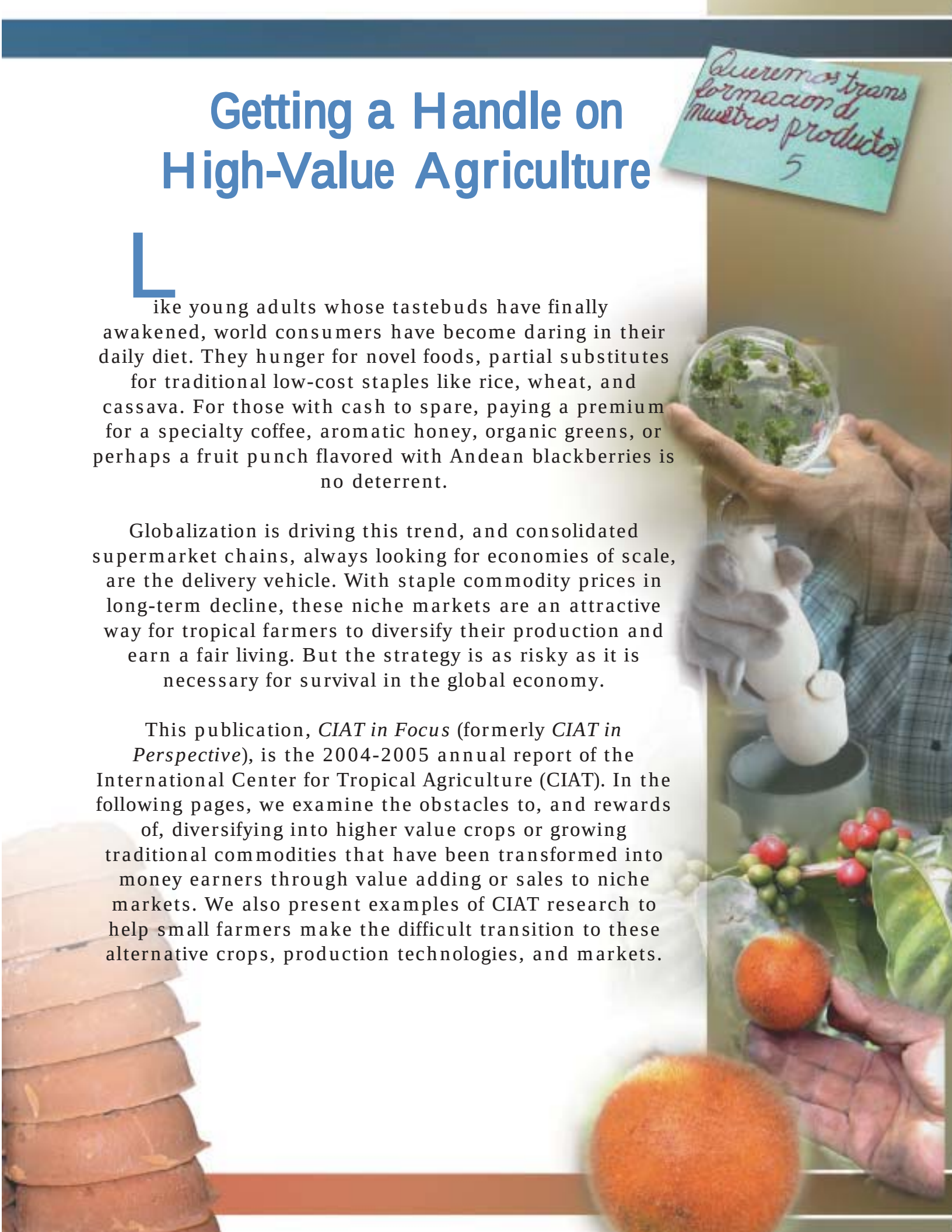
Silk production in Colombia's southwestern Cauca Department.

Getting a Handle on High-Value Agriculture

Like young adults whose tastebuds have finally awakened, world consumers have become daring in their daily diet. They hunger for novel foods, partial substitutes for traditional low-cost staples like rice, wheat, and cassava. For those with cash to spare, paying a premium for a specialty coffee, aromatic honey, organic greens, or perhaps a fruit punch flavored with Andean blackberries is no deterrent.

Globalization is driving this trend, and consolidated supermarket chains, always looking for economies of scale, are the delivery vehicle. With staple commodity prices in long-term decline, these niche markets are an attractive way for tropical farmers to diversify their production and earn a fair living. But the strategy is as risky as it is necessary for survival in the global economy.

This publication, *CIAT in Focus* (formerly *CIAT in Perspective*), is the 2004-2005 annual report of the International Center for Tropical Agriculture (CIAT). In the following pages, we examine the obstacles to, and rewards of, diversifying into higher value crops or growing traditional commodities that have been transformed into money earners through value adding or sales to niche markets. We also present examples of CIAT research to help small farmers make the difficult transition to these alternative crops, production technologies, and markets.



Helping Small Farmers Cash in on the Global Appetite for High-Value Products

Director General's Message

With their neatly organized shelves of dry goods, beverages, vegetables, bread, fruits, meat, fish, and dairy products, today's supermarkets offer consumers in both the industrial and developing countries an amazing range of fresh, frozen, and processed products. The choice—all in one location too—is something their grandparents never dreamed of. The revolution in global food sourcing and retailing that supermarket chains embody is largely driven by consumer demand, in turn influenced by rising incomes and changing lifestyles.

Apart from a wider selection of products, what exactly do consumers want and what are the coordinated food supply chains doing to satisfy those appetites? Most important from CIAT's perspective, what room is there for small farmers in developing countries to tap into those supply chains to boost their family incomes?

Ham and sausage versus pigs

Demand boils down to a few key factors: taste, appearance, safety, nutrition, ease of preparation, packaging and shelf life, and consistency of supply. For these traits, often guaranteed by a brand name, consumers will pay a premium over the price of more conventional "nondifferentiated" foods.

In short, there is a huge and growing global market for high-value products, particularly niche crops, such as fruits, specialty coffees, flowers, medicinal plants, and nontimber forest resources whose production or harvest can't be mechanized. We're also talking about more conventional crops (cassava, for example) and livestock, to which value has been added along the market chain—through inspection, grading, processing, or perhaps packaging. As a Filipino friend and former colleague of mine often tells the indigenous farmers with whom he works: "Don't sell your pigs for cash. Sell ham and sausage."

As for the role of food supply chains in meeting demand, procurement specialists make suppliers jump through many hoops. These include minimum weight or volume of supply, timing and frequency of delivery, product traits like color and shape, sanitary measures, and packaging and traceability. And when it comes to quality and safety, today's private industry standards are typically more onerous than public ones.

One-stop supermarket shopping has, of course, been a fixture of economic life in the richer countries for more than half a century. But the forces of globalization are now accelerating the integration of food procurement and retailing in the vastly larger markets of the populous tropics.

On-farm sale of dried chilies at Camalote in Bolivia's Chuquisaca Department.

Small-scale production of anthurium flowers in Cauca Department, Colombia.

The downside of economic globalization for small-scale farmers has mostly to do with their dwindling competitiveness in cultivating conventional staples like rice, maize, wheat, barley, potato, and soybean. The same applies to milk production. More liberalized trading regimes and better international transport and communications have made it exceedingly difficult for smallholders to continue making a living from such traditional commodities.

Clearly, the growing demand for high-value products—in step with what one US economist has dubbed the "supermarketization" trend—can serve as a counterbalance to the livelihood dilemma facing small-scale farmers due to foreign competition on traditional commodities. Recognizing the great potential of high-value products as an antidote to rural poverty, the Science Council of the Consultative Group on International Agricultural Research (CGIAR) explicitly covered this topic under two of its five recently stated priority research areas for the next decade.

Three lessons

Since its creation, CIAT has devoted great effort to improving production and protection of our four mandate crops—beans, cassava, forages, and rice—as well as to the management of soils needed for their production. But in recent years we have also recognized the urgent need to help poor farmers add value to their conventional crops and to diversify into higher value products, such as fruits and livestock.

In working with our clients on diversification, CIAT emphasizes three lessons or guidelines. First, in selecting new crops or products, small farmers should focus on those requiring specialized labor rather than on capital-intensive crops. An example of this is naranjillo (*Solanum quitoense*). Known as lulo in Colombia, it is a popular crop among the country's hillside communities, some of which are currently working with CIAT and private industry to exploit the fruit commercially. Lulo is a high-value semiperennial well suited to small-scale production for the fruit juice market. The economic return doesn't come from heavy capital investment. Rather it accrues from the farm family's "tender loving care"—in staking and pruning the plants and in selective harvesting.

The second guideline can be summed up in three words: organize, organize, organize. While any new crop or product must of course suit on-farm resources and agroecological conditions, farmers also must work together to master the technological, regulatory, and marketing aspects. This is an area to which CIAT has devoted significant resources, particularly through its projects on participatory research and agroenterprise development.

Finally, a key factor to be considered by developing country farmers, and by the R&D organizations supporting them, is their overall comparative advantage. Producers should regularly step back and analyze where and how they fit into the global agricultural picture. One of the watchwords here is "tropical." There are numerous crops—mangoes and cassava, to name just two—for which tropical locations are especially advantageous to commercial production. In this sense, climate can be seen as a resource. Software tools such as CIAT's Homologue, which uses climate and soil data to associate crops with locations where they might grow well, is designed to help tropical farmers exploit their competitive advantages.

When food commerce is left solely to market forces, it is nearly always the large players who win. For small farmers in developing countries to benefit from diversifying into high-value products, they need to be supported by good organization, information, and policies. If donors, research organizations, and development agencies can help small producers participate competitively in market chains, then we will have helped them find new escape routes from poverty. As our annual report for 2004-2005 demonstrates, this is a fundamental social investment to which CIAT is devoting significant research effort.

Unloading vegetables at the marketplace in Punata, Cochabamba Department, Bolivia.

Joachim Voss
Director General, CIAT

On the Road to High-Value Production

Linking tropical farmers to new markets

Globally speaking, changes in the human diet over the past few decades have been nothing short of remarkable. We now eat more vegetables, fruits, meat, dairy products, and fish than ever before, relying far less on traditional staple grains and other commodities like wheat, rice, maize, potatoes, and cassava. This largely positive nutritional trend is expected to continue strongly for many years. It will, on the whole, improve our health status as a species. But beyond that, increased consumption of these higher value products is resculpting our agricultural landscape and will indelibly alter economic relations among continents, countries, and communities. The crucial task for CIAT is to help the rural poor actively exploit these changes in economically and environmentally sustainable ways rather than become passive bystanders or, worse, victims of the entrepreneurial success of others.

A diverse human diet is just the tip of the iceberg. It is one of the more obvious signs of the much broader dynamic we loosely refer to as globalization—changes in international trade, corporate structure, commodity prices, methods of buying and selling, and information and communication technologies. In this new reality, the world's food consumers, their voices ventriloquized for better or worse by supermarket chains, now call the shots. For their part producers must listen carefully to consumers' requirements for product variety as well as quality and safety.

In the next few pages, we look at recent trends in global food production, marketing, and consumption, and what they mean for tropical farmers, scientists, and their development partners. We also review recent research by CIAT to help farmers make the difficult but necessary transition to producing higher value products and linking to existing or newly emerging domestic and export markets for those products. As we will see, this research is fully consistent with CGIAR priorities and with CIAT's pursuit of the three global research-for-development challenges that guide its work: Agrobiodiversity, Agroecosystem Management, and Rural Innovation.

More trade but declining commodity prices

From 1980 to 2003, world trade in food, expressed as the value of exports, more than doubled. And the annual value of world trade in agricultural products is now approaching US$600 billion. The industrialized world exports slightly more than the developing countries combined, but it imports substantially more. For tropical producers it is a huge and potentially lucrative market. But with the last vestiges of pure subsistence farming now vanishing, developing country markets too are on the rise and present substantial opportunities for raising farmers' incomes.

What's of special significance here is the product balance. Bulk commodities like grains and oilseeds have dwindled in economic importance, now making up only one-sixth of global trade in agricultural products. Their place has been taken by a range of processed and high-value food items, which now account for more than 80 percent of trade. For example, exports of fruits and vegetables rose 330 percent during the post-1980 period; in Latin America, they shot up 400 percent, with Central America becoming a major supplier. World meat exports also rose dramatically, by some 250 percent, with the increase reaching 300 percent in Latin America.

The growth of trade has been accompanied by rising pressure on prices. World prices for wheat, maize, and rice, adjusted for inflation, are the lowest they have been over the past century. And prices for commodity pulses (dried legumes) are about half what they were in 1989–90. Producers of traditional cash crops, such as coffee and tea, have also faced severe price declines. In all these cases, the reasons are a mix

A truckload of dried chilies on its way to Sucre, Chuquisaca Department, Bolivia.

of increased supply and sluggish demand, leading to market saturation.

"Prices of the top 20 or so commodities are at historic lows," says Shaun Ferris, manager of CIAT's agroenterprise development project. "If we continue to focus just on the productivity of those commodities, we lock rural people into poverty. We're arguing for much greater investment in helping farmers diversify into different sectors, so they have a range of options in supplying high-value products."

Globalization has increased both the supply of and demand for food, and altered the product mix. In particular, it has simultaneously created both threats to traditional field-crop production in tropical countries, due to stiff competition from efficiently produced cheap foreign imports, and an array of new opportunities due to consumer hunger—in the good sense—for variety and quality. Globalization, then, supports market supply from new sources. Among the commercial trends that can link tropical farmers to new markets, we note the rise of trade houses, supermarkets, and niche markets (for specialty coffees, for example), as well as the Fair Trade movement and the growing popularity of organic produce.

A stated research priority

Anyone who listens to agricultural scientists talk about shifting tropical research to high-value crops and other products is bound to hear the word diversification. It is closely linked to the economics of survival in the rural tropics. The connection is spelled out in research priorities for the period 2005-2015, set out by the CGIAR's Science Council (see box on page 6).

The five CG priorities were selected to contribute directly or indirectly to seven of the eight UN millennium development goals. The Science Council proposes that within 3 years 80 percent of the CGIAR budget be devoted to the five priorities, one of which is "reducing rural poverty through agricultural diversification and emerging opportunities for high-value commodities and products." The Council sees the added income for farm families coming from several sources: fruits, vegetables, livestock, fish, and nontimber forest products. Pursuing this priority is expected to contribute directly to the first two millennium goals: curtailing extreme poverty and hunger, and reducing gender disparity. The CGIAR also sees diversification as contributing indirectly to the goals of lowered child mortality, better maternal health, and environmental sustainability.

The priorities document calls for the CGIAR's research on fruit and vegetables, currently at a low level, to be expanded significantly. CIAT's project on tropical fruits, launched 3 years ago, as well as its longer-standing focus on value added and marketing, through its agroenterprise project, are already in step with this thinking.

The marketplace at Punata, Cochabamba Department, Bolivia.

A framework for realistic action

Flower production at Tunía in Cauca Department, Colombia.

A group of about 40 experts in diverse aspects of high-value agriculture gathered recently at CIAT headquarters to examine how the poor, especially neglected groups such as rural women, can benefit from growing markets for these products. Convened by the Global Forum on Agricultural Research (GFAR) and the CGIAR Science Council, the workshop was organized by the secretariats of these groups in collaboration with CIAT, the World Vegetable Center (AVRDC), International Plant Genetic Resources Institute (IPGRI), and International Federation of Agricultural Producers (IFAP).

The meeting was an important first joint initiative following the Science Council's recent decision to prioritize agricultural diversification and high-value products, such as fruits, flowers, vegetables, and livestock products. The experts were quick to acknowledge that, while small farmers enjoy some advantages, such as the limited economies of scale in markets for high-value products, they also face significant challenges, including the need to organize, acquire new knowledge and skills, and gain access to business support services.

Workshop participants made a good start toward doing a better job of helping farmers meet those challenges. Specifically, they reached a shared understanding of what high-value products are, reviewed strategies used in different regions for linking smallholders to markets, identified high-priority issues for a shared research agenda, and began creating informal networks and alliances for addressing key themes. The CGIAR and key partners now have the makings of a solid framework for realistic action.

Diversification in coffee zones

One obvious entry point for research on high-value products is the coffee supply chain. Coffee has suffered a slow decline as a cash crop in recent decades. International prices fell on average a little more than 5 percent a year from 1977 to 2001. The trend jeopardizes the livelihoods of some 25 million growers in about 70 countries, particularly poor hillside farm families working small plots of environmentally vulnerable land.

Under a 3-year project, CIAT is designing a three-part research strategy to help coffee and other smallholder farmers find viable higher value crop replacements that match demand from markets. In some cases, the recommended diversification will include continued coffee production but aimed at specialty markets that appreciate specific quality traits and are willing to pay a premium for them. In addition to specialty coffee, the project is working on tropical fruits, medicinal plants, high-value fodder crops, and specialty honeys, with the aim of developing concepts and methods to facilitate the participation of small farmers in high-value product supply chains.

At the heart of the diversification strategy is a triad of activities: market analysis, use of geographic information, and crop management tailored to match products from particular environmental niches with specific markets. Together, these activities can help bridge the gap between what farmers might successfully grow, given local climate and soils, and what buyers want—a gap that has plagued earlier crop diversification schemes.

Tropical fruits are another promising option for smallholders (see box). Their cultivation is generally well suited to the intensive management that can be readily provided at a small scale—such as coffee farms, 70 percent of which are less than 5 hectares. And

Coffee producer in Cauca Department, Colombia.

since many fruits are perennials, they fit well into coffee production systems from an environmental standpoint: They ensure continuous groundcover, protecting slopes from erosion.

"To fully benefit from growing and selling such higher value crops, you need more specialized knowledge, such as production requirements and market intelligence," says Thomas Oberthür, a GIS specialist with CIAT's land use project. This is important not only for the smooth operation of production and distribution, but also for ensuring an equitable distribution of benefits along the supply chain. The slice of the pie that goes to the tropical farmer is small and shrinking. An analysis of the distribution of benefits from African coffee production, for example, showed that the farmer got only US$0.12 of the $26 for which one kilogram of coffee retailed in London in 2002.

Processing specialty coffee in Cauca Department, Colombia.

Fulfilling the promise of tropical fruits

Since its establishment several years ago, CIAT's tropical fruits project has channeled its efforts mainly in two directions. First, it is creating information tools that help partners decide what species can best be grown where. And second, it is developing methodologies and technologies that can be applied with numerous fruit species to accomplish key tasks or solve major problems.

One of the main obstacles to expanding and improving production of some high-potential tropical fruits, such as lulo (*Solanum quitoense*) and soursop (*Annona muricata* L.; *guanábana* in Spanish) is the difficulty farmers face in obtaining high-quality planting materials for clonal propagation.

To support our partners' search for solutions to this problem, we are developing, to cite just one example, participatory methodologies that enable lulo growers to select elite clones as well as tissue culture methodologies for rapid in vitro multiplication of these elite materials on a large scale. "In vitro propagation can provide farmers with a source of healthy plant material. Some of them have reported increased productivity with these materials," comments geneticist Zaida Lentini, who coordinates this work.

A second major challenge for small farmers is how to manage major diseases and pests attacking diverse fruit species. "A serious attack, by reducing both the quantity and quality of fruit, can quickly wipe out producers' investment," notes Alonso González, manager of CIAT's tropical fruits project. For that reason the project will put increased effort into integrated management of diseases and pests like fruit flies, he explains.

Another promising but challenging line of research is aimed at developing practical means for genetic control of flowering in mango as a model for other tropical fruit species. If farmers were to gain the ability to control flowering in fruits, they could better target their produce to markets with narrow windows of opportunity. Recent ground-breaking research on this theme, funded by the Rockefeller Foundation, focuses on achieving in vitro regeneration of plantlets, using tissue culture techniques. This is required for developing an efficient protocol for genetic transformation, which would make it possible to splice in genes for flowering control and other valuable traits.

In vitro multiplication of the tropical fruit lulo.

The CIAT strategy, which combines expertise from several disciplines and four on-going research projects, recognizes that agroecological conditions vary widely in the highlands, between farms and even between fields within the same farm. So, not all farmers in an area may be able to grow the same crop and a single smallholder may need to diversify into other products. In these environments, regional one-size-fits-all strategies won't work, says Oberthür, and fragmentation of supply is a risk. Successful diversification, then, requires farmers to cooperate among themselves, as well as with service providers and other actors, to build a viable market chain. They must know their clientele and their tastes, the technical requirements of the supply chain, such as product quality, volume, and timing of delivery, and the specific characteristics of the higher value crop they are selling.

As a Colombian exporter told Oberthür: "We've got to learn more about our product at both ends. These producers want to know where their product is going."

Higher value through commodity rejuvenation

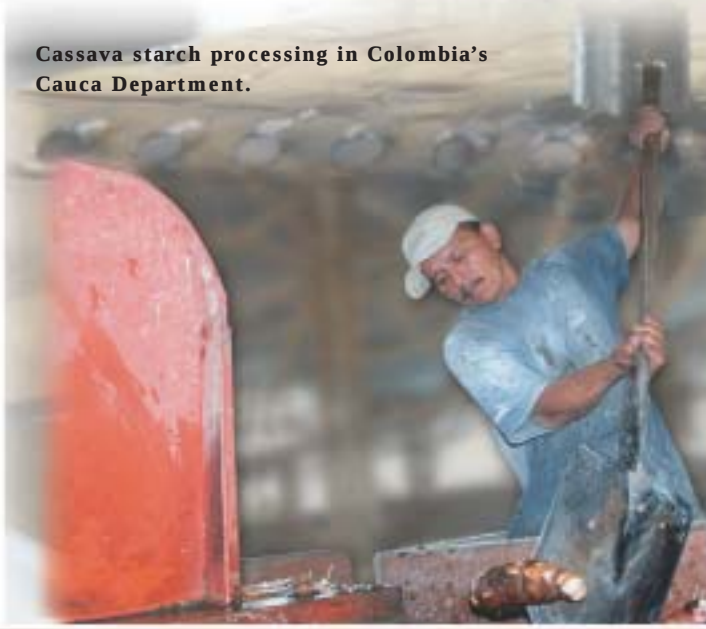
The drive to raise rural incomes may take the form of direct diversification into new, higher value crops, or even off-farm activities, related or not to agriculture. But changes in the production, grading, processing, and marketing of the crops farmers already grow may also open economic doors. A traditional food staple like cassava, for example, can also be grown as a source of industrial starch or processed into chips for animal feed. Both types of alternative product, typically involving a switch to new cassava varieties, will provide higher and more stable incomes than if the roots are merely sold fresh in local markets.

CIAT has worked for many years with numerous farmer groups on such nontraditional uses of cassava and has increasingly incorporated industrial requirements into its cassava breeding strategy. Its collaboration with the Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA), headquartered in the Agronatura Science Park on CIAT's campus, has helped stimulate and maintain a creative dialog between the R and the D in the consortium's name.

Following major yield improvements in recent years, Hernán Ceballos, manager of CIAT's cassava project, says that the crop can now compete with other sources of starch at commercial levels. This has fueled scientific and commercial interest in complementary qualitative improvements. "We are interacting closely with the industry to find out exactly what it is they want."

One opportunity is protein enhancement for improved nutrition of both people and livestock. While the leaves of cassava are rich in protein, the bulk of the edible portion of the plant, the roots, is not. Root protein is generally only 2 to 3 percent. But Ceballos notes that promising exceptions to the rule have recently been observed in some Central American cultivars, which have protein levels as high as 8 percent and more than twice the normal levels of pro-vitamin A carotenoids.

Improving the quality of cassava starch will also add value to a field crop produced mainly by poor people. Starch consists of two compounds, amylose and amylopectin, the latter being the more abundant and also responsible for the texture of "waxy" starch, which fetches a high price. One CIAT strategy, then, is to select for lower amylose content. In decades past



Cassava starch processing in Colombia's Cauca Department.

Analysis of cassava starch quality at CIAT headquarters.

CIAT cassava researchers analyzed only about 300 cassava samples a year for starch quality. In 2005 the Center began to beef up its analytical capacity. Throughput is expected to reach 300 samples a week during 2005.

Perhaps the most novel aspect of CIAT's new cassava breeding strategy is the introduction of mutagenesis to induce new value-adding traits. "Inbreeding allows you to push for the appearance of recessive genes, most of which will be bad for the plant but which can be easily bred out," says Ceballos. The key is to increase the chances that useful recessive genes—such as ones coding for quality starch traits—will express themselves. With support from CIAT, national research programs in India, Thailand, Vietnam, Uganda, Ghana, Cuba, and Brazil began projects in 2004 to incorporate inbreeding into their cassava research.

The message is clear. Even with a traditional food staple like cassava, there is excellent potential to add value, thus rejuvenating the commodity.

Better buffaloes from improved forages

CIAT's work with smallholders in Southeast Asia to improve the supply of forages is also a good example of the economic power of quality improvement. The forage technologies, developed with support from the Australian Agency for International Development (AusAID) and the Asian Development Bank (ADB), help farmers raise healthier animals, with less investment of time and energy (especially in collecting fodder and herding animals). When farmers adopt such technologies, says Rod Lefroy, CIAT's regional coordinator for Asia, "they cease being livestock keepers and become livestock producers." It is a change in both outlook and behavior. Instead of keeping animals mainly as an insurance policy, to be sold for cash to cope with emergencies like crop failure or family funeral expenses, the farmers begin to see their animals as a source of income, of products they can market on a regular basis.

Lefroy cites the case of Hmong highland farmers in Laos and their draft animals. After buying a single buffalo at the beginning of the cropping season, a farmer would typically see the animal's physical condition slowly deteriorate due to inadequate nutrition. But now, with good-quality forages available, the buffalo can be properly fed with less investment of family time and labor. As animals are in better health and show significant weight gain instead of loss, some farmers are buying and selling more than one animal per year, providing a welcome boost to their income. Traders coming to the village, explains Lefroy, are willing to pay more per kilo of live buffalo thanks to simpler marketing (i.e., buying more animals in one visit) and better quality animals. "This amounts to improvements in livestock production and the overall livestock marketing chain."

Potato farmers enter the fast-food lane

Good planning and organization by farmers is another means of boosting the de facto value of agricultural products, whether traditional commodities or new high-value niche crops. For example, pooling research, technology, production, equipment, transport, and support services, as well as working out clear delivery timetables with customers, yield economies of scale and other efficiencies that put money directly into producers' pockets. The same is true of business development strategies, such as formal contract farming and the use of information services. CIAT is actively investigating various organizational options, notably through its projects on participatory research and agroenterprise development.

An enterprise in Uganda demonstrates how good planning and organization can help bring farmers financial success with a traditional product. In the country's hilly southwest, the Nyabyumba Farmers'

Water buffaloes at Ta Village in Pek District, northern Laos.

Potato production near Kabale in southwestern Uganda.

Group, originally set up in 1998 as a spinoff from a Farmer Field School, now supplies high-quality, pregraded chipping potatoes to a fast-food restaurant in Kampala, part of the Nandos chain.

CIAT trained staff of the NGO Africare in market facilitation methods; Africare in turn helped the farmers plan and set up their business. The group set out strict planting schedules for members to synchronize their production with the client's needs. The group also changed their planting density to obtain the required size of potato for this market. These and other technical innovations were designed with the help of Uganda's National Agricultural Research Organisation (NARO).

With Africare's help the group also sorted out conditions of sale with Nandos. These related to price, terms of payment, potato variety, timing of delivery, volume, and quality. Deliveries of 190 tons per month as of May 2005 have earned the group the equivalent of US$33,000.

Several lessons from this experience stand out. First, while a market orientation does enable smallholder farmers to plug into higher value markets, the process requires long-term support from research and development partners. Second, access to innovations at critical points, such as production, postharvest handling, and marketing, are vital to success. Third, participatory methods allow market chain participants and service providers to better understand each other's needs and challenges. Finally, by consolidating relationships with buyers and opening communication channels with all market chain participants, farmers gain confidence and improve their negotiating power.

The high road to high value: Hurdles and rewards

Diversification into novel high-value crops, or at least ones the farmer has never grown before, may be the boldest strategy for raising farm revenues. But it is also a strategy prone to great uncertainty. While traditional commodity production also carries with it certain risks, like a poor harvest due to a pest outbreak, experienced farmers can anticipate the threat and make plans to cope with it. It is the devil they know. With crops that are new to them, the uncertainty, even about the production risks involved, is high. And on top of these are the risks associated with marketing.

On the supply side, information and knowledge bases may be weak (see box), and relevant technical expertise and business services scarce. Farmers may also lack sufficient investment capital and inputs, and face technical constraints such as inappropriate germplasm. Other obstacles have to do with a "demanding" demand side—buyers who impose increasingly stringent quality, safety, and traceability requirements, especially in industrial countries. As CIAT's director of research, Douglas Pachico, notes, "We're seeing that market entry issues are often more important than production problems."

Agroenterprise service providers may need to alter objectives and retool. With a history of largely unsuccessful supply-driven agricultural development haunting them, their learning curve can be as steep as the farmers'. A pitfall any new support strategies must avoid is loss of service to the poorest. Since high-value crops generally require more technology, knowledge, organization, communication, and cash investment than standard food staples, there is a risk that those who lack such resources will be left on the sidelines. Furthermore, R&D organizations must not become too enamored of their favorite product list, since today's high-value crop may be tomorrow's loss maker.

So the road to high-value cropping is strewn with many obstacles. But the rewards are enticing.

Delivering a load of agave fiber in Cauca Department, Colombia.

Cyberspace and the rural marketplace

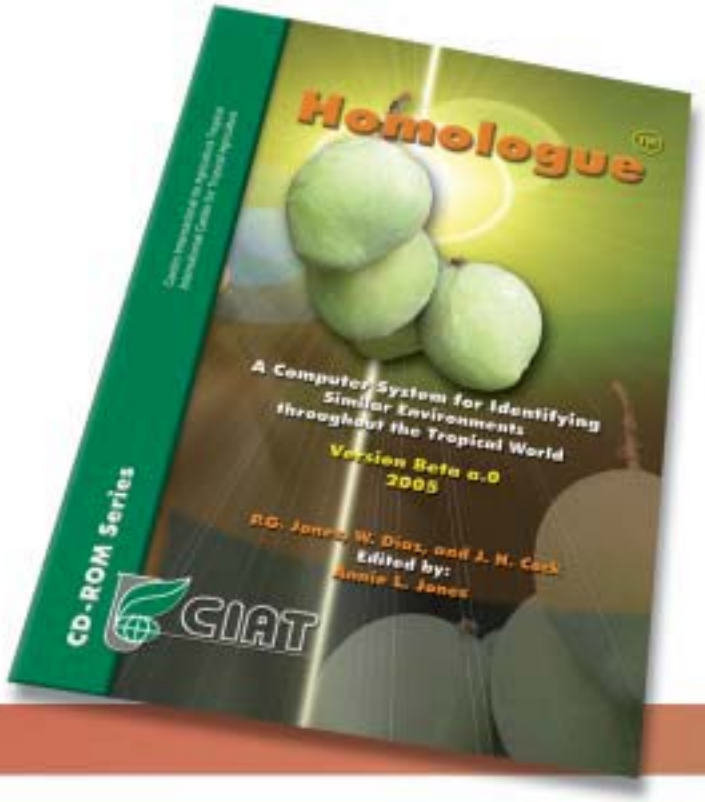
Development partners, farmer groups, and other actors in chains for high-value products are keenly aware of the need for stronger links with multiple sources of market-related information. Exciting opportunities to strengthen information services are being created by the gradual spread of Internet access and other new information and communications technologies (ICTs) in developing countries.

In order for rural communities and organizations to reap the potential benefits of ICT use, further interventions are required beyond the initial investment in connectivity and training. One of these involves the creation of local content that responds to rural people's needs. During recent years CIAT has gained valuable experience in determining how to promote the generation of market-related content at the regional, national, and local levels.

A notable example is CIAT's relationship with the African software developer Busylab, with whom we have developed market information systems for Africa (www.tradenet.biz) and Central America (www.agroemprendedor.org).

Through complementary research in Colombia and Bolivia, the Center has also developed an approach for creating local information systems for rural agroenterprise development, or SIDERs

(their acronym in Spanish). These systems are constructed in a participatory manner with community-based stakeholder groups, representing farmer associations, other chain actors, and local organizations. Trained to act as "information and communications promoters," the groups develop and disseminate market-related content, using Web sites (see, for example, www.caucasider.org) and diverse conventional media, such as radio, printed bulletins, and local drama.



What to grow? Ask Homologue

The first question asked by farmers wanting to diversify into higher value crops is, "What can we grow profitably in our fields?" Choosing an appropriate high-value product is critical, but the decision may not come easily, especially if the producer has been growing the same mix of crops for many years and has little marketing experience. The first step is to find out which new high-value crops will thrive in the farmer's agroecological zone. In highland areas, where soil and climate conditions vary widely over short distances, what's suitable for one farmer may be inappropriate for another.

CIAT has designed a computer tool called Homologue that can provide part of the answer. Homologue is a Windows application that uses climate and soil information about one or more locations to

identify other places with similar characteristics. An agroenterprise service provider could use Homologue to answer these questions: "Where on earth are there farms like ours? What high-value crops are being grown there that we too could try out?" Similarly, researchers or development agencies looking to put improved crop varieties into farmers' hands can use Homologue as a targeting tool.

The result of collaboration between CIAT's tropical fruits and land use projects, Homologue is a self-contained, user-friendly mapping system. The user simply points the cursor to a target site on the screen to generate a display of homologous locations elsewhere on the continental or world map. Future releases will have high enough resolution to allow a specific farm field to be selected as the input point.

CIAT is also helping to reinforce the global knowledge base on high-value crops through various information services, including the recently launched New World Fruits Database. This is a joint effort with the International Plant Genetic Resources Institute (IPGRI). The database, which allows for Web-enabled searches, holds information on more than 1,200 fruit species from the Americas. In addition to pictures, this resource covers taxonomy, common names, uses of the species, and geographic distribution. It also provides bibliographic references for further research and links to information on the availability of germplasm. Work was under way in 2005 to allow the database to be used in tandem with Homologue and other geographic information systems (GIS) tools.

Learning alliances for agroenterprise development

While good crop information tools are essential to high-value production, farmers need direct assistance with many other aspects of agroenterprise development as well, especially organizational and economic aspects. Through "learning alliances" with Catholic Relief Services (CRS), CARE International, SNV Netherlands Development Organisation, and other major international development agencies, CIAT and its partners are developing and testing a comprehensive participatory approach to helping farmers design, set up, and manage small agroenterprises.

Sale of specialty coffee at Marcala, La Paz Department, in northwestern Honduras.

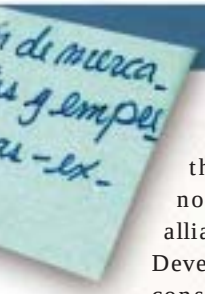
As the approach is refined through action research conducted across different locations and products, it is being widely implemented through development projects. In Central America, for example, CIAT's international partners work with more than 30 local organizations in four countries, who, in turn, support enterprise development for more than 125,000 rural families. The learning alliance thus provides a strong leverage point for achieving impact on a large scale.

The alliances have already allowed CIAT to help thousands of rural entrepreneurs in Latin America, Africa, and Southeast Asia. Shaun Ferris, manager of CIAT's agroenterprise development project, comments that the alliances are "an incredibly useful way to build capacity around the relatively complicated task of enterprise development."

In addition to building the capacity of local business service providers, the learning alliances provide a platform for demand-driven action research carried out by CIAT and its partners. Through such research we can help development practitioners, the private sector, and policy makers design or adapt new approaches and tools that support enterprise development. Moreover, this work enables CIAT scientists to draw on a wealth of field cases for strategic research resulting in international public goods that help create new options for small farmers in high-value agriculture.

In Southeast Asia, with support from the Swiss Agency for Development and Cooperation (SDC), CIAT and local partners are helping farmer groups in six districts of Vietnam to diversify into higher value products using its four-step agroenterprise development process. A major success to date has been a significant increase in peanut production. This was achieved through a technique known as market chain analysis, which brings all players in the chain together in a participatory approach to problem solving.

Farmer Jong Bor of Pha Kom Village in Xieng Khouang Province, Laos, has expanded his peanut production and improved his marketing of the product.



Mark Lundy is an agroenterprise specialist and the main architect of CIAT's learning alliances. He notes that in Central America, where the learning alliance is supported by Canada's International Development Research Centre (IDRC), there is strong consumer interest in high-value products, including organically grown produce.

Many poor farmers in Central America live in environmentally sensitive highland areas, where they try to make a living from tiny holdings, often just a hectare or two. Together, the farmers and service organizations with which CIAT has worked decided that, with so little land available, intensive vegetable production would be a good bet. But the big urban supermarket buyers are very demanding about quality and also about the use of ecologically sound production practices. So the farmers, says Lundy, have to consider many factors as they switch into or enhance vegetable production. Besides economic feasibility, they have to decide on the types of inputs they will use and how they are going to manage their natural resources sustainably.

There's also the issue of product volume. Fortunately, scaling up to provide a sufficient quantity of quality products creates postproduction jobs—sorting, grading, washing, and packing—which tend to benefit women. "It's a simple kind of value adding, but it's occurring at or near the farm level," says Lundy. He cites the example of a project in El Salvador, where farmers produce high-quality vegetables for a city supermarket with backing from CRS. "This project has generated livelihoods, not just for smallholders, but also for family members who help prepare the vegetables for delivery."

The high-value horn of plenty

That and the other experiences and achievements described in this report reflect a conviction that CIAT shares with growing numbers of scientists, development practitioners, and rural people: The journey toward sustainable livelihoods depends, not just on the staple foods that sustain life, but also on a cornucopia (the "horn of plenty" from Greek mythology) of higher value products that could improve life's quality.

Based on its work and accomplishments so far, what has CIAT learned about tapping the potential of such products for reducing rural poverty? One clear lesson is that, while building on our traditional strengths in crop improvement, we must learn to exercise those strengths differently.

In research on cassava and tropical forages, for example, this means developing new traits or promoting uses of crops that better enable farmers to seize emerging market opportunities. Another challenge is to derive generic tools and approaches (sometimes from work that originally centered on staple foods), which our development partners can adapt and apply to a wide range of tropical products. For example, the robust participatory methods devised by CIAT's agroenterprise project build on our experience in developing new markets for cassava.

To guarantee that such methods are widely implemented and can achieve large-scale impact, we must also create more effective models of collaboration, such as CLAYUCA and the learning alliances described above, which involve traditional and nontraditional partners. Precisely because the high-value horn of plenty offers so many possibilities, it will take an unprecedented collaborative effort to identify and develop options that can deliver on the promise of high-value products.

Producers and other actors in the chili supply chain in Chuquisaca Department, Bolivia.

The marketplace at Punata, Cochabamba Department, Bolivia.

Research-for-Development Highlights

Stories about progress toward a more competitive and sustainable agriculture

In the sections that follow, we present highlights from the three global research-for-development challenges—Agrobiodiversity, Agroecosystem Management, and Rural Innovation—that guide the work of CIAT's projects. Each of the stories told here represents a step forward on the road to a more competitive agriculture that is economically and socially sustainable.

"Smart" fertilizers and nitrogen-efficient crops

Researchers at CIAT and the Japan International Research Center for Agricultural Sciences (JIRCAS) are moving full steam ahead to exploit a rare biochemical phenomenon from some tropical pasture grasses—biological nitrification inhibition (BNI). Triggered by chemical compounds released from the roots of an African grass widely grown in South America, this natural process, once harnessed, is expected to make nitrogen fertilizer use far more efficient.

Nitrification is a process in which soil bacteria convert ammonium—the nitrogen form in most commercial fertilizers—into nitrite, and then into nitrate, releasing nitrous oxide, a powerful greenhouse gas, in the process. Although nitrate is crucial to the growth of nearly all crops, most of it leaches down to the subsoil and often pollutes surface and groundwater. So, finding a way to slow down nitrification to a rate compatible with good crop growth would both reduce fertilizer requirements and minimize the deleterious impacts of agriculture on the environment.

In 1982, CIAT scientist Rosemary Sylvester-Bradley noticed that soil in which the forage grass *Brachiaria humidicola* was growing had more ammonium and less nitrate than would normally be expected. This observation has led to research collaboration between CIAT and JIRCAS on BNI.

A joint JIRCAS-CIAT project, launched in January 2002, aims to get to the bottom of the BNI phenomenon and put it to practical use. The incentive to combat nitrification is strong. The direct economic cost of nitrogen losses in cereal production alone is estimated at US$16.4 billion per year. Moreover, global agriculture continues to be an important source of the greenhouse gases implicated in global warming, and nitrate pollution of water is a growing threat to the environment and human health.

Recent advances are highly promising. The JIRCAS team has perfected a test that identifies and measures the BNI trait. Joint work by JIRCAS and CIAT in 2004 also proved that *B. humidicola* root exudates are highly effective at inhibiting nitrification in soil and that the effect is long-lasting. JIRCAS researchers G.V. Subbarao and Osamu Ito believe that unravelling the mechanisms of BNI in *B. humidicola* will have important implications for developing "smart" nitrogen fertilizers that do not undergo rapid nitrification in soils.

The work to date suggests several promising strategies to harness BNI, some of which are currently being pursued. During 2004 the CIAT team used the JIRCAS assay to screen 10 samples of *B. humidicola* from the Center's seed bank. "We found three accessions of *B. humidicola* that have significantly greater capacity for BNI than the standard cultivar Tully, and we're now testing these in the field," says Marco Rondón, a biogeochemist with CIAT's Tropical Soil Biology and Fertility (TSBF) Institute.

Apart from conventional breeding to enhance BNI, it should also be possible, over the longer term, to isolate, sequence, and clone BNI genes from *B. humidicola* and introduce them into economically important field crops through genetic transformation. Building "fuel efficiency" right into the very genomes of major crops has enormous potential to cut both production costs and global agriculture's share of greenhouse gas emissions and nitrate pollution of water.

An experiment at CIAT headquarters aimed at better understanding the mechanisms involved in nitrification inhibition.

Integrating folk and formal soil ecology

For Kenya's small farmers, soil fertility management is not just a matter of maintaining a chemical balance in the topsoil but rather brings into play their knowledge of soil ecology. With support from Canada's International Development Research Centre (IDRC), researchers in CIAT's Tropical Soil Biology and Fertility (TSBF) Institute are testing an interactive learning strategy with four communities in western Kenya to promote dialog between farmers' "folk" ecology and formal scientific knowledge.

This approach contrasts with conventional agronomic research methods, which often ignore local knowledge systems. While not a panacea, farmers' knowledge about factors such as soil types, nutrient content, composting, and crop response to organic and inorganic amendments is vital, since it guides their decisions about farming.

Through dialog, experiment design and implementation, evaluation, and knowledge sharing between farmers, researchers, and extensionists, CIAT researchers are creating a more dynamic approach to solve soil fertility problems.

"Our project results dispel the idea that integrated soil fertility management is somehow too complicated a topic for participatory research with farmers," says CIAT anthropologist Joshua Ramisch. "Yes, it's complex, but farmers deal with complexity all the time —with weather, pests, diseases, soils, and multiple crops. You *can* use soil management as an entry point for participatory research on natural resource issues." The challenge now, he says, is to scale up the use of community-based learning strategies so that knowledge sharing can take place among larger numbers of farmers and development partners. This is a key aim of the second 3-year phase of the project, which has continuing support from IDRC.

Strong community interest is driving the push to scale up the process. Since 2001 participating farmer groups have grown from four to twelve. Today, the groups conduct eight collective experiments and over 200 individual ones. And they're applying soil fertility management concepts, not just to maize and beans (the region's main staples), but also to women's high-value vegetable crops and to other staples like millet and cassava.

Documenting the process and its results is crucial. The project team has produced a manual outlining the use of interactive learning techniques. The farmer groups have also been busy documenting their work and creating communications products, such as local language data sheets giving soil experiment results, calendars with photos and descriptions of successful practices, and short dramas, poems, and songs for building community awareness.

Estimating future health gains from biofortified crops

In a study of the potential human health benefits of breeding cassava and beans with higher micronutrient content, CIAT social scientists have come up with a wide range of possible benefit levels for the scenarios they modelled. The analysis behind these "educated guesses," they say, suggests that the size of the benefit per population is highly context-specific, depending especially on postharvest losses of micronutrients (such as iron and vitamin A), on people's eating habits, and on existing levels of micronutrient deficiency.

Under an optimistic scenario for Northeast Brazil, cassava rich in vitamin A could curtail ill health and deaths due to deficiency in that vitamin by 19 percent. Under a pessimistic scenario, the reduction would be only 4 percent. In the case of iron-rich beans, optimistic and pessimistic scenarios were modelled for Nicaragua as well as Northeast Brazil. In Brazil the reduction in health problems would range from 24 to 47 percent and in Nicaragua from 19 to 45 percent.

Members of the Mukhome farmer field school, which seeks to improve soil fertility management in western Kenya's Vihiga District.

Participants in a workshop on bean improvement for nutritional value and drought tolerance, held at CIAT headquarters.

The yardstick used by the researchers is called disability adjusted life years, or DALYs. Commonly used to evaluate health interventions, this system of measurement incorporates both mortality and morbidity (sickness) into a single index of human health-related well-being.

Estimates of two key variables were used to set out the optimistic and pessimistic scenarios. These were the projected postharvest losses of the micronutrients—for example, through processing of cassava into flour—and estimates of future varietal adoption rates among farmers.

Besides that, the scenarios took account of breeders' views as to the potential increases in micronutrients they might be able to achieve under the HarvestPlus Challenge Program of the Consultative Group on International Agricultural Research (CGIAR). In the case of beans, CIAT breeders expect to be able to raise iron content by 80 percent. As for cassava, specially bred varieties will likely end up having around 15 parts per million of beta-carotene, the precursor of vitamin A, versus a near-complete lack of that compound in the cassava varieties currently eaten by most people.

CIAT coordinates the crop breeding component of HarvestPlus, which is a global program. For the breeding work, it has responsibility for micronutrient biofortification of beans and cassava.

Strategies for seed security during African emergencies

Like many of the natural and human-made disasters that afflict Africa over and over, seed aid given in response to crisis has itself become chronic. So much so that several countries have seen the rapid and dramatic rise of "relief seed systems," offering entrepreneurs opportunities to profit from the misfortune of others.

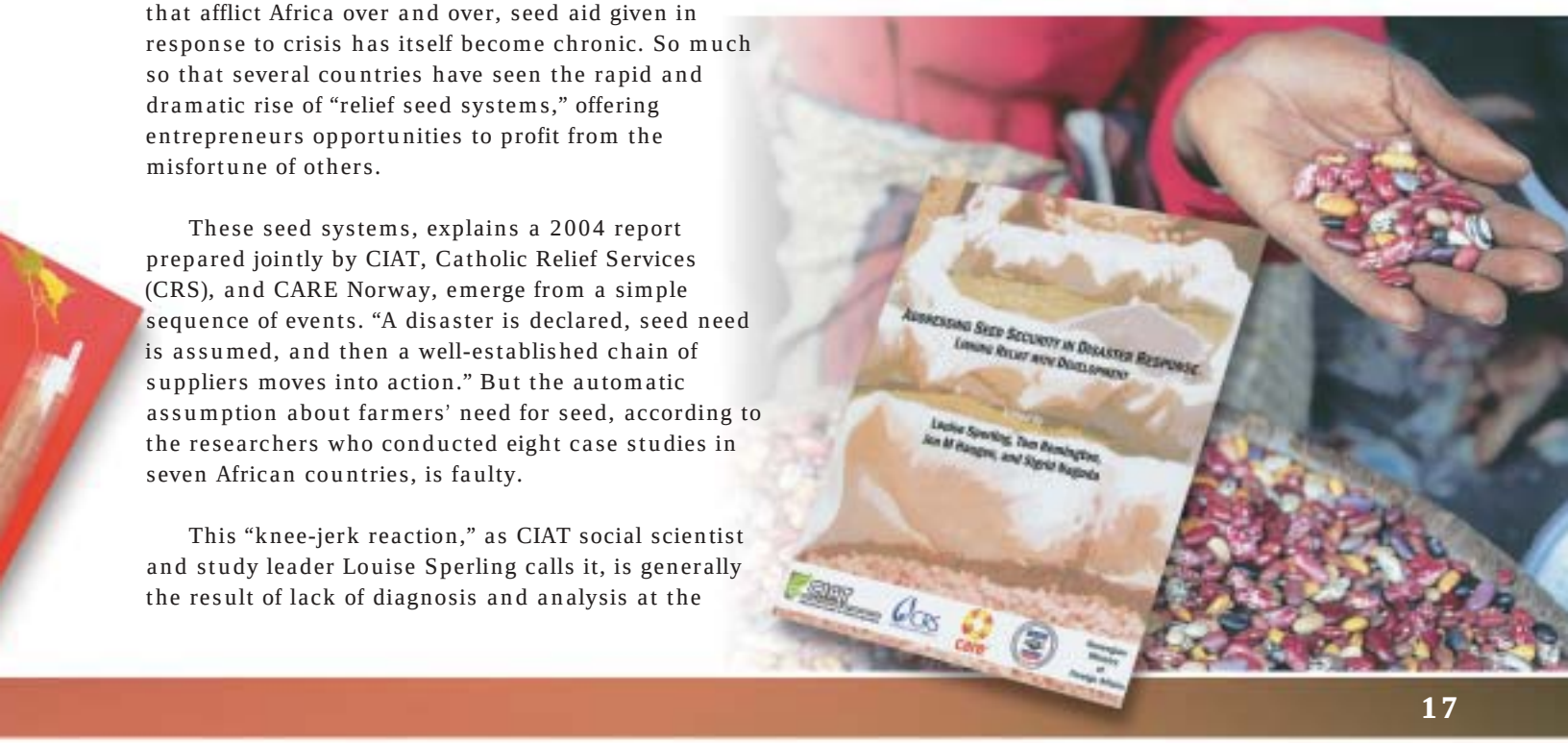
These seed systems, explains a 2004 report prepared jointly by CIAT, Catholic Relief Services (CRS), and CARE Norway, emerge from a simple sequence of events. "A disaster is declared, seed need is assumed, and then a well-established chain of suppliers moves into action." But the automatic assumption about farmers' need for seed, according to the researchers who conducted eight case studies in seven African countries, is faulty.

This "knee-jerk reaction," as CIAT social scientist and study leader Louise Sperling calls it, is generally the result of lack of diagnosis and analysis at the outset of an emergency. The research results show that during events such as drought, floods, and war, farmers actually get most of their seed from local channels. The study confirms the "availability of seed on a large scale" even when outside aid is being offered, suggesting that local seed systems are more resilient than governments and relief agencies have generally thought.

"We now know that sometimes doing nothing is better than doing something," says Sperling. "There are ways of responding that may undermine agricultural systems, and there are ways to stabilize and strengthen them." By adding a learning component to seed aid, she adds, practitioners increase the probability of long-term benefits from current and future interventions.

The case studies were conducted jointly with public and private organizations involved in seed relief work in Burundi, Ethiopia, Kenya, Malawi, Mozambique, Uganda, and Zimbabwe. Funding was provided by the Office of Foreign Disaster Assistance of the US Agency for International Development (USAID) and the Norwegian Ministry of Foreign Affairs.

A series of 12 "practice briefs"—on topics such as seed system security assessment, agrobiodiversity and relief, the introduction of new crop varieties, and a checklist for preparing seed security proposals—has been produced for seed aid practitioners. These will be available in print and on the World Wide Web from CIAT and other organizations by late 2005. A manual for rapidly assessing seed system security in the field during or before an emergency is also near completion.



Fighting food insecurity through agroenterprise development in Haiti

Haiti's chronic vulnerability to political and other types of upheaval is accompanied by the unfortunate distinction of being the poorest country of the Americas. The causal links among grinding poverty, loss of forest cover, the effects of natural disasters (such as deadly flooding in 2004), the shoe-horning of 8.5 million people into the western third of an island that covers only 76,000 square kilometers, an intense dry season that bakes the soil, and lack of economic opportunity are hard to untangle. But together they spell a perennial threat: food insecurity for millions of poor people.

CIAT is working closely with World Vision to tackle this issue by assisting farmer groups in three target areas with the establishment of seed production systems and other agroenterprises. In cooperation with the Ministry of Agriculture, CIAT staff are also building R&D capacity among government institutions and community groups.

A continuing concern about food security is the need for a timely and large enough supply of good-quality seed. "There's always a shortage during the planting season," says Aart van Schoonhoven, former director of CIAT's Agronatura Science Park. "Aid agencies are always worried that farmers will be forced to eat their seed rather than plant it."

In the case of dry beans, a key source of dietary protein, farmers usually buy seed at local food markets and therefore have little idea of the nonobvious traits that the resulting crop will display. Under a 2-year project that began in mid-2004, CIAT is working with local community groups to set up bean seed production systems. The first farmer cooperative was formed in late 2004. Technicians and farmers have been trained to establish and manage local seed production and commercialization.

CIAT and World Vision are also helping community groups set up solar cassava-drying enterprises to supply the animal feed market. Inexpensive and easy to manage, the drying plants provide a model for development in other communities.

To enhance the effectiveness of these efforts, CIAT is introducing participatory extension methods, which help fuse local knowledge with formal science. In the hands of technicians with World Vision and other NGOs, these methods contribute to wider adoption of technical innovations.

Combining disease resistance with consumer tastes in cassava

With funding from the Rockefeller Foundation, CIAT began an ambitious 6-year effort in 2003 to help Tanzania exploit recent genetic improvements to cassava, an important food staple. The idea was to transfer new disease- and pest-resistant cassava genotypes from CIAT in Colombia to Africa and then cross them with local cultivars to produce cassava suited to African conditions. Now, 2 years later, hundreds of plants are growing in the Tanzanian crossing block. The symptoms of cassava mosaic disease (CMD), which appeared shortly after planting and had scientists worried about a possible breakdown of their germplasm's CMD resistance, have vanished. The plants are strong and healthy.

The CMD resistance is particularly important since this disease is found only in Africa and is highly destructive. Moreover, an aggressive strain of the plant virus that causes CMD, spread by whiteflies, has been devastating crops in eastern Africa for more than a decade. In Uganda in the mid-1990s, it even triggered deadly famine in some areas.

About 12 years ago, a new source of CMD resistance was discovered by CIAT's sister center, the International Institute of Tropical Agriculture (IITA).

The harvest from cassava variety trials in Haiti.

Cassava improvement in collaboration with CIAT and IITA's national partners in Tanzania.

Later, CIAT identified molecular markers for the gene responsible for the resistance. The markers allow for accelerated breeding, a big plus given the long growth cycle of cassava. Under the Tanzanian project, national scientists are being trained in marker-assisted selection methods.

The experimental cassava also possesses New World genetic diversity, which African breeders can now exploit for various purposes—to alter plant architecture for easier weeding, boost the protein content, or improve nutrition, for example. Broadening the gene pool will create alternatives for both African breeders and farmers, such as cassava production for industrial starch. "We're giving the farmers not only new materials but new economic opportunities," says CIAT molecular geneticist Martin Fregene.

But breeding cassava for home consumption and to meet consumer food preferences is also important. "The local varieties are very good for giving the right quality of flour," notes Edward Kanju, an IITA cassava breeder working in a Rockefeller Foundation-funded project on resistance to cassava brown streak disease in eastern Africa. "What we will do now is select genotypes that combine both sets of traits."

The final test of success, though, will be acceptance of new varieties by producers. To ensure research relevance, the project calls for strong farmer participation through varietal testing and selection of crosses.

Participatory rice research: An entry point for crop diversification

For many people rice conjures up the image of a big internationally traded commodity, a cash crop produced on large tracts of irrigated land using modern mechanized methods. But in Central America, as in many other parts of the world, this image doesn't fit reality. In Nicaragua, for example, about two-thirds of rice production is cultivated under rainfed conditions, most often by small farmers using traditional techniques.

Participatory selection of upland rice varieties in Nicaragua.

CIAT's rice research project focuses on these small producers and, to a lesser extent, on medium-scale producers in Latin America. While upland rice provides them with some cash and a measure of food security, the international price is so low that earnings are rarely enough to pull rural families out of poverty.

In collaboration with France's Center for International Cooperation in Agricultural Research for Development (CIRAD), CIAT has been working since May 2002 with more than 100 farmers and farmer groups in Nicaragua to improve and select varieties of upland rice. "Nicaragua is a good laboratory and testing ground," says rice breeder Gilles Trouche, who coordinates CIAT and CIRAD's participatory rice research in that country. "It is very representative of Central America, where upland rice is grown under a range of agroecological conditions using diverse cultural practices."

Part of the poverty-alleviation rationale for the participatory research is that improved rice production —made possible by varieties that yield better, mature earlier, or tolerate drought—will give farmers greater flexibility in their use of land and labor. This in turn will allow them to more easily diversify into higher value crops, without losing the food security provided by rice. Participatory research on rice (as well as sorghum) also provides a practical entry point for building farmers' capacity to innovate and organize, says CIAT's rice research project manager Lee Calvert.

Varietal selections were made from a range of available CIAT and CIRAD germplasm by participating farmer-researchers during 2003 and 2004 in four different rice ecosystems. In 2005, six promising rice lines entered the validation phase, in which they will be evaluated in commercial plots by larger groups of farmers—the final step before new varieties are officially released by INTA, Nicaragua's National Institute of Agricultural Technology.

The project has helped, in a modest but real way, to strengthen these farmer groups. "In addition to the new skills they have acquired," says Trouche, "they are also better now at interacting with scientists and presenting experiment results to other farmers."

Prize-winning collaboration to protect plantain

Smallholder farmers in Colombia have been working with international and national scientists and extension agents for the past 3 years to save their stands of plantain from bacterial wilt—"moko" in Spanish. Among the promising weapons in the emerging arsenal is a liquid biocide that does double duty as an organic fertilizer.

Called a lixivium, the liquid is produced inexpensively on-farm by composting plantain residues, specifically the hanging, spine-like shafts called rachises from which the flowers and fruit protrude. This is the part of the plant that farmers routinely discard after harvest.

"We wanted to give the farmers simple, easy-to-use solutions because they don't like complex technology," says Silverio González, director of Colombia's National Federation of Plantain Producers (FEDEPLATANO) and chief designer of the composting system. "Our members prefer to solve problems using their own local resources." The lixivium biocide is much more environmentally friendly than the formaldehyde farmers typically use to disinfect soils.

CIAT's collaborative work with FEDEPLATANO and other organizations over the past 3 years, via a broad alliance called Club del Moko, was one of three winners at Innovation Marketplace 2004. The exhibition-cum-competition is designed to strengthen partnerships between centers of the Consultative Group on International Agricultural Research (CGIAR) and civil society organizations. The winners were announced during the CGIAR's annual general meeting at Mexico City in October 2004.

CIAT plant pathologist Elizabeth Alvarez, who has long experience in farmer participatory research, has worked with FEDEPLATANO on several aspects of moko control. She has also collaborated with the Colombian Corporation for Agricultural Research (CORPOICA), a Club del Moko member, to study the genetic diversity of the bacterium that causes moko, *Ralstonia solanacearum*. Using molecular markers, Alvarez and colleagues identified 68 strains in samples of plant tissues, soil, water, and insects. However, detecting the bacteria not only in the laboratory but also in farmers' fields is essential to make best use of control measures like the lixivium. Development of an on-farm diagnostic kit is therefore a priority in the next research phase.

Indigenous agroforestry: A bright spot in land management

A form of agroforestry practiced by 6,000 hillside farm families in Honduras has proven highly successful at not only protecting land and water resources but also improving rural livelihoods. Known as *Quesungual* agroforestry, this indigenous farming system was enhanced and promoted under a project launched by the Food and Agriculture Organization of the United Nations (FAO) in the early 1990s.

In a recent evaluation of that experience, scientists from CIAT and FAO conclude that the Quesungual system, or elements of it, could be successfully adapted for use in highland areas of Africa, Asia, and South America. Their evaluation was part of the "Bright Spots" Project, carried out by a consortium of nine institutions, including CIAT.

Quesungual is the village in western Honduras from which the agroforestry system takes its name. Under this form of natural resource management and cropping, native trees share space with field crops such as beans, maize, sorghum, millet, and forage grasses, as well as newer high-value crops, mostly fruits and vegetables. The hillside trees are carefully pruned to reduce nutrient competition with food and forage crops and to provide mulch.

Composting of plantain residues to produce a biopesticide.

Honduran and Nicaraguan farmers exchange knowledge and technology for sustainable agroforestry.

The system contrasts strongly with the slash-and-burn shifting agriculture typically practiced in the highlands of Central America. Under the Quesungual system, farmers never burn the hillside vegetation as a way to prepare land. And they use no-till and direct seeding methods for food crop cultivation. That way the land is permanently covered, protecting soil from two extremes to which the region is prone: torrential rains, which cause severe erosion, and drought, which saps soil moisture.

The evaluation report notes that farmers were able to double both bean and maize yields. This allowed them to meet their own household food needs and still have a surplus to sell. Their higher incomes have allowed farmers to invest in higher value crops like vegetables and fruits, and to buy chickens and pigs. The evaluation study authors also comment that enhanced access to credit, along with policies on burning, overgrazing, and water management, were essential to the project's success.

Building an arable layer of soil in the savannas

Brazil, Colombia, Venezuela, and other countries endowed with vast tropical savannas have great expectations for these resources. They see them as a last frontier of arable land, a means of expanding crop production and generating regional economic wealth within their borders. But, as the research experience of CIAT and other scientists has demonstrated, this will be nothing but a pipe dream unless the currently infertile, degraded soils of the savannas can first be built up—almost from scratch.

Savanna soils are often acidic, high in aluminum (which is toxic to plants), and low in organic matter. Without dramatic improvements in the physical, chemical, and biological characteristics of these Oxisols and Ultisols, it won't be possible to introduce sustainable, no-till crop agriculture.

CIAT has worked on the problems of savanna soils for about 30 years, using an area of Colombia's Eastern Plains called the Altillanura as its living laboratory. With Colombian partner organizations, it has designed a two-phase set of soil management practices for building an arable layer.

In the first phase, aimed at improving the soil's physical and chemical properties, the earth is cultivated with a rigid set of curved chisels that reach a depth of 30 centimeters. This tillage system replaces traditional disk harrowing, which penetrates the native savanna only 5 to 8 centimeters. This first phase also includes the application of chemical fertilizers to build up essential nutrients.

Next is the biological phase. Forage grasses and legumes adapted to tropical savanna conditions are planted. Taking advantage of the loosened soil and nutrient bonus, these plants produce abundant root systems that penetrate the full profile of the topsoil. As the soil improves in fertility and structure, it becomes more suitable for direct sowing of commercial crops such as maize, soybean, and rice. In the cropping phase of this soil-building exercise, farmers are advised to follow specific crop and pasture rotations in their newly emerging agropastoral systems, based on improved germplasm.

"We're making productive an area that has been unproductive for so many years," says CIAT soil physicist Edgar Amézquita. He adds that the arable layer system is not only technically feasible but also economically attractive to farmers. In a 2004 study of the potential impact of these technologies, the three agropastoral options evaluated by Amézquita and colleagues all scored high for potential profitability. Expressed as internal rates of return, scores ranged from 20 to 57 percent.

CIAT's principal partners in this work are CORPOICA, the National Program for the Transfer of Agricultural Technology (PRONATTA), the Colombian Institute for the Development of Science and Technology (COLCIENCIAS), and the Colombian Ministry of Agriculture and Rural Development.

Improved tillage for the acid-soil savannas of South America.

An Overview of CIAT

The International Center for Tropical Agriculture (CIAT) is a not-for-profit 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 the 15 centers funded mainly by the 58 countries, private foundations, and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

Our donors

CIAT currently receives funds through the CGIAR or under specific projects from the countries and organizations listed below. We gratefully acknowledge their commitment and contributions. CIAT also receives funds for research and development services provided under contract to a growing number of institutional clients.

Asian Development Bank (ADB)
Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
Australia
- Australian Agency for International Development (AusAID)
- Australian Centre for International Agricultural Research (ACIAR)

Austria
- Austrian Federal Ministry of Finance (BMF)

Belgium
- General Administration for Cooperation in Development (AGCD)

Bill and Melinda Gates Foundation
Brazil
- Brazilian Agricultural Research Enterprise (Embrapa)

Canada
- Canadian International Development Agency (CIDA)
- International Development Research Centre (IDRC)

Colombia
- CHEMONICS Foundation
- Colombian Corporation for Agricultural Research (CORPOICA)
- Colombian Institute for the Development of Science and Technology (COLCIENCIAS)
- Ministry of Agriculture and Rural Development (MADR)

Common Fund for Commodities (CFC)
European Commission (EC)
Food and Agriculture Organization (FAO) of the United Nations
France
- Center for International Cooperation in Agricultural Research for Development (CIRAD)
- Ministry of Foreign Affairs

Germany
- Federal Ministry of Cooperation and Economic Development (BMZ)

International Fund for Agricultural Development (IFAD)
Italy
- Ministry of Foreign Affairs

Japan
- Ministry of Foreign Affairs
- The Nippon Foundation

Latin American and Caribbean Consortium to Support Cassava Research and Development (CLAYUCA)
Latin American Fund for Irrigated Rice (FLAR)
Mexico
- Grupo Papalotla
- Secretariat of Agriculture, Livestock, and Rural Development

Netherlands
- Catholic University of Leuven
- Directorate General for International Cooperation (DGIS)
- Ministry of Foreign Affairs

New Zealand
- New Zealand Agency for International Development (NZAID)

Norway
- Norwegian Agency for Development Cooperation (NORAD)
- Royal Ministry of Foreign Affairs

OPEC Fund for International Development

Peru
National Institute of Agricultural Research (INIA)
Regional Fund for Agricultural Technology (FONTAGRO)
Spain
National Institute for Agricultural Research (INIA)
Sweden
International Programme in the Chemical Sciences (IPICS) of Uppsala University
Stockholm Environment Institute (SEI)
Swedish International Development Cooperation Agency (SIDA)
Switzerland
Swiss Agency for Development and Cooperation (SDC)
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Swiss Federal Institute of Technology Zurich (ETH)
Technical Centre for Agricultural and Rural Cooperation (CTA)
Thailand
Department of Agriculture
United Kingdom
Department for International Development (DFID)
Natural Resources Institute (NRI)
United Nations Environment Programme (UNEP)
United States of America
The Rockefeller Foundation
United States Agency for International Development (USAID)
United States Department of Agriculture (USDA)
W.K. Kellogg Foundation
World Vision
World Bank

Our mission

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

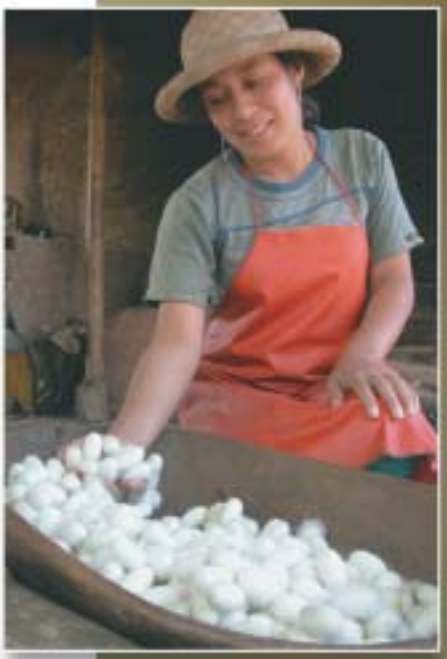
Our project portfolio

In recent years CIAT has organized its diverse project portfolio around three new initiatives, called research-for-development challenges: (1) Enhancing and Sharing the Benefits of Agrobiodiversity, (2) Improving Agroecosystem Health in the Tropics, and (3) Enhancing Rural Innovation. Responding to development issues of global significance, these three initiatives serve as the cardinal points that give strategic direction to our research.

Agrobiodiversity
Conserving and Using Tropical Genetic Resources
Bean Improvement for the Tropics
Cassava Improvement for the Developing World
Rice Improvement for Latin America and the Caribbean
Tropical Grasses and Legumes
Tropical Fruits

Agroecosystem Management
Crop and Agroecosystem Health Management
Tropical Soil Biology and Fertility (TSBF) Institute
Communities and Watersheds
Geographical Information and Land Use

Rural Innovation
Rural Agroenterprise Development
Participatory Research Approaches
Information and Communications for Rural Communities



Financial highlights

CIAT's financial position and statement of activity for 2002, 2003, and 2004 are provided in the accompanying tables. An especially noteworthy trend in our finances is the continuing sharp reduction in unrestricted core funding. The Center has compensated somewhat for this decline through highly successful efforts in fund raising for special projects. Nonetheless, the decline in core funds has reached the point at which it is beginning to compromise our agenda of long-term strategic research.

CIAT's Financial Position (thousand US$)

	2004	2003	2002
Assets			
Current assets			
Cash and cash equivalents	11,197	12,749	5,267
Accounts receivable			
Donors	6,011	7,988	7,063
Employees	259	350	234
Others	3,104	2,016	1,754
Inventories	334	227	326
Prepaid expenses	173	196	210
Total current assets	**21,078**	**23,526**	**14,854**
Noncurrent assets			
Property and equipment	10,093	9,701	10,015
Other assets	11	18	38
Total noncurrent assets	**10,104**	**9,719**	**10,053**
Total assets	**31,182**	**33,245**	**24,907**
Liabilities and net assets			
Current liabilities			
Accounts payable			
Donors	7,179	8,374	5,706
Employees	595	495	375
Others	4,643	2,366	2,523
Accruals and provisions	163	126	119
Support to partners, Challenge			
Programs	852	2,932	-
Funds in trust	267	2,739	302
Total current liabilities	**13,699**	**17,032**	**9,025**
Noncurrent liabilities			
Accruals and provisions	860	698	3,072
Others	536	-	-
Total noncurrent liabilities	**1,396**	**698**	**3,072**
Total liabilities	**15,095**	**17,730**	**12,097**
Net assets			
Undesignated	5,041	4,368	2,079
Designated	11,046	11,147	10,731
Total net assets	**16,087**	**15,515**	**12,810**
Total liabilities and net assets	**31,182**	**33,245**	**24,907**

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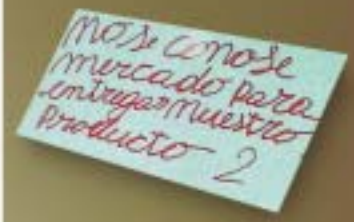
CIAT's Statement of Activity (thousand US$)

	Unrestricted	Restricted Temporary	Restricted Challenge Programs	Total 2004	Total 2003	Total 2002
Revenue						
Grants	11,832	22,670	1,506	36,008	31,723	30,670
Other revenues and support, net	968	-	-	968	968	1,324
Total revenues	**12,800**	**22,670**	**1,506**	**36,976**	**32,691**	**31,994**
Expenses and losses						
Program-related expenses	7,958	22,261	1,469	31,688	28,205	27,770
Management and general expenses	5,974	409	37	6,420	5,613	5,831
Other expenses	358	-	-	358	599	622
Subtotal expenses and losses	**14,290**	**22,670**	**1,506**	**38,466**	**34,417**	**34,223**
Indirect cost recovery	(2,025)	-	-	(2,025)	(1,794)	(1,623)
Total expenses and losses, net	**12,265**	**22,670**	**1,506**	**36,441**	**32,623**	**32,600**
Net surplus (deficit)	**535**	-	-	**535**	**68**	**(606)**
Transfer from accruals and provisions	37	-	-	37	2,637	-
Net assets at beginning of the year	15,515	-	-	15,515	12,810	13,416
Net assets at end of year	**16,087**	-	-	**16,087**	**15,515**	**12,810**
Operating expenses by natural classification						
Personnel costs	9,682	8,358	544	18,584	17,422	17,164
Supplies and services	725	7,387	728	8,840	8,543	9,046
Collaborators-partnership costs	-	4,144	104	4,248	2,730	3,012
Operational travel	826	2,372	93	3,291	2,781	2,312
Depreciation of fixed assets	1,032	409	37	1,478	1,147	1,066
Total operating expenses, net	**12,265**	**22,670**	**1,506**	**36,441**	**32,623**	**32,600**



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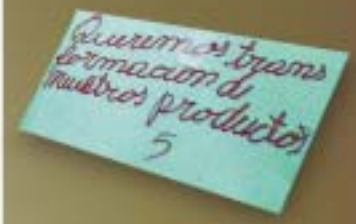

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Erika Mosquera: 12
Nathan Russell: 9 (left and right), 16 (left), 17
Gilles Trouche: 19

Colombian farmer Hermes Vitelio Menza.

Multiplying the Benefits of Tropical Fruits

According to Vitelio Menza, his 2-hectare farm in southwestern Colombia provides him and his family with everything they need. Obviously proud of his coffee, avocado, plantain, and other crops, Vitelio is especially grateful to the semiannual fruit lulo. “It always helps me out,” he says. He can harvest and sell lulo more quickly than coffee, and there’s scope for expansion, since fruit juice processors in Colombia are clamoring for the fruit.

One of the reasons Vitelio and his neighbors haven’t responded more strongly to market signals is the lack of high-quality planting materials. When they sow seed from superior plants, only some offspring express the desirable traits of the parent.

In search of an alternative, 20 Colombian lulo growers are working with CIAT scientists to develop a tissue culture procedure for rapid in vitro multiplication of elite clones selected by farmers. Vitelio hopes that, with support from a local NGO, they will be able to create a steady supply of diverse but genetically stable clones that are a hit in the marketplace.

Solutions That Cross Frontiers

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