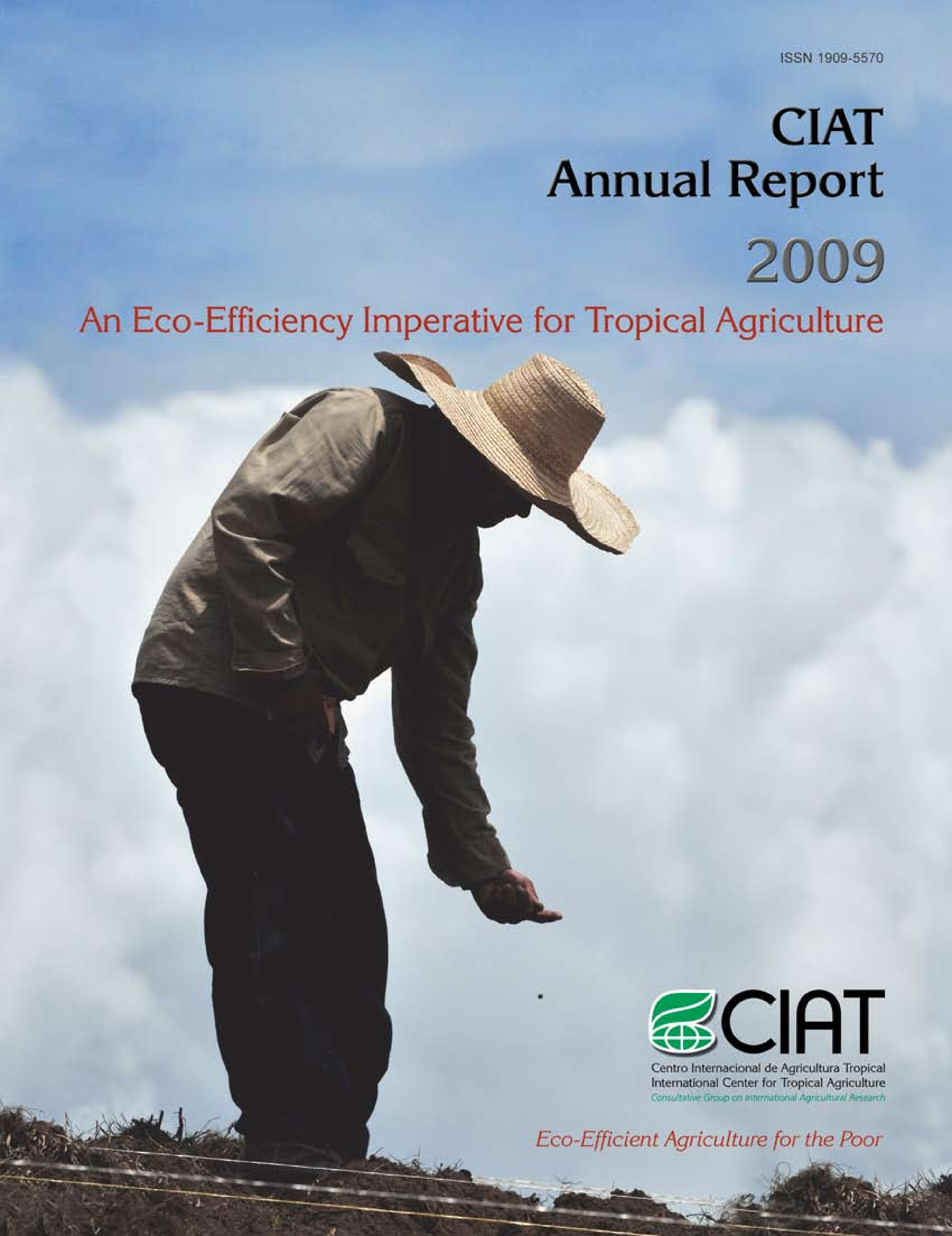

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CIAT Annual Report 2009

An Eco-Efficiency Imperative for Tropical Agriculture

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture
Consultative Group on International Agricultural Research

Eco-Efficient Agriculture for the Poor

Contents

Eco-Efficient

Message from the Board Chair and

CIAT will apply the concept of eco-efficiency through networking with key partners in Latin America and the Caribbean (LAC) and other regions of the developing world.

CIAT began to implement new strategic directions during 2009, taking into account major reforms in the CGIAR, or Consultative Group on International Agricultural Research, and focusing on global challenges, particularly climate change, food security, and poverty.

Our scientists, working with partners, will help confront these challenges by applying in practical ways the concept of eco-efficient agriculture. This is an agriculture that (1) uses resources more effectively to achieve sustainable increases in productivity, (2) reduces the degradation of natural resources, and (3) creates opportunities for boosting incomes and employment in rural areas.

Revitalizing Our Alliances

CIAT is reengaging with key partners in Latin America and the Caribbean (LAC) and other regions of the developing world. We began in 2009 a process of repositioning the Center simultaneously in Colombia (our host country), in LAC as well as in Sub-Saharan Africa and Asia. The process has already given rise to new research agendas, based on shared interests and compatible knowledge, experience, and capacities.

In Colombia, CIAT has found that it shares with organizations such as the Colombian Institute for the Development of Science and Technology (COLCIENCIAS), the National Planning Department, and the National University a strong interest in promoting investments in agricultural science and opportunities for training, thus making better use of the Center's capacities.

CIAT continues to work with the Colombian Corporation of Agricultural Research (CORPOICA) and the Ministry of Agriculture and Rural Development (MADR) while promoting new research development partnerships with the local private and public sectors through the Agronatura Science Park and FUNDACIAT.

Within the LAC region, we have revitalized our alliances with strategic partners such as the Tropical Agricultural Research and Higher Education Center (CATIE), the Brazilian Agricultural Research Corporation (Embrapa), the Regional Fund for Agricultural Technology (FONTAGRO), the Forum for the Americas on Agricultural Research and Technology Development (FORAGRO), and the Inter-American Institute for Cooperation on Agriculture (IICA) on themes of common interest, such as crop improvement, training, and knowledge management.

At the global level, CIAT has strengthened its collaboration with France's Center for International Cooperation in Agricultural Research for Development (CIRAD) and with other organizations that share our commitment to research on climate change, the creation of biotechnology and training platforms, and rice improvement.

Agriculture

the Director General

In addition, the Center has agreed on a new agenda of collaborative work with the Chinese Academy of Agricultural Sciences (CAAS) and the Chinese Academy of Tropical Agricultural Science (CATAS), both of which are deeply interested in developing research projects with us, both within China and in Southeast Asia to facilitate the exchange of bean, cassava, forage, and rice germplasm.

Those and other partnerships, which CIAT hopes to construct in the future, will constitute the key mechanism by which we make research results more accessible and useful.

Rich Gains from Research

CIAT's research programs are organized around key pillars, that is, genetic improvement of food crops, tropical soils, agronomy, climate change, and policy analysis. All of our programs registered significant achievements and impacts in 2009, demonstrating what the principle of eco-efficient agriculture means in practice.

Research on tropical forages, for example, yielded new insights into the ability of a tropical grass species to inhibit nitrification in the soil, greatly reducing nitrous oxide emissions and water pollution while enhancing the efficiency of crop production. Meanwhile, the Decision and Policy Analysis (DAPA) Program, through the use of simulation models, began working with Colombia and other countries to identify the adjustments needed so that their agriculture and livestock sector can cope successfully with the effects of climatic change. And the Soil Fertility Program joined forces with the Alliance for a Green Revolution in Africa (AGRA) to develop an information service on African soils, consisting of a spatial database on soil properties across the continent.

Highlights of CIAT's research in Africa included renewed support from the Canadian International Development Agency (CIDA) and the Swiss Agency for Development and Cooperation (SDC) for the Pan-Africa Bean Research Alliance (PABRA), which started another 5-year phase in 2009. In Southeast Asia, our scientists documented the remarkable transformation of subsistence agriculture into profitable and sustainable production, as small farmers adopt tropical forages and build strong market links.

To speed the process by which CIAT's research results reach farmer organizations, research organizations, and others, we have begun to implement an institutional policy called "Open Access," which aims to widen the exchange of knowledge generated by our researchers with partners around the world.

Working in the New CGIAR

Among the most recent outcomes of the CGIAR reform process is the progress made in the creation of the Consortium of centers and a CGIAR Fund.

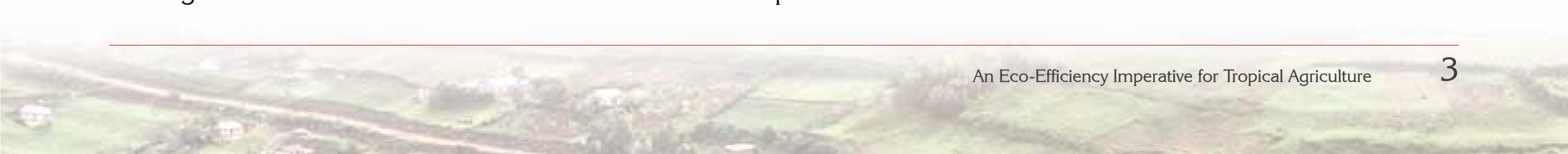
A new strategy and set of new megaprograms will offer CIAT multiple ways to take part in research on crop improvement, soil fertility management, climate change, and other topics.

As part of a reformed CGIAR, the Center will have valuable opportunities to combine its efforts with those of other CGIAR centers and key research partners. Only by working more closely together, can we contribute effectively to meeting the major challenges that humanity faces in the 21st century. CIAT hopes that the new CGIAR will reach funding levels of about US$1.5 billion which would be approximately 7.5% of the total current global public research funding estimated at US$20 billion. A larger and more strategic CGIAR budget will have a stronger leverage effect on the global research agenda.

In 2009, CIAT laid strong organizational, scientific, and financial foundations on which to pursue new research directions over the next decade. The Center is thus well prepared to carry out its mission of reducing hunger and poverty and improving human health in the tropics through research aimed at making agriculture eco-efficient.

Juan Lucas Restrepo
Board Chair

Ruben G. Echeverría
Director General



An Eco-Efficiency Imperative for Tropical Agriculture

In charting strategic directions for its research over the coming decade, CIAT set a new course toward a more eco-efficient agriculture—one that offers multiple benefits to the world's poor. Eco-efficiency has been part of the international discourse on sustainable agriculture for nearly 2 decades.

But in recent years, it has taken on greater significance and urgency, as multiple crises have converged to pose unprecedented challenges for tropical agriculture. Across the developing world, climate change, the reemergence of food price volatility, unabated degradation of natural resources, and other threats have aggravated hunger and poverty, while also threatening the ecosystems from which rural people derive a livelihood.

In response, CIAT believes that one imperative for tropical agriculture, on which most of the rural poor depend, is to undergo a genuine revolution in eco-efficiency.

From Industry to Agriculture

The term "eco-efficiency" was first used by the World Business Council for Sustainable Development in its 1992 publication, *Changing Course*. It was defined as creating more goods and services, while using fewer resources and permitting less waste and pollution. The 1992 Earth Summit endorsed the concept, calling for industries to implement Agenda 21—the Summit's program of sustainable development—in the private sector.

A few years later, agricultural experts from the public sector, particularly in North America and Europe, took up the cause of eco-efficiency as well. Some scientists began exploring its relevance to agriculture in the developing world, viewing this as a necessary feature of sustainable farming systems worldwide. They believed that, at the farm level, eco-efficiency could best be achieved through appropriate crop rotations, better integration of crops with livestock, and other practices that permit more efficient use of resources, especially plant nutrients and energy.

Toward an Eco-Efficient Agriculture

To grasp the value of eco-efficiency as a guiding principle for research, it is helpful to examine this notion against the background of more than half a century of only partially successful efforts to transform tropical agriculture.

The story begins with the Green Revolution, which originated in Mexico during the 1960s and quickly spread to other developing countries. Widespread adoption of high-yielding wheat and rice varieties, together with fertilizer use, brought about large increases in crop yields, mainly under irrigation. The resulting production gains drove the specter of famine from Asia and offered environmental benefits as well by lessening agricultural pressure on tropical forests and other vulnerable ecosystems.

In terms of eco-efficiency, the Green Revolution gave mixed results. More intensive production permitted far more efficient use of land, water, and solar radiation. But it also damaged natural resources, accelerating soil degradation, prompting the misuse of herbicides and pesticides, and leading to the release of pollutants into the atmosphere in the form of the greenhouse gases nitrous oxide and methane and into water supplies in the form of nitrate and phosphate.

Growing concern about the environmental hazards of agricultural modernization in the developing world prompted new rounds of research from the early 1990s, aimed at achieving "sustainable agriculture". The idea was to spark a "doubly Green Revolution", as distinguished British scientist Gordon Conway put it, leading to a better balance between agricultural productivity and environmental conservation.

CIAT and other centers of the Consultative Group on International Agricultural Research (CGIAR) took bold steps to foster sustainable agriculture, including the creation of new centers and programs. But just as these were getting under way, support for agricultural research went into a steep decline, eventually stalling the doubly Green Revolution.

The food price crisis of 2008 served as a rude "wake-up call", creating tremendous hardship for poor consumers across the developing world. While the crisis had multiple causes, certainly a major factor was more than 15 years of relative neglect of agricultural research for development. The silver lining was that the crisis seemed to shake governments and development agencies out of their complacency. That, together with rising awareness about climate change impacts on developing-country farmers, resulted in the restoration of agriculture to its rightful place on the international development agenda.

A Guiding Principle for Research

Global recommitment to agriculture offers researchers an opportunity to renew the long-delayed march toward sustainable agriculture. But CIAT believes they need a new approach that is tailored to new challenges. If developing countries are to succeed in meeting the food needs of a rapidly growing population, while also adapting to climate change and contributing to its mitigation, then tropical agriculture must undergo a more thorough transformation than any before—one that better harmonizes economic, social, and environmental aims.

The goal, CIAT believes, must be an eco-efficient agriculture that is:

- More productive, providing inexpensive and nutritious food for poor consumers.
- More profitable and competitive, creating new opportunities for the poor to increase their incomes.
- More sustainable, causing less harm to the environment.
- More resilient, adapting to the harsher growing conditions caused by continued land degradation and climate change.
- More equitable, providing new opportunities for rural women and other marginalized groups.

"Eco-Efficiency" may not be as strong a rallying cry as "Green Revolution", but it is exactly what tropical agriculture needs to cope successfully with the daunting challenges of the 21st century.

Putting the Eco-Efficiency Principle into Practice

The sections that follow are organized according to CIAT's three research areas—two of which are thematic (agrobiodiversity and tropical soils) and the other ecoregional, dealing with Latin America and the Caribbean. The highlights presented offer an overview of recent research results, which demonstrate how Center scientists are putting the principle of eco-efficiency into practice.

Agrobiodiversity: Solutions in the Seeds

Crop improvement at CIAT offers abundant evidence that plant genetic resources are essential for achieving eco-efficiency in agriculture.

Just as improved varieties figured importantly in past efforts to transform tropical agriculture, so they must in CIAT's new strategy for achieving eco-efficiency. But new generations of improved germplasm will consist, not just of a few widely adapted materials, but of many genetically diverse varieties possessing specialized traits that are required both to meet environmental threats and seize economic opportunities.

Science Triumphs in a Much-Contested Biopiracy Case

Crop improvement at CIAT offers abundant evidence, as the following sections illustrate, that plant genetic resources are essential for achieving eco-efficiency in agriculture. The year 2009 saw definitive proof that the technical knowledge of CIAT's Genetic Resources Program is a powerful tool for ensuring that those resources are distributed and used fairly, in keeping with hard-won international agreements. During 2010—which the United Nations has designated the International Year of Biodiversity—Center researchers will join many others in bringing attention to the value of agricultural biodiversity.

Ten years ago, CIAT asked the U.S. Patent and Trademark Office (USPTO) to reexamine a patent on beans with a yellow seed coat, which the patent holder had named 'Enola'. In 2008, the USPTO's Board of Patent Appeals and Interferences declared the patent to be invalid, in support of two

previous rulings. The U.S. Court of Appeals for the Federal Circuit in Washington, D.C., confirmed the Board's decision this year.

The positive outcome of the case was due in large part to scientific evidence compiled by CIAT. This showed that numerous germplasm samples conserved in its genebank possess the distinctive sulfur-yellow color of the Enola bean, casting serious doubt on the novelty of this trait. The initial evidence was later reinforced by the results of molecular genetic studies conducted at CIAT and elsewhere, showing that Enola is essentially identical with other yellow beans. Such beans have been grown and consumed in Mexico and other parts of Latin America for centuries.

During the 1970s, Mexican bean breeders developed and released several yellow-seeded varieties, relying in particular on a landrace from Peru. In a clear case of biopiracy, the Enola bean patent holder derived this product from seeds of a Mexican variety, most likely one named 'Azufrado Peruano 87'. CIAT holds samples of that and many thousands of other bean varieties in trust for humanity under the International Treaty on Plant Genetic Resources for Food and Agriculture. Commonly referred to as the "Seed Treaty", it replaces several previous agreements with the Food and Agriculture Organization (FAO) of the United Nations.

Since the Enola bean was not obtained from the CIAT genebank, the Center was not strictly obliged to send science to the rescue. It did so to make a point: Only by demanding respect for the terms of the Seed Treaty, can CIAT and other curators of valuable agrobiodiversity guarantee that the solutions in the seeds remain freely available to all who need them.

Common Beans that Defy Conventional Wisdom

CIAT researchers have made a surprising discovery recently that stems from their success in developing drought-tolerant varieties of common bean (*Phaseolus vulgaris*). Contradicting conventional wisdom, they have shown that the new varieties are highly efficient in mobilizing the resources needed to produce grain under different types of stress, as well as under favorable growing conditions.

This finding offers new hope for the great majority of small-scale bean growers who often face scarcity of key inputs, especially water and nutrients. An estimated 60% of their production worldwide is highly vulnerable to drought. It is also limited by low soil phosphorus and low nitrogen. Toxic levels of aluminum in widespread acid soils aggravate the effects of drought and infertile soils on beans by limiting root growth.

The prospects for improved input supplies are not good. Climate change is making drought more frequent and severe. And chemical fertilizers have become more expensive as a result of higher prices for petroleum, from which fertilizers are derived. Diminishing reserves of phosphorus will eventually make matters even worse.

While improving beans for multiple stresses over the last decade, the CIAT Bean Program has put special emphasis on tolerance to drought. Many years of persistent effort are finally paying off, with impressive gains in small-seeded Mesoamerican beans and good progress with the large-seeded Andean types as well. An important recent milestone in this work was the release of drought-tolerant varieties in Nicaragua and Rwanda, with more to come in other countries.

Building on that progress, CIAT researchers have now incorporated into drought-tolerant lines of common bean the aluminum toxicity tolerance possessed by a related species, runner bean (*P. coccineus*). Several improved bean lines resulting from crosses between the two species show tolerance to both stresses, as well as excellent yield potential. At the same time, researchers are developing bean lines whose roots can recover phosphorus from fertilizer more efficiently and also function well in soils with inherently low levels of this nutrient. In 2009, they identified lines that are drought tolerant, disease resistant, and also perform well under low phosphorus.

Conventional wisdom suggests that such traits are antithetical. For example, while deeper roots favor drought tolerance, better performance under poor soil fertility implies the opposite: shallow, abundant roots. Similarly, higher yields under good growing conditions and improved performance under physical stress are often thought to be mutually exclusive.

But that is not what CIAT researchers observed when they compared new drought-tolerant lines with commercial cultivars. On the contrary, while performing significantly better under drought, according to a 2008 article in the journal *Crop Science*, the tolerant lines also yielded up to 25% more in favorable environments. Some also gave superior yields under low phosphorus, beating the competition by up to 41%.

The researchers explain this paradox by pointing out that seed production in common bean is inhibited by its profuse vegetative growth, which is a survival mechanism inherited by the domesticated crop from its wild ancestors. Apparently, selection for drought tolerance reveals genes that suppress this survival response. The result is a bean variety that is generally more efficient and higher yielding under both good growing conditions and bad.

Innovative Partnerships for Impact in Africa

In order for more efficient varieties of beans and other crops to have development impact requires an efficient approach for ensuring that they are widely available to farmers. During 2009, several developments in eastern and southern Africa demonstrated the efficacy of an approach developed by CIAT and its partners for reaching small farmers—especially women, who are Africa's main bean producers—in areas where drought and other stresses are frequent and severe.

The approach begins with timely release of new bean varieties by national organizations, a process that is greatly facilitated by the CIAT-supported Pan-Africa Bean Research Alliance (PABRA). Thanks to its collective approach, even countries where warfare has disrupted agricultural research can still release new varieties. In 2009 alone, five countries (Burundi, Democratic Republic of Congo, Kenya, Malawi, and Zambia) released 31 new varieties that are high yielding, disease and pest resistant, and tolerant to stresses like low soil fertility.

Partnerships are also key for getting high-quality seed of released varieties into the hands of large numbers of small farmers. In recent years, for example, a novel partnership involving the Kenya Agricultural Seed Unit, a private company, and a not-for-profit organization have tested an innovative marketing strategy, in which small seed packs of 100 grams or less are sold in markets, country stores, and other places where farmers buy food and other basics.

In 2009 alone, about 35,000 farmers bought the small seed packs, and the Kenyan partners have extended the approach to other crops, like maize, soybean, and pigeonpea. Similarly, this year in Malawi, a private company sold 416 tons of bean seed in small packs through 90 small shops across the country, reaching 400,000 farmers. By means of PABRA, the approach is spreading to other countries as well.

Harnessing a Physiological Phenomenon in Tropical Grass

One category of crops that shows great promise for making agriculture more eco-efficient consists of diverse tropical forages, which are a prominent feature of agricultural landscapes worldwide. In 2009, scientists at CIAT and in two Japanese partner institutions reported a major breakthrough in forage research, involving the tropical grass *Brachiaria humidicola*. Their discovery could generate large economic and environment benefits, resulting from radically improved management of soil nitrogen.

An article appearing this year in the *Proceedings of the National Academy of Sciences* describes how the researchers discovered and characterized a chemical compound (they named it "brachialactone"), which occurs in fluid released from the grass's roots and controls a phenomenon referred to as "biological nitrification inhibition" (BNI).

Nitrification is a process in nitrogen cycling, by which microbial activity converts one form of nitrogen, ammonium into another more mobile form, nitrate. One consequence is nitrate pollution of ground and surface water, which damages plant and animal life and can harm human health as well. Another is released into the atmosphere of nitrous oxide—a potent greenhouse gas whose global warming potential is nearly 300 times higher than that of carbon dioxide and about 13 times more than for methane. Field trials at CIAT have shown that *B. humidicola* suppresses nitrous oxide emissions almost entirely.

The new research found that brachialactone accounts for up to 90% of the grass's inhibitory effect. This finding, which resolves a longstanding mystery about BNI, is the product of many years of collaboration between the Japan International Research Center for Agricultural Sciences (JIRCAS), the Japanese National Food Research Institute (NFRI), and CIAT's Tropical Forages Program.

The environmental damage resulting from nitrification has multiplied greatly in the last 4 decades, as the use of nitrogen fertilizers has increased by a factor of seven, contributing to a doubling of agricultural production. In addition to the enormous environmental costs, nitrogen loss through nitrification has a significant economic impact in agriculture. Researchers have shown that only about 40% of the nitrogen fertilizer farmers apply is taken up by crops; they estimate the value of the nitrogen wasted at US$17 billion per year from cereal production alone.

So, the potential economic and environmental benefits of the BNI trait in *B. humidicola* are hard to exaggerate. One region that could reap large gains is South America's vast savannas, occupying about 250 million hectares. Though most of this land is under native grass or introduced pastures, about 11 million hectares in the Cerrados region of

The new research found that brachialactone accounts for up to 90% of the *Brachiaria's* inhibitory effect.

Brazil have been converted to soybean and maize production. Another 35 to 40 million could be brought under cultivation as well, with major impacts on the region's nitrous oxide emissions.

BNI could be used to avert such an outcome. But to harness this phenomenon will require major efforts to determine its genetic basis through "gene discovery". Researchers hope they can introduce BNI genes into both food crops and forages, and then integrate these into improved pastures and crop-livestock systems, which would then permit only limited nitrification and nitrous oxide emissions.

Lengthening Cassava's Shelf Life

Throughout its lengthy growth cycle, cassava shows extraordinary efficiency, delivering a sizable root yield, regardless of whether the crop has been pampered or punished. But then it all goes rapidly to waste soon after the roots are harvested.

Having served their purpose of storing energy to help the plant bounce back from stresses like drought and insect attack, the roots spoil within just a few days through a relentless process called "postharvest physiological deterioration", or PPD. In 2009, CIAT cassava researchers took a big step toward solving this problem by confirming that PPD tolerance is present in diverse sources and operates through different biochemical and genetic mechanisms.

A genetic solution to PPD is one of the most important contributions one can imagine for transforming cassava into a truly eco-efficient option that reduces rural poverty while also strengthening food security. Already a key staple across much of Africa and in many parts of tropical America, the crop is also becoming a cash crop, especially in Asia, as a result of rising demand from starch and animal feed industries.

But cassava development, whether for food or industrial raw material, is severely limited by PPD. The crop is generally grown in marginal environments, which often have poor roads and are a long way from markets and processing centers. Given cassava's short shelf life, getting it to customers can be costly and risky, greatly reducing farmers' market options.

Researchers have already identified and characterized genes responsible for PPD, suggesting that it should be possible to find genetic variability. In search of tolerant genotypes, the CIAT Cassava Program has screened a wide range of materials. In 2009, researchers evaluated several potentially tolerant genotypes, scoring the roots 5, 10, 20, and 40 days after harvest.

Clones from two different groups of genotypes showed no symptoms of PPD, even 40 days after harvest. One group consisted of germplasm that is high in carotene, while the other included genotypes with the so-called "waxy-starch" mutation. Other clones, including some that had resulted from crosses with a cassava wild relative, gave promising results as well, which will be reported in the journal *Crop Science*.

For some of those genotypes, it is clear what accounts for their PPD tolerance, while for others it is not. In the case of the high-carotene genotypes, the explanation lies in the antioxidant properties of carotenoids, that is, their ability to slow biochemical chain reactions that damage plant cells. On the other hand, there is no apparent reason why a waxy-starch genotype would be tolerant to PPD.

The important point is that researchers now possess diverse sources of tolerance, showing different but perhaps mutually reinforcing tolerance mechanisms. Now, they need to identify molecular markers linked to the trait, which will accelerate breeding for PPD tolerance by permitting early identification of tolerant genotypes.

From So-Called Minor Crops, Major Impacts in Asia

Like its work in Africa, CIAT's research in Asia offers compelling examples of how agricultural research can contribute to eco-efficiency. It also demonstrates convincingly how strong partnerships and innovative approaches to working with farmers can translate research results into major development impact. Two examples from the region involve effective use of the agrobiodiversity safeguarded in CIAT germplasm collections.

The first concerns high-yielding, high-starch varieties of cassava, which have been adopted by more than half of Asia's more than 7 million cassava growers. By better enabling these farmers to access new markets, the improved varieties have enabled many rural people to escape the downward spiral of poverty and natural resource degradation.

Until the 1970s cassava was a relatively minor food crop that proved useful mostly in times of crisis. But then, at about the time when CIAT initiated cassava research in Asia, the crop was transformed into a major export and key raw material for various processing industries. As a result, the region now accounts for about one third of world production, as well as more than 90% of the cassava traded internationally. It also has a large cassava processing industry. The many uses of cassava include animal feed, processed foods, other industrial uses of modified starches and bioethanol. Though much remains to be done to guarantee the sustainability of Asia's cassava production, new technologies developed through strong partnerships with national institutions and private-sector partners have already generated major benefits, improving the livelihoods of small farmers and leading to better management of natural resources.

The second case involves the story of how some 15,000 innovative small farmers in Southeast Asia have transformed subsistence livestock farming into a productive and profitable, market-oriented enterprise, starting with the adoption of tropical forage grasses and legumes for feeding livestock. Apart from the robust forages themselves, other factors that contributed importantly to this outcome include a client-oriented participatory approach, competent and committed national researchers and extension workers, and steadily rising prices for livestock.

Livestock was already important for many small farmers in the region, providing one of the only options for savings and insurance against hard times. But the new forages and improved management enabled farmers to add value to their livestock by greatly enhancing productivity, reducing sickness, and increasing fertility without increasing labor demands. More diverse, productive, and resilient farming systems also allowed growers to cut back on labor-intensive and unsustainable practices, such as slash-and-burn agriculture.

In both cases, improved germplasm was critical for success. But it generated impact mainly because researchers (1) employed farmer participatory approaches to foster adoption and (2) found effective ways to link farmers with markets.

An Elegant Way to Use Wild Species for Rice Improvement

Results from CIAT rice research confirmed this year the value of a novel genetic resource—referred to as a CSSL (chromosome segment substitution lines) library—for detecting genes associated with key traits needed to achieve eco-efficient production.

For rice improvement, CSSL libraries are derived through successive backcrossing of cultivated African rice (*Oryza glaberrima*) or wild species to a recurrent Asian rice (*O. sativa*) parent. Molecular markers are used to monitor the introduction of chromosomal fragments, which are arranged contiguously to represent the entire rice genome.

By means of such analysis, CIAT researchers were able to locate, for the first time, the exact region of the rice genome that is responsible for resistance to rice stripe necrosis virus. This discovery showed concretely how CSSL libraries can be used to detect quantitative trait loci, which are genetic segments associated with two or more genes controlling complex traits.

Rice is the most important staple food in South America and the Caribbean, and demand is growing. Regional production has responded well in recent years, expanding at an annual rate of 3% during 1990–2004, faster than anywhere else in the world. LAC's rice sector is thus well placed both to strengthen regional food security and also to widen its share of world rice markets.

In order to succeed, however, the sector must sharpen its competitive edge by reducing production costs through more efficient use of water and nitrogen, as well as agrochemicals. Data collected recently by the Latin American Fund for Irrigated Rice (FLAR) suggest there is wide scope for improvement. In several countries, rice farmers raised yields by 1–2 tons per hectare, while reducing production costs, through a combination of improved rice varieties and agronomic practices.

But to achieve and maintain such gains in the coming decades, the rice sector will have to overcome new obstacles resulting from climate change. Simulation models project that mean temperatures will increase by 2 ^{0}C - 3 ^{0}C in 2050 and that rainfall will become more variable, with significant impacts on rice yields.

In response, the CIAT Rice Program must begin now to develop lines that are adapted to drought and higher temperatures. Researchers have known for a long time that various species related to Asian rice are an important potential source of those and other useful traits. But progress has been hindered by the tendency of crosses between species to produce infertile offspring and by the difficulty of separating useful traits from undesirable ones with conventional methods.

CSSL libraries provide "an elegant way of circumventing those issues", according to an article published recently in the journal *BMC Plant Biology*. By demonstrating the distinct advantages of this genetic resource, the CIAT researchers who authored the article are helping to open the way toward molecular marker-assisted selection for stress tolerance, which is vital for the rice varieties of the future.

Tropical Soils: Solutions that Embody Eco-Efficiency

The combination of improved crop varieties and chemical fertilizers provided a potent driving force for last century's Green Revolution. But a new transformation of tropical agriculture in this century requires more holistic solutions to the problem of low soil fertility, solutions that better recognize the economic, social, and environmental realities of small-scale agriculture.

Integrated soil fertility management (ISFM) embodies particularly well the principle of eco-efficiency.

CIAT is actively pursuing such solutions, using an approach referred to as "integrated soil fertility management", or ISFM. It combines improved crop varieties with the use of both mineral fertilizers and organic matter, taking into account key features of the surrounding agricultural landscape, such as input and produce markets. ISFM embodies particularly well the principle of eco-efficiency, and it is rapidly gaining acceptance among researchers and farmers.

More Robust Cereal–Legume Intercropping

CIAT's research on ISFM targets several major agroecologies in which soil fertility decline is a serious problem, undermining the food security of large numbers of poor people. Such is the case in the moist savannas of western, eastern, and southern Africa, where many farmers practice intercropping or rotations of cereals like maize and sorghum with various grain legumes, including common bean, cowpea, and groundnut. In 2009, CIAT scientists registered important advances in determining how nitrogen, water, and other inputs can be used more efficiently in such systems.

An important source of protein, edible oils, and vitamins for people, soybeans are also a key component of livestock feed, and help improve soil fertility.

A study on maize–legume intercropping in central Kenya, for example, demonstrated the ample benefits of a modified arrangement referred to as MBILI, which is the acronym for "managing beneficial interactions in legume intercrops" but also means "two" in *Kiswahili*. Departing from the conventional pattern of one maize row followed by one of a legume, MBILI has two maize rows alternating with two of the legume. The advantage is that more light reaches the legume without reducing maize plant density.

CIAT researchers put MBILI to the test in an area characterized by highly variable rainfall, using two sites, one with inherently good soil fertility and the other poor. In an article published in the journal *Field Crops Research*, the researchers concluded that the modified system is quite robust, giving positive effects at both sites but especially at the poor one. There MBILI boosted net economic benefits by 12%–37% (depending on the legume used), raising yields of maize and cowpea. The researchers cautioned, however, that modest amounts of nitrogen fertilizer would be needed to sustain increased yields over the long term.

Making Way for Soybean

In addition to fine-tuning traditional cereal–legume systems, CIAT scientists are promoting a nontraditional option for Kenya—the versatile soybean—hoping to repeat successes achieved with this crop in Nigeria and Zimbabwe.

An important source of protein, edible oils, and vitamins for people, soybeans are also a key component of livestock feed, and help improve soil fertility. Kenya's production currently stands at around 5000 tons annually, even though demand from domestic food and feed processing industries is high, requiring the importation of 50,000 to 100,000 tons of soybeans each year. This amount is projected to increase by another 50,000 tons over the next decade.

Two recent CIAT studies point the way toward more vigorous soybean development in Kenya. One focuses quite specifically on nitrogen fixation in this legume, while the other encompasses the entire soybean value chain.

The first study, published in the journal *Plant and Soil*, reports on *Bradyrhizobium* strains indigenous to Kenya that stimulate nodulation in soybean roots for fixation of nitrogen from the atmosphere. When soybean is introduced in areas where it has not been grown previously, the seed must be inoculated with *B. japonicum* if it is to achieve effective nodulation. In most African countries, the need for inoculation with this species represents a significant barrier to soybean adoption.

Researchers at the International Institute of Tropical Agriculture (IITA) found a way around that obstacle some years ago by developing so-called "promiscuous" soybean varieties, which nodulate with various indigenous *Bradyrhizobium* strains.

Nonetheless, there is still much scope for enhancing the nodulation and grain yield of these varieties through inoculation with effective indigenous strains.

By determining the genetic diversity of such strains in Kenya, the analysis carried out by CIAT scientists represents a valuable first step toward better management of biological nitrogen fixation in soybean and hence better grain yields and stronger beneficial effects on soil fertility.

The second study addresses the larger question of how to promote successfully in Kenya a relatively new crop like soybean. Drawing lessons from recent successes in Nigeria and Zimbabwe, as well as from past failures in Kenya, the study proposes a three-tier approach focusing on:

1. Household production and processing of soybean for consumption in the home and for sale.

2. Community-level processing of surplus soybean production into products like soy milk and soy yoghurt.

3. Development of soybean markets that link farmers with processing industries.

Researchers tried out the approach over a 2-year period with farmer groups at three "action sites". The results increased interest in soybean production, processing, and consumption, as reflected by growth in the number of farmer groups across sites from 7 to 105. The groups obtained good profits from the sale of new soybean products, and

The groups obtained good profits from the sale of new soybean products, and some began supplying large-scale processors.

some began supplying large-scale processors.

The two CIAT studies made clear that to improve soil fertility management, particularly through the introduction of a new crop like soybean, requires a major effort, both to improve production and strengthen farmers' market links.

A Pioneering Soil Information Service for Africa

CIAT researchers embarked on a path-breaking initiative in 2009—the African Soil Information Service (AfSIS)—which will permit far better targeting of ISFM, water harvesting, and other practices that can enhance eco-efficiency across the continent's diverse agricultural landscapes.

Funded by the Bill & Melinda Gates Foundation (BMGF) and the Alliance for a Green Revolution in Africa (AGRA), the AfSIS project forms part of a larger effort aimed at creating a global digital soil map. Such a map, according to a recent *Science* magazine article, "is essentially a spatial database of soil properties, based on statistical sampling". The spatial distribution of the properties, which are measured in laboratories, is determined on the basis of field sampling, the authors explain.

In the case of AfSIS, which covers an area measuring some 18.1 million square kilometers, this sampling is being carried out by survey teams in 60 so-called "sentinel landscapes". These locations, each measuring 100 square kilometers, represent the variability of the entire project area in terms of climate, topography, and vegetation. Based on data collected in the sentinel landscapes, the digital map will be able to estimate soil properties accurately at locations not sampled.

Within about 4 years, AfSIS should be generating high-resolution, up-to-date information on key soil properties,

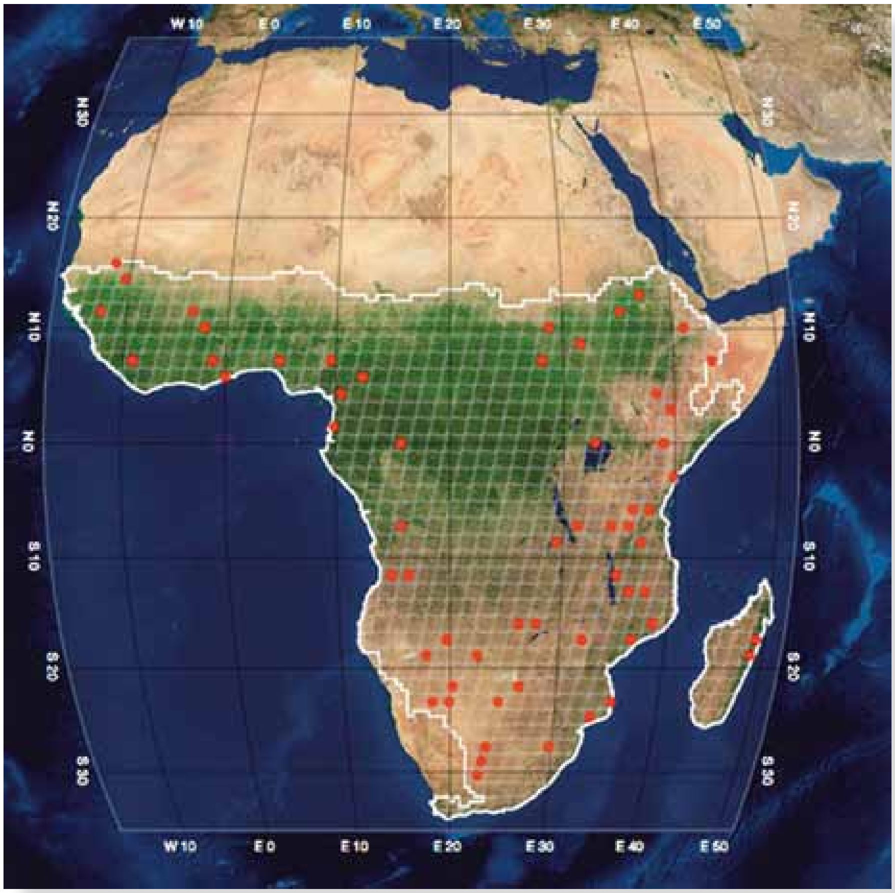
such as depth, texture, and organic matter content. It will also provide useful tools that draw on such information, such as a land degradation or soil fertility index.

As the digital soil map takes shape, researchers will add another powerful feature, involving the delivery of soil management recommendations for specific locations, based on recent research results. For this purpose, the project will carry out diagnostic trials at sites within the sentinel landscapes, aimed at pinpointing major soil constraints, such as nutrient deficiencies. Next, it will conduct agronomic trials to validate best-bet options for ISFM determined through previous research. The results will take into account the various economic and social conditions that influence adoption of those technologies.

In the project's first year, researchers have developed and tested methodologies, such as protocols for the field surveys and diagnostic trials, and got the collection of analysis of data under way. The final product of their labors will be an indispensable tool for soil management, providing farmer associations, extension services, researchers, and other users across the continent with reliable information about the type and amount of inputs needed, on the basis of actual soil status.

AfSIS should enormously boost to efforts to halt soil degradation in Africa, which is rapidly undermining essential ecosystem services, such as food production, hydrological cycling, and biodiversity conservation. Demand for those services will increase dramatically in the next few decades, as Africa's population doubles. Reversing land degradation is thus one of the continent's most pressing imperatives.

Based on data collected in the sentinel landscapes, the digital map will be able to estimate soil properties accurately at locations not sampled.



Latin America and the Caribbean: Fertile Ground for Eco-Efficiency

In 2009, CIAT's Decision and Policy Analysis (DAPA) Program, along with several partners, delivered an impressive body of information, reflecting extensive analysis of the implications of climate change for Colombia.

CIAT's home region, with its rich resource endowment and breadth of development experience, offers fertile ground for research aimed at achieving eco-efficiency in agriculture. The Center pursues an ecoregional approach in its research for Latin America and the Caribbean (LAC), which encompasses major crops, as well as natural resource management in key agricultural environments. CIAT's agenda for that research, shaped by recent consultations with a wide range of partner organizations, closely matches the priorities of the region, while also complementing the Center's efforts in Sub-Saharan Africa and Southeast Asia.

What Climate Change Means for Colombia's Agriculture

Improved crop varieties and practices will not add up to eco-efficient agriculture across an entire country or ecoregion, unless their development and dissemination are supported by appropriate policies and strategic decisions. In 2009, CIAT's Decision and Policy Analysis (DAPA) Program, along with several partners, delivered an impressive body of information, reflecting extensive analysis of the implications of climate change for Colombia. The results are already proving valuable to the country's government, as it designs national policies for confronting this challenge.

The analysis was performed in coordination with the Colombian Corporation of Agricultural Research (CORPOICA), the National Planning Department, the Ministry of Agriculture and Rural Development, United Nations Development Programme (UNDP), and others. It shows that agriculture is a big part of the climate change problem but can also figure significantly in the country's efforts to cope.

Agriculture accounts for about 45% of Colombia's total annual greenhouse gas emissions. Another 9% comes from deforestation and other changes in land use, which are driven to a large extent by agricultural expansion. The two biggest sources of agriculture's direct emissions are methane from livestock, contributing almost 37%, and nitrous oxide emissions from inefficient soil fertility management, which amount to just over 34%.

A number of agricultural technologies show potential to reduce those emissions, while also boosting productivity. Among the most promising options are changes in livestock diets; adoption of minimum tillage in the production of cotton, maize, sugarcane, and other crops; and project development under new mechanisms that offer payment in exchange for the capture of greenhouse gases or reduction of their emissions through improved agricultural practices like agroforestry.

While helping to mitigate climate change, Colombia's agricultural sector will also need a lot of help in adapting to its impacts. These will affect most of the country's crops, but especially perennials, over more than 60% of the cultivated area. Niches suited for coffee, tropical fruits, cocoa, and others can be expected to shrink as a result of temperature change. And increased rainfall will damage major production areas, for example, by accelerating soil erosion in the Andean Zone and by increasing flooding along the Caribbean and Pacific Coasts.

There is still time and much scope for reducing the vulnerability of Colombia's agriculture, as long as significant investment goes to impact evaluation, research, and technology transfer. In the short term, it is imperative that small farmers obtain new options for risk management, specifically crop and livestock insurance.

Keys to Competitive Production of Tropical Fruits

More than 1100 edible fruit species are produced in LAC, many of them for well-established and growing markets. The region's rich array of tropical fruit diversity constitutes one of its most promising options for increasing rural incomes, while also enhancing human health and the environmental sustainability of agricultural systems.

To realize those benefits requires research aimed at achieving eco-efficient production, which provides small farmers with a strong basis for competing in national and international markets. Two projects carried forward by CIAT's Tropical Fruits Program during 2009 illustrate particularly well how such research can contribute.

The first involves identification of avocado (*Persea americana* Mill.) germplasm with resistance to root rot disease, a serious threat to production in Colombia, and caused by the fungus

Niches suited for coffee, tropical fruits, cocoa, and others can be expected to shrink as a result of temperature change.

Disease-resistant clones would also allow farmers to cut back on chemical treatments, lowering production costs, and health risks, while offering a more acceptable product for local niche markets or even for international buyers.

Phytophthora cinnamomi. Resistant clones, by providing a guarantee that the trees planted have been grafted onto rootstocks of known disease resistance, would reduce farmers' risk of economic losses, including the complete loss of trees just a few years after planting. Such clones would also allow farmers to cut back on chemical treatments, lowering production costs and health risks, while offering a more acceptable product for local niche markets or even for international buyers.

In search of resistant germplasm, CIAT scientists, working in collaboration with CORPOICA and a private nursery, visited infected plantations throughout the country, where they identified a number of "escapes", that is, vigorous trees showing no disease symptoms. At the same time, researchers developed an efficient technology for clonal propagation of resistant rootstocks. Currently, they are further evaluating several resistant clones.

In a second project, CIAT scientists are studying the feasibility of deriving bioethanol from waste fruit of plantain or banana (*Musa* spp.) fruit in two contrasting production systems. One of these consists of Costa Rican coffee plantations, where plantains are grown mainly to provide shade for coffee plants rather than for commercial purposes. In this case, bioethanol can be produced from two sources: (1) coffee pulp, which is a contaminant but also an excellent source of biomass, and (2) plantains. These would complement the highly seasonal coffee pulp, helping to sustain bioethanol production all year round and providing a much-needed new source of income. The second system involves banana monocropping in Ecuador.

Based on data collected through interviews with farmers, researchers will identify the requirements for an economically, socially, and environmentally sustainable bioethanol production chain.

Getting REDD Right in the Amazon

One of the most promising recent developments in international climate negotiations is the firm decision to include REDD (reducing emissions from deforestation and forest degradation) in a new climate agreement. The idea is to provide developing countries that possess significant areas of tropical forest with financial incentives for REDD, in recognition of the value of the carbon stored in these forests.

Much research effort is now focused on implementing REDD, while also conserving biodiversity, through schemes involving payment for environmental services (PES). If implemented effectively and equitably, PES schemes could generate sizable economic benefits for rural communities that depend on forests for a livelihood.

Such efforts are particularly urgent in the Amazon because of its vast carbon reserves, significant carbon emissions, rich stores of biodiversity, and widespread rural poverty. Globally, deforestation and forest degradation, which are driven to a large degree by agricultural expansion, account for nearly 20% of greenhouse gas emissions, second only to those from the energy sector.

In 2009, Brazil's Minister of the Environment launched a key study addressing the complex question of how to incorporate PES schemes into the country's overall strategy for implementing REDD. The Ministry of Environment strongly endorsed the study, citing it as the basis for a national bill soon to be passed by the Brazilian congress. Scientists working in the framework of the Amazon Ecoregional Research Program, which CIAT hosts on behalf of the CGIAR, contributed importantly to the study.

Also involving scientists from the Center for International Forestry Research (CIFOR) and the World Agroforestry Centre (ICRAF), as well as the Brazilian Agricultural Research Corporation (Embrapa), the study reviewed ongoing PES schemes worldwide, identifying not only opportunities for Brazil to implement such schemes but also constraints. To assess the feasibility of PES, researchers made spatially specific estimates of its opportunity costs.

Scientists working in the framework of the Amazon Ecoregional Research Program, which CIAT hosts on behalf of the CGIAR, contributed importantly to the study.

The most promising areas are those where returns to timber extraction are low and where extensive cattle production and slash-and-burn agriculture are the predominant land uses.

The study concluded that, at current carbon prices, PES could compensate for more than half of future forest loss by 2016, based on historical rates of deforestation in the Amazon. The most promising areas are those where returns to timber extraction are low and where extensive cattle production and slash-and-burn agriculture are the predominant land uses. The researchers cautioned, though, that even where the opportunity costs for PES are favorable, the lack of well–defined land tenure rights represents a major obstacle to large-scale implementation.

A related study, requested by the National Service of State-Protected Areas (SERNANP) of Peru's Ministry of the Environment, to examine the feasibility of PES for forest conservation in the Peruvian Amazon also gave favorable results. It found that, for almost half of the annual deforestation in this region, the resulting net incomes could be compensated for with payments equivalent to the average prices for carbon credits in voluntary markets.

The minimum value of transfers needed to reduce deforestation by half during 10 consecutive years was calculated to be around US$540 million. For the average land user in the region, this would result in annual payments of $231 per hectare of avoided deforestation. The study also shows that incentives for PES-type conservation can be designed in line with national legislation.

Rising Demand for Farmer Participatory Methods

Much experience at CIAT and in other centers of the Consultative Group on International Agricultural Research (CGIAR) has demonstrated the value of gender-sensitive methods for involving farmers in research on crop improvement and natural resource management.

The need for such methods can only increase as new challenges, especially climate change, require that farmers adapt their practices to new conditions and demands. The pressures on women will be especially great, as many of them farm in vulnerable marginal areas. In work with farmers to devise adaptation strategies, participatory methods will be critical for tapping the unique indigenous knowledge that rural people have accumulated through many years of experience in coping with harsh and variable weather.

For more than a decade, the CGIAR Systemwide Program on Participatory Research and Gender Analysis (PRGA) hosted by CIAT, has investigated and supported the use of such methods in all of the CGIAR centers and in many of their partner organizations. Just recently, for example, the International Center for Agricultural Research in the Dry Areas (ICARDA) used a small grant from the PRGA Program to advance its work on a methodology called evolutionary-participatory plant breeding. The idea is to put crop populations showing wide genetic variability into the hands of small farmers, so that germplasm can gradually evolve and adapt to climate change by means of natural outcrossing and farmer selection.

The PRGA Program supports research aimed at achieving eco-efficiency, based on a long history of collaboration with CIAT researchers, including work on agroenterprise development, tropical soil biology and fertility, and bean variety development. With the aim of expanding such collaboration, focusing particularly on Latin America and the Caribbean, the Program is taking steps to gauge demand for training and methodological support among CIAT researchers.

A New Niche for the Agronatura Science Park

With the aim of building stronger partnerships in its home country and region, CIAT incorporated the Agronatura Science Park into its ecoregional approach for Latin America and the Caribbean (LAC) this year. Over the last decade, the park has provided a platform at Center headquarters for promoting alliances with organizations that share CIAT's mission to reduce hunger and poverty, and improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture.

The new arrangement is aimed at strengthening ties with current members of Agronatura, while attracting new ones into a wider effort to realize the vision of an eco-efficient agriculture in Colombia and LAC. A couple of recent additions to the park's membership are:

- FUNDACIAT, an independent not-for-profit Colombian organization, which will focus mainly on linking research with development through projects for technology and knowledge transfer, carried out with the private sector and government extension services.

- Corporation for Rural Business Development (CODER) was created by former CIAT employees to continue with the rural business development projects that were being executed by the former Rural Agroenterprise Development Project at CIAT. Its mission is to facilitate the formulation and execution of rural development projects that have a business and market approach. It also promotes a greater business and marketing orientation in organizations of small rural producers and their respective support entities.

Agronatura Institutional Members

Alexander von Humboldt Biological Resources Research Institute (Instituto Humboldt): Not-for-profit organization, which operates under the auspices of the Colombian Ministry of Environment, Housing, and Territory Development. The Institute has a public mandate to conduct basic and applied research on the genetic resources of Colombia's flora and fauna, and develop a scientific inventory of the mega-biodiversity found in this country.

Colombian Agricultural and Livestock Institute (ICA): National public entity, affiliated with the Colombian Ministry of Agriculture and Rural Development. ICA works in the areas of crop and animal health, and food safety in primary production, with the goal of projecting Colombian agrobusiness to the world.

Colombian Sugarcane Research Center (CENICAÑA): Private, not-for-profit organization. Its mission is to help develop a competitive sugarcane sector through research, technology transfer, and provision of specialized services. The goal of this sector is to achieve and maintain excellence while playing an outstanding role in the socioeconomic progress of sugar-producing zones and the conservation of productive, pleasant, and healthy environments in those zones.

Corporation for the Development of Biotechnology (Corporación BIOTEC): Belongs to Colombia's national science, technology, and innovation system. Its biotechnological work is carried out within social construct schemes to generate value for agricultural, agroindustrial, and bioindustrial sectors through value chains in the areas of research, development, and technology transfer.

Corporation for Rural Business Development (CODER): It's mission is to facilitate the formulation and execution of rural development projects that have a business and market approach. It will also promote a greater business and marketing orientation in organizations of small rural producers and their respective support entities.

Foundation for Agricultural Research and Development (FIDAR): Nongovernmental organization that promotes the conservation and sustainable use of genetic resources, food sovereignty and security, and the use of agricultural technologies and practices that will enhance, in harmony with the environment, the competitiveness of the small and medium-scale farmers of Colombia.

Institute of Marine and Coastal Research "José Benito Vives de Andréis" (INVEMAR): Affiliated with the Colombian Ministry of Environment, Housing, and Territory Development. INVEMAR conducts basic and applied research on renewable natural resources and the environment of coastal, marine, and oceanic ecosystems. Its goal is the sustainable management of resources, recovery of marine and coastal environments, and improvement of Colombia's quality of life.

An Overview of CIAT

Mission

To reduce hunger and poverty, and improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture.

Vision

CIAT will engage its key scientific competencies to achieve significant impact on the livelihoods of the poor in the tropics. Interdisciplinary and applied research will be conducted through partnerships with national programs, civil society organizations, and the private sector to produce international public goods that are directly relevant to their users. These goods include improved germplasm, technologies, methodologies, and knowledge.

Values

- **Impact orientation**
  Research and related activities are demand driven, and are monitored and evaluated for social and environmental impact and relevance.

- **Scientific integrity**
  Research is carried out with integrity and transparency, and according to an agenda that is socially and environmentally responsible.

- **Innovation, creativity, diversity, and continuous learning**
  Innovative approaches in research and organizational activities are pursued by taking advantage of gender and cultural diversity, and applying effective approaches for knowledge sharing and learning.

Financial Results 2009

Revenues increased by $1.8 million or 4% from $47.1 million in 2008 to $48.9 million in 2009. CIAT continues on its way to financial stability and has achieved a surplus of $2.2 million in 2009, compared to $0.9 million in 2008. Net assets, excluding capital invested in fixed assets, increased from $4.5 million in 2008 to $6.8 million in 2009. The hedging operation, once again, proved valuable in protecting the 2009 budget exchange rate in the extremely volatile Colombian currency market. CIAT, in compliance with international accounting policies and reporting standards, reports on the temporary variances of the currency hedges.

Operating reserves, expressed in days of daily operating expenditures, have reached 56 days in 2009, compared to the low of just 18 days in 2006. However, meeting the CGIAR target of 75 to 90 days will require continued commitment and management, focus on resource mobilization, stringent management of costs and expenses, and continued commitment with the "Full Cost Recovery" process implemented in 2008. Consistent with accounting methods used in 2008, the temporary variance of the hedging operation is not included in the calculation of operating reserves. Indirect cost recovery has increased from $3.7 million in 2008 to $4.1 million in 2009, which represents a recovery rate of 80%. Direct cost recovery reached $4.2 million in 2009, which represents 81% of total direct costs.

Unrestricted funds, compared to total revenues, increased slightly by $1.4 million. However, self-generated funds decreased by $0.8 million to $1.2 million, primarily as a result of depressed interest rates around the world.

In line with the new Strategic Directions and the comprehensive Business Plan developed in 2009, CIAT organized its research activities around 3 Research Areas and 11 Research Programs and Initiatives.

In February 2009, a new Head of Finance joined CIAT. Grants Management, with its two functions of Contract Management and Financial Planning & Reporting of Projects, is now fully integrated into the Finance Unit. CIAT has initiated a plan of recuperating and renovating its infrastructure. For example, the former Graphic Arts building was converted into a biotechnology laboratory. In total, 65% of capital investments were dedicated to research, 25% went to research services, and 10% was committed to renovating infrastructure for Administration.

Financial Outlook for 2010

The way CGIAR Research Centers will operate in the future is expected to change significantly as a result of changes that are taking place at the system level and in response to the creation of the CGIAR Consortium. CIAT is planning for a transition in 2010 and 2011 but is assuming a stable environment with regard to project funding and, particularly, with regard to unrestricted income from core donors. The 2010 budget approved by the Board is based on total revenues of slightly more than US$51 million and net reserves, expressed in days of daily operating expenditures, are planned to be within reach of the CGIAR-mandated range. It now appears that the Colombian peso will continue its trend of strengthening against the U.S. currency, and thus will present the Center with ongoing financial and operational planning challenges.

CIAT Statement of Financial Position
December 31, 2009 and 2008
(US$ in thousands)

	2009	2008
Assets		
Total current assets	36,582	37,770
Total non-current assets	5,446	5,599
Total assets	**42,028**	**43,369**
Liabilities and net assets		
Total current liabilities	27,549	34,261
Total non-current liabilities	1,603	1,170
Total liabilities	**29,152**	**35,431**
Total unrestricted net assets	12,876	7,938
Total liabilities and net assets	**42,028**	**43,369**

CIAT Statement of Activity
December 31, 2009 and 2008
(US$ in thousands)

	2009	2008
Grants	47,682	42,605
Transition Plan support	-	2,521
Other revenues and gains	1,182	1,933
Total revenues and gains	**48,864**	**47,059**
Program related expenses	45,622	39,756
Management and general expenses	4,504	7,260
Other losses and expenses	605	327
Subtotal expenses and losses	**50,731**	**47,343**
Indirect cost recovery	(4,077)	(3,665)
Total expenses and losses	**46,654**	**43,678**
Operating surplus from ordinary activities	**2,210**	**3,381**
Extraordinary items		
Transition Plan costs	-	(2,521)
Net surplus	**2,210**	**860**
Operating expenses by natural classification		
Personnel costs	22,578	19,661
Supplies and services	12,678	12,935
Collaborators and partnerships costs	10,258	8,971
Operational travel	2,925	3,788
Depreciation of fixed assets	2,292	1,988
Indirect cost recovery	(4,077)	(3,665)
Net total operating expenses	**46,654**	**43,678**

Board of Trustees

CIAT is pleased to announce that Dr Juan Lucas Restrepo, a Colombian citizen, is the new Board Chair, starting January 2010. His appointment was confirmed at the Board meeting in November 2009. Dr Restrepo will be supported by Dr Gordon MacNeil, Vice-Chair, until December 2010.

+ Regrettably, Emilia Boncodin passed away at the moment of printing this report.

Further details on Board members can be accessed at:
www.ciat.cgiar.org/AboutUs/People/Pages/BoardofTrustees.aspx

Donors

CIAT receives funds through the Consultative Group on International Agricultural Research (CGIAR) or for specific projects from different countries and organizations. The Center also receives, from a growing number of institutional clients, funds for research and development services that are provided under contract.

These contributions allow CIAT to maintain continuity of its research activities; strengthen its scientific alliances with national, regional, and global partners; improve its pathways to reach end users; and create biotechnology and training platforms.

CIAT gratefully acknowledges the donors' commitment and confidence, as expressed in their contributions and support. Below, is an extract from the complete 2009 list of donors found at: www.ciat.cgiar.org/Donors/Paginas/donors.aspx.

Australia
- Australian Centre for International Agricultural Research (ACIAR)

Austria
- Austrian Development Agency (ADA)

Belgium
- Belgian Development Cooperation (DGDC)

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

Colombia
- Additional Investment for Sustainable Alternative Development (Programa MIDAS)
- Ministry of Agriculture and Rural Development (MADR)

European Commission

Forum for Agricultural Research in Africa (FARA)

France
- Institute of Research for Development (IRD)
- The French Ministry of Food, Agriculture and Fisheries

Generation Challenge Programme (GCP)

Germany
- Federal Ministry for Economic Cooperation and Development (BMZ)
- German Agency for Technical Cooperation (GTZ)

Global Environment Facility (GEF)

Italy
- Global Crop Diversity Trust
- International Fund for Agricultural Development (IFAD)

Japan
- Japan International Research Center for Agricultural Sciences (JIRCAS)
- Ministry of Foreign Affairs of Japan (MOFA)
- The Nippon Foundation

Kenya
- Alliance for a Green Revolution in Africa (AGRA)

New Zealand
- New Zealand's International Aid & Development Agency (NZAID)

Norway
- Norwegian Agency for Development Cooperation (NORAD)

Spain
- National Institute of Agriculture and Food Research and Technology (INIA)

Sweden
- Swedish International Development Cooperation Agency (SIDA)

Switzerland
- Swiss Agency for Development and Cooperation (SDC)

Thailand
- Thai Tapioca Development Institute (TTDI)

The Netherlands
- Common Fund for Commodities (CFC)
- Wageningen University

United Kingdom
- Department for International Development (DfID)

United Nations Environment Programme (UNEP)

USA
- Bill & Melinda Gates Foundation
- CH2M Hill, Inc.
- Citizens Network for Foreign Affairs (CNFA)
- National Starch
- Regional Fund for Agricultural Technology (FONTAGRO) - Inter-American Development Bank (IDB)
- Rainforest Alliance
- RiceTec, Inc
- United States Agency for International Development (USAID)

World Bank

Partners

A key component in the implementation of CIAT's Strategic Directions are partners and their strengthening. CIAT takes this opportunity to sincerely thank all national agricultural research institutes, universities, advanced research institutes, other CGIAR centers, NGOs, private sector, and farmer organizations for their confidence, commitment, and support during 2009.

Among other strategic partners CIAT collaborates in LAC with Embrapa, FORAGRO, FONTAGRO, CATIE, and CIRAD.

CIAT participates in the following CGIAR Challenge Programs: Water and Food, Generation, HarvestPlus, Sub-Saharan Africa, and Climate Change.

An alphabetical list of partners, together with their links, can be accessed at:
www.ciat.cgiar.org/AboutUs/Paginas/PartnersandCollaborators.aspx

Awards

FESCO Award, granted by the Foundation for the Encouragement of Social Contribution (Japan) to Kazuo Kawano and Reinhardt Howeler for their contributions towards improving the livelihoods of cassava farmers in Thailand, Vietnam, China, and Indonesia through their cassava research and direct work with farmers.

Best Poster Award, 2009 World Water Week, organized by the Stockholm International Water Institute (SIWI) to Aracely Castro, on behalf of CIAT and its partners, for their poster "Improving the efficiency of rainwater use on hillsides in the subhumid tropics: the agricultural and environmental benefits of the Quesungual system".

2009 IFAR Award to Jeremiah Mosioma Okeyo (Kenya) to further his research on understanding the effect of long-term conservation tillage (i.e., reduced or no tillage) on soil physical properties under experimental conditions in the subhumid tropics.

2009 IFAR Award to Marie-Chantal Niyuhire (Burundi) to further her research on documenting the dissemination and adoption of improved bean varieties on the basis of rural household and market surveys.

International Ebbe Nielsen Prize to Andy Jarvis in recognition of his innovative work to predict and prevent the effects of climate change on agrobiodiversity.

A complete list of awards granted to CIAT staff is available at: www.ciat.cgiar.org/AboutUs/People/Pages/Awards.aspx

Publications

In 2009, CIAT researchers again published widely, with 137 articles in refereed journals and another 218 documents in other sources. A list of these and other documents published in the last 10 years can be accessed at:
webapp.ciat.cgiar.org/biblioteca/articles2009.htm

A collection of over 13,000 documents published by CIAT researchers during the Center's 43 years of existence can be retrieved through CIAT's electronic library catalog at:
ciat.catalog.cgiar.org/ciat_bibliography.html

Capacity Strengthening

Over 1000 researchers and professionals have benefited from training opportunities supported by CIAT. About 850 professionals participated in specialized courses. In 2009, one course was carried out in 10 different departments in Colombia with the support of the Ministry of Agriculture and Rural Development, benefiting 728 Colombian tropical fruit growers and specialists. Nearly 150 students carried out undergraduate, masters, or PhD research work. At least 70 individuals, mainly mid-career professionals, took advantage of individualized specialization opportunities under the supervision of CIAT researchers.

CIAT's first Distance Education student successfully completed her Masters Degree in Environmental Sciences at the University of Florida and has become leader of a project on payment for environmental services.

Training activities in Africa and Asia are rapidly growing in number and importance and are now being compiled and reported more systematically. However, as to be expected, CIAT's host country benefited most from overall training opportunities, with almost 6000 researchers and professionals trained over the past four decades (50% of all trainees).

Many of these training events were made possible through financial support from national entities such as the Colombian Ministry of Agriculture and Rural Development, COLCIENCIAS, ICETEX, CORPOICA, national federations and research centers, and international organizations based in Colombia.

Capacity Strengthening

Professionals trained at CIAT headquarters, in Africa and Asia, 1967–2009

Training	Participants (No.)			
	1967–2008	Year 2009		
		HQ	Africa	Asia
By modality				
Group				
Multidisciplinary and specialized courses	5,339	802	8	36
Specialized distance learning course	22	2		
Individualized specialization	3,952	66	2	2
Thesis work towards:				
An undergraduate degree	726	44	2	1
A master's degree	345	32	29	2
A doctorate	308	8	26	1
Total	**10,692**	**954**	**67**	**42**
By region (based on country of origin)				
Latin America and the Caribbean (excluding Colombia)	4,625	27		
Colombia	4,928	891		
Africa and Asia	542	14	67	42
Europe	397	18		
North America	200	4		
Total	**10,692**	**954**	**67**	**42**

CIAT Staff* and Offices**

Management Team

Ruben G. Echeverría, Director General

Robin Buruchara, Regional Coordinator for Africa, Coordinator of PABRA (Uganda)

Albin Hubscher, Deputy Director General for Corporate Services

Rod Lefroy, Regional Coordinator for Asia (Lao PDR)

Nteranya Sanginga, Tropical Soil Fertility Research Area Director (Kenya)

Joseph Tohme, Agrobiodiversity Research Area Director

Agrobiodiversity Research Area

Joseph Tohme, Research Area Director

Program Leaders

Stephen Beebe, Bean Program

Hernán Ceballos, Cassava Program

Daniel Debouck, Genetic Resources Program

César P. Martínez, Rice Program

Michael Peters, Tropical Forages Program

Researchers

Elizabeth Álvarez, Plant Pathologist, Cassava, Tropical Forages, Tropical Fruits

Tin Maung Aye, Agricultural Biochemist, Cassava (Thailand)

Sarah Ayling, Bioinformatics

Luis Augusto Becerra, Molecular Biologist, Cassava

Matthew Blair, Breeder and Molecular Geneticist, Bean

Marc Châtel, Plant Breeder, Rice

* As of December 2009. Countries are indicated only for staff working outside Colombia.

** Acronyms used:

CLAYUCA: Latin American and Caribbean Consortium to Support Cassava Research and Development; DAPA: Decision and Policy Analysis Program; FLAR: Latin American Fund for Irrigated Rice; ISFM: Integrated Soil Fertility Management Program; PABRA: Pan-Africa Bean Research Alliance; PRGA: Participatory Research and Gender Analysis Program; SADU: Small-Scale Agroenterprise Development in the Uplands of Lao PDR and Vietnam; SLM: Sustainable Land Management Program.

Rowland Chirwa, Bean Breeder, Bean (Malawi)
Luciano de Campos Carmona, Rice Production Specialist, FLAR
Beata Dedicova, Biologist, Cassava
Dominique Dufour, Food Science Specialist, Cassava, Tropical Fruits
Keith Fahrney, Agronomist, Cassava (Lao PDR)
Gerardo Gallego, Head of Laboratory, Biotechnology Unit
Cecile Grenier, Scientist, Rice
Henrieus Hendrickx, Coordinator, Product Development Delivery, HarvestPlus (Netherlands)
Federico Holmann, Livestock Economist, Tropical Forages
Manabu Ishitani, Molecular Biologist, Bean, Tropical Forages
Enid Katungi, Economist, Bean (Uganda)
Paul Kimani, Breeder, Bean (Kenya)
Mathias Lorieux, Geneticist, Biotechnology Unit
Brigitte Maass, Forage Agronomist, Tropical Forages, ISFM (Kenya)
Jean D'Amour Manirere, Country Crop Manager, Bean, HarvestPlus (Rwanda)
Siriwan Martens, Animal Nutritionist, Tropical Forages
John Miles, Plant Breeder, Tropical Forages
Gloria Mosquera, Pathologist, Bean, Rice
Clare Mukankusi, Bean Breeder, Bean (Uganda)
Rachel Muthoni, Monitoring and Evaluation Expert, Bean (Uganda)
Mel Oluoch, Product Delivery Manager, HarvestPlus (Tanzania)
Bernardo Ospina, Agricultural Engineer and Executive Director, CLAYUCA
Helena Pachón, Human Nutritionist, AgroSalud
Soroush Parsa, Entomologist, Cassava, Tropical Forages
Wolfgang Pfeiffer, Breeding Coordinator, HarvestPlus
Jagadish Rane, Plant Physiologist
Idupulapati Rao, Plant Nutritionist and Physiologist, Bean, Tropical Forages
Jean-Claude Rubyogo, Seeds Expert, Bean (Malawi)
Louise Sperling, Anthropologist and Seed Systems Expert, Bean, Cassava (Tanzania)
Werner Stür, Forage and Livestock Systems Expert, Tropical Forages (Lao PDR)***
Edgar Alonso Torres, Rice Breeder, FLAR
Yoshimi Umemura, Molecular Biologist
Roger Urbina, Seed Specialist (Nicaragua)
Rein van der Hoek, Forage Expert, Tropical Forages (Nicaragua)
Alison Wilson, Economist, Tropical Forages (Lao PDR)
David Wozemba, Marketing Specialist, Bean (Uganda)
Gonzalo Zorrilla, Executive Director, FLAR (Uruguay)

Latin America and the Caribbean Research Area

Ruben G. Echeverría, Acting Research Area Director

Program Leaders

Patricia Biermayr-Jenzano, Program Coordinator, PRGA
Alonso González, Tropical Fruits Program
Andy Jarvis, DAPA
César Sabogal, Amazon Ecoregional Program (Brazil)

Researchers

Robert Andrade, Impact Assessment Officer, DAPA
Jan Börner, Environmental Services Expert, Amazon Ecoregional Program (Brazil)***
Wanjiku Chiuri, Rural Development Specialist and Gender, DAPA (Rwanda)
Laure Collet, Spatial Analyst and Modeling, DAPA
Simon Cook, Spatial Analyst, DAPA***
Andy Farrow, Spatial Analyst, DAPA (Uganda)
Sophie Graefe, Agronomist, Tropical Fruits
Glenn Hyman, Spatial and Impact Analyst, DAPA
Peter Laderach, Climate Change and High-Value Goods, DAPA
Mark Lundy, Markets Specialist, DAPA
Marcela Quintero, Ecosystem Services Specialist, DAPA
Carlos Arturo Quirós, Associate Scientist, Cambio Andino
Simone Staiger-Rivas, Facilitating Impact Expert, DAPA
Ana Isabel Vargas, Agronatura Science Park Coordinator
Tiago Wandschneider, SADU Team Leader in Vietnam (Vietnam)***

Tropical Soil Fertility Research Area

Nteranya Sanginga, Research Area Director (Kenya)

Program Leaders

Jeroen Huising, SLM (Kenya)
Bernard Vanlauwe, ISFM (Kenya)

Researchers

Eliud Birachi, Market Economist, ISFM (Rwanda)
Jonas Chianu, Socioeconomist, ISFM (Kenya)
Marc Corbeels, Soil Scientist and Modeler, SLM (Zimbabwe)***
Lulseged Tamene Desta, Soil Scientist, SLM (Malawi)
Laetitia Herrmann, Biotechnologist, ISFM (Kenya)
Joyce Jefwa, Microbiologist, ISFM, SLM (Kenya)
Wanjiku Kiragu, Project Administrator, Africa Region (Kenya)
Saidou Koala, Soil Scientist and African Network Coordinator, ISFM (Kenya)
Patrick Lavelle, Soil Ecologist, SLM

*** Left on 31 December 2009.

Didier Lesueur, Microbiologist, ISFM (Kenya)
Nelson Mango, Rural Sociologist, SLM (Zimbabwe)
Elizabeth Lutomia Nambiro, Scientist, SLM (Kenya)
Martha Nyagaya, Human Nutritionist, ISFM (Uganda)
Generose Nziguheba, Soil Scientist, ISFM, SLM (USA)
Peter Okoth, Extension Specialist, SLM (Kenya)
Cheryl Ann Palm, Soil Scientist, ISFM, SLM (USA)
Pieter Pypers, Soil Scientist, ISFM (Kenya)
Kristina Roing, Agronomist, ISFM (Kenya)
Pedro Sánchez, Soil Scientist, ISFM, SLM (USA)
Jérôme E. Tondoh, Soil Ecologist, ISFM, SLM (Mali)
Markus Walsh, Ecologist, ISFM, SLM (Tanzania)
Shamie Zingore, Soil Scientist, ISFM, SLM (Kenya)

Corporate Services

Albin Hubscher, Deputy Director General
Germán Arias, Legal Office
Edith Hesse, Corporate Communications and Capacity Strengthening
Carlos Meneses, Information Systems
Andrés Palau, Central Services
Gustavo Peralta, Human Resources
José G. Rodríguez, Finance

CIAT Offices:

Headquarters
Km 17, Recta Cali–Palmira
Apartado Aéreo 6713
Cali, Colombia
Phone: +57 2 4450000 (direct) or +1 650 8336625 (via USA)
Fax: +57 2 4450073 (direct) or +1 650 8336626 (via USA)
E-mail: ciat@cgiar.org
Web: www.ciat.cgiar.org

CIAT–Nicaragua
Residencial San Juan de Los Robles
Casa #303
Apartado Postal LM-172
Managua, Nicaragua
Phone: +505 22709965
Fax: +505 22709963
E-mail: ciatnica@cablenet.com.ni
m.e.baltodano@cgiar.org

CIAT–Honduras
Apartado Postal #15159
Edificio de DICTA/SAG, Boulevard Centroamérica
2do. Piso, Oficina 225
Tegucigalpa, Honduras
Phone: +504 2502624
E-mail: v.escober@cgiar.org

CIAT–Africa, Regional Office Agrobiodiversity
c/o NARO
CIAT Africa Coordination
Kawanda Agricultural Research Institute
13 km Gulu Road
P.O. Box 6247
Kampala, Uganda
Phone: +256 414 567259, 567670, or 567116
Fax: +256 414 567635
E-mail: r.buruchara@cgiar.org / ciat-uganda@cgiar.org

CIAT–Africa, Regional Office Tropical Soil Fertility
ICRAF Campus
UN Avenue, Gigiri
P.O. Box 30677-00100
Nairobi, Kenya
Phone: +254 20 7224766, 7224755, or 7224770
Mobile: +254 711 034000
Fax: +254 20 7224763
E-mail: tsbfinfo@cgiar.org

CIAT–Asia, Regional Office
c/o NAFRI Compound
Dong Dok, Ban Nongviengkham
P.O. Box 783
Vientiane, Lao PDR
Phone: +856 21 770090
Fax: +856 21 770091
E-mail: r.lefroy@cgiar.org

Hosted Centers:

Bioversity International
c/o CIAT, Apartado Aéreo 6713, Cali Colombia
Phone: +57 2 4450048; 57 2 4450049
Fax: +57 2 4450096

CIMMYT: International Maize and Wheat Improvement Center
Phone: +57 2 4450025 (office)
Fax: +1 650 8336626 (via USA)

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