

INTERNATIONAL CENTER FOR TROPICAL AGRICULTURE

CIAT

1967-2017



CIAT is a CGIAR Research Center



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# FOREVER PIONEERS

CIAT: 50 years contributing to a sustainable food future  
...and counting

A SUMMARY





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# Foreword

Until now, a written history of CIAT had not been produced, and the closest attempt were the papers presented at the 30<sup>th</sup> anniversary celebration, which focused on the early development of the Center.<sup>1</sup>

The 50<sup>th</sup> anniversary offers an opportunity to fill this void. But what makes up the history of an institution, particularly a research institution? It must start with the ideas and the context that went into its initial design and then examine how the organization adapted, changed, and evolved in relation to a dynamic external environment.

The first section of this history of CIAT charts its birth and evolution, and how it responded to a changing external context, the changes and various reforms of CGIAR,<sup>2</sup> and the agri-food development context within which CIAT operates and which defines its mission. This context, including the global development agenda and financing environment, has changed radically over the last 50 years and varies significantly by region.

The second section is a survey of the research programs – the main components of a research center. These have not remained constant over time; some have expanded or contracted. At one time when there were financial constraints, the programs even disappeared completely in favor of project clusters. Nevertheless, there is a certain coherence across program structures that has been maintained, and research programs have become the pillars of CIAT's achievements and its innovative lines of research.

The final section was written in close consultation with the current Director General, Ruben Echeverría, and builds on these historical foundations to project the future development of the Center.

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1 CIAT. 1998. 30 Anniversary of the Foundation of CIAT 1967-1997. CIAT Publication No. 308. CIAT, Cali, Colombia. 101 p.

2 'CGIAR' was originally the acronym for the 'Consultative Group on International Agricultural Research'. In 2008, CGIAR redefined itself as a global partnership. To reflect this transformation and yet retain its roots, 'CGIAR' was retained as a name. CGIAR is now a global research partnership for a food-secure future. See: [www.cgiar.org](http://www.cgiar.org)



In the 1950s, Latin America had a population growth at around 2.9% a year, higher than in any other region of the world, and stagnant food production.

# 50 years of adaptation and innovation

## The birth of CIAT: A center to fight food insecurity in Latin America and help feed the world

After World War II, concerns about global food security escalated, especially in war-ravaged countries of Europe and Asia, driven by the rapid world population growth and the decline in cereal production per capita in the developing world.

Latin America was no exception and population growth at around 2.9% in the 1950s was higher than for any other region of the world. Per capita grain production had fallen from 254 kg in the pre-War period to 213 kg in 1957–59.<sup>3</sup> Many countries in tropical Latin America had population growth above 3% and at least eight tropical countries including Colombia, Peru and much of Central America, had per capita calorie supplies of about 2,000 calories per day or less – a level considered by the Food and Agriculture Organization of the United Nations (FAO) to be well below adequate energy levels.

Yet, the potential for increasing agriculture production in the region was very high: only 5% of the estimated 850 million hectares of land experiencing good rainfall were being cultivated. Bringing this land into production would not only allow to feed Latin America but also help feed the world.

While the North talked of the tropical lands of Latin America as a potential solution to the world food problems, countries of the region looked inwards and focused on achieving food self-sufficiency. Within Latin America, there was indeed growing political interest in developing the unused lowland tropics, but the local scientific knowledge and capacity were limited. National agricultural research institutes, known as INIAs, were being established across the region by the early 1960s, but at the time there was an overall lack of trained agricultural scientists.

A predecessor of CIAT can probably be found in the Rockefeller Foundation program in Mexico. The program was created in 1943 under the leadership of J. George Harrar, who would become the Foundation's president during the 1960s, to support agricultural research and training. A similar program was launched in 1950 following the same model and provided the genesis of CIAT: the Colombian Agricultural Program (CAP).

At its peak in the early 1960s, the CAP had some 19 Rockefeller Foundation staff and over 130 Colombian staff that worked in a broad ranging research program of seven crops, four livestock species, and pastures, supported by many disciplinary programs across different ecologies in the country.<sup>4</sup> CAP also trained many

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<sup>3</sup> Brown LR. 1963. Man, land and food: Looking ahead at world food needs (No. 143860). Foreign Agricultural Economic Report No. 11. Regional Analytics Division, Economic Research Service, United States Department of Agriculture (USDA), Washington, DC, USA.

<sup>4</sup> Rockefeller Foundation. 1963. Program in the agricultural sciences: Annual report 1962–63. Office of Publications, NY, USA.

Colombian scientists. By 1966, some 80 scientists had been sent for graduate degrees in the US and over 200 had received in-service training.<sup>5</sup> But apart from the early successes of the Rice Program initiated in 1958 with the finding of resistance to hoja blanca virus, the productivity impacts of CAP have been patchy.<sup>6</sup>

The Rockefeller Foundation had been moving from bilateral programs to regional and international programs from 1950. As early as 1951, Harrar was calling for "international integrated programs of agricultural sciences with free exchange of material, information and personnel... toward the goals of greater food production and subsequent social benefits."<sup>7</sup>

President John F. Kennedy on the centennial celebration of the National Academy of Sciences (NAS) in October 1963 in Washington DC even stated in his speech:

*I look forward eventually to the establishment of a series of international agricultural research institutes on a regional basis throughout the developing world.*

*I can imagine nothing more unwise than to hoard our knowledge and not disseminate it and develop the means of disseminating it throughout the globe.<sup>8</sup>*

Following this vision, two Centers were created in 1967 with almost identical names: the International Institute of Tropical Agriculture (IITA), based in Ibadan, Nigeria, and the International Center for Tropical Agriculture (CIAT), headquartered near Cali, Colombia.<sup>9</sup> Unlike the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT), which were created as commodity Centers in 1959 and 1966, respectively, IITA and CIAT were designed not around one or two commodities but around an important ecological zone, the humid tropics, within their respective regions, sub-Saharan Africa and Latin America. CIAT would receive support from the Rockefeller and Ford Foundations and the United States Agency for International Development (USAID) and would follow the same institutional model as IRRI,<sup>10</sup> with similar international governance and staffing.

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5 Stakman EC; Bradfield R; Mangelsdorf PC. 1967. Campaigns against hunger. Berknap Press of Harvard University Press, Cambridge, MA, USA.

6 Ardila J; Hertford R; Rocha A; Trujillo C. 1975. Returns to agricultural research in Colombia. In: Pinstrup-Andersen P; Byrnes FC. Methods for allocating resources in applied agricultural research in Latin America: CIAT/ADC workshop, 26-29 November 1974, Cali, Colombia.

7 Harrar JG. 1963. Strategy for the conquest of hunger. Rockefeller Foundation, NY, USA.

8 Kennedy JF. Address at the Anniversary Convocation of the National Academy of Sciences. 22 October 1963. Online by Peters G; Woolley JT. The American Presidency Project. [www.presidency.ucsb.edu/ws/?pid=9488](http://www.presidency.ucsb.edu/ws/?pid=9488)

9 The Rockefeller Foundation funded another program for the arid lands ecological region at the University of California, Riverside, in 1964.

10 CIMMYT, which started with no legal status or campus of its own in 1963, followed the IRRI model when it was constituted as an autonomous organization under Mexican law in 1966, bringing together the international wheat improvement program and a loose federation of Rockefeller Foundation (RF)-supported maize programs, including the RF program in Colombia. Only then did it begin the process of identifying suitable land and constructing a new headquarters. See: Byerlee D. 2016. The birth of CIMMYT: Pioneering the idea and ideals of international agricultural research. CIMMYT, El Batán, Mexico.

A Colombia location for CIAT was discussed during a conference at Cornell University at the end of 1965 involving CAP's Lewis (Jocko) M. Roberts and Loy Crowder, and Armando Samper, a Colombian graduate in agricultural economics from Cornell, and at the time, Director General of the Inter-American Institute for Cooperation on Agriculture (IICA).<sup>11</sup> In many ways, Colombia was a logical choice: it was the poorest of the medium and large countries in Latin America, had per capita calorie supply at just 2,080 calories per day, and large amounts of unexploited areas of lowland humid tropics.

The Government of Colombia expressed its interest in hosting the Center.<sup>12</sup> Roberts and Lowell Hardin from the Ford Foundation recommended that the new Center be located near Palmira. Based on the Roberts-Hardin proposal, the Rockefeller and Ford Foundations and the Government of Colombia moved quickly to create CIAT. By 12 May 1967, an agreement had been reached with the Government of Colombia on the charter and statutes of CIAT. The preamble to that agreement reads:

*The warm, tropical lowlands of Latin America, Africa, and Asia offer the greatest potential of adding new lands to production. Much of the knowledge, however, which might permit rational utilization of the lowland tropics for food production remains to be developed. These tropical regions, except for export crop technology developed by*

*colonial powers, have been largely bypassed by modern agricultural science. Consequently, an obvious and urgent need arises for strengthening those research and training programs existing in these areas to promote timely and efficient production of food of both plant and animal origin.*<sup>13</sup>

The Act of Foundation and Statutes of CIAT were officially registered on 17 October 1967 and approved by the Government of Colombia on 4 December of the same year.

## **The first five years: Building the commodity programs**

In early 1968, the director of the Colombian Agricultural Program, Ulysses Jerry Grant, and Colombian colleagues, especially Armando Samper until he stepped down as Minister of Agriculture, and Jorge Ortiz Méndez, Director General of the Colombian Agricultural Institute (ICA), worked quickly to build CIAT's programs and infrastructure. The Government of Colombia made a major contribution to the founding of CIAT when it acquired 520 ha of irrigated land in the fertile Valle del Cauca in February 1967 and leased it to CIAT at a symbolic price for agricultural research activities.

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11 Many CIAT founders and early directors had a Cornell pedigree – Lowell Hardin, PhD Cornell in 1943, Armando Samper BS in 1943, Ulysses Jerry Grant PhD in 1952, Eduardo Álvarez Luna in 1964, and Colin McClung in 1950.

12 Roberts L; Harrar G. 1966. Trip report. Rockefeller Foundation archives.

13 CIAT. 1970. Legal documents. p 29. Available at: <http://bit.ly/2z0RqH5>

A Board of Trustees was appointed and met in June 1968 for the first time. Francisco (Chicho) Sola, a businessman and Harvard graduate from El Salvador, led the Board for the critical first five years. Other Board members were drawn from countries of the region, including four from Colombia and the president of the Inter-American Development Bank. Roberts and Hardin, authors of the 1966 CIAT proposal, represented the two initial donors, the Rockefeller and Ford Foundations, respectively.<sup>14</sup> The Kellogg Foundation was the third donor from 1969 and was also represented on the Board. Grant, who was already acting as interim director, was appointed the first Director General in the inaugural Board meeting.

A detailed implementation plan for CIAT was ready by May 1968. Although it did not specify CIAT's mandate, it listed six broad objectives:<sup>15</sup>

1. To stimulate and facilitate the economic development of nations;
2. To increase food production potential by developing economically feasible solutions to the problems of crop and animal production and distribution;

3. To facilitate rapid spread and use of improved materials and practices by developing and employing selected social strategies and techniques;
4. To contribute to the health and physical well-being of the people – rural and urban;
5. To increase the numbers of professionals and sub-professionals trained in agricultural research, production systems and effective extension;
6. To develop and strengthen national institutions, public and private, concerned with the agricultural and economic development, research, education, and extension.

By 1969, CIAT had hired 21 staff and was up and running with an ambitious mission “to accelerate agricultural and economic development and to increase agricultural productivity in order to improve the diets and welfare of the people of the world.”<sup>16</sup>

The original program structure designed in 1968 (see organigram on p. 5) was carried forward for the next five years.

The names of all commodity units were changed in 1970 by adding “production systems” to emphasize their systems orientation.<sup>17</sup> However, systems thinking was a moving target, and the commodity production systems were complemented

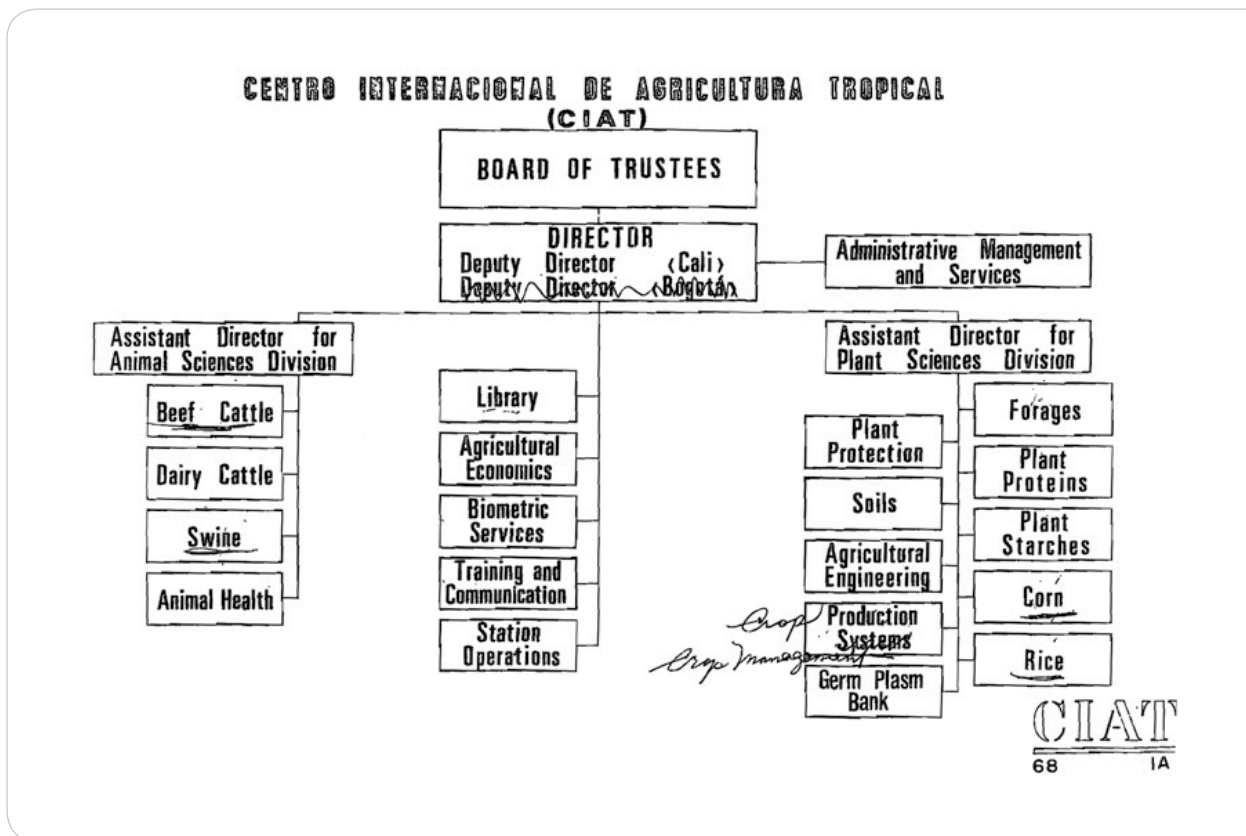
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<sup>14</sup> CIAT. 1970. Annual Report 1969. Proposed Program, Staff and Budget 1968. Cali, Colombia.

<sup>15</sup> However, the Rockefeller Foundation stated that the mandate of CIAT was to develop “agricultural systems of the tropics of the Americas with emphasis not only on crops but also on the animal species that could convert vast quantities of unused grasses and legumes to meat and dairy products.” See: Rockefeller Foundation. 1969. President's Five-Program Review and 1968 Annual Report. NY, USA. p 12.

<sup>16</sup> CIAT. 1970. op. cit.

<sup>17</sup> Food legumes was considered an exploratory thrust in the 1970 Annual Report.



**Figure 1** Original organigram of CIAT, 1968.

Note: This is the only surviving copy of the original organigram. The notes on this figure indicate much uncertainty. Forages is separate from Beef Cattle, and Agricultural Economics is a service function separate to the other disciplines.

Source: CIAT. 1970. op. cit.

by another unit, variously named in the first five years as agronomy systems, agricultural systems, agricultural production systems and, finally, small farm systems in 1973. CIAT was clearly searching for a more comprehensive approach to inserting its commodity technologies into systems to enhance productivity over the long term, as well as gravitating toward a focus on small farmers.

Perhaps as important as the research, CIAT immediately launched a large and comprehensive training program that attracted 56 professionals from the region in the first full year of operation (1969), about half of whom were undertaking postgraduate studies. By 1974, the number of trainees had grown to a truly impressive 162 annually. The training program was complemented by strong information services, including the library and several regional and international conferences. Many of these activities were supported by the Kellogg Foundation, which not only built the training and conference facilities, but also provided significant operational budget.

An important landmark during this period was the completion and inauguration of the new headquarters near Palmira, the current site of CIAT, on 13 October 1973.

CIAT research was closely focused on Colombia during the first years. However, after reaching its initial staffing complement and moving to its new headquarters, CIAT actively engaged in research in the wider region.

## **The influence of CGIAR and the search for another Green Revolution (1973–1990)**

### **Interdisciplinary crop research programs**

A major milestone in the external environment was the creation of CGIAR in 1971. This had two immediate implications for CIAT. First, the funding was now channeled via CGIAR. Second, the CGIAR Technical Advisory Committee (TAC) was very active in the early years in setting the overall direction for the CGIAR System. One area that was on almost every meeting agenda was food legumes, given the ongoing priority on increasing the proportion of protein in human diets. During this period, CIAT and IITA had active legume programs and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was founded in 1972, also with a major focus on legumes.

The formation of CGIAR led to the creation of four more Centers by 1975 with the continuing objective of ensuring global food security.<sup>18</sup> The emerging priority was to generate a Green Revolution in rain-fed, upland areas especially where crops other than rice and wheat were grown. An issue was how best to organize international research around this agenda, and especially how to find a balance between commodity and systems research, create linkages between CGIAR Centers, and work with national programs. This concept of balance was at the heart of the next phase of CIAT program development.

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<sup>18</sup> The four centers were CIP, ICRISAT, ILCA, and ILRAD.

A characteristic of CIAT's development is that the Director General has always played a critical and leading role in setting the strategic direction of the Center, and this strategic direction would change with each Director General. John Nickel, who was appointed in 1974 and served for 15 years at CIAT, came from IITA with a clear vision of the changes he would introduce. His first term saw a significant restructuring as he organized interdisciplinary crop research programs, consolidating the research programs begun under Grant by integrating the disciplinary units within four commodity programs, namely beans, cassava, rice, and tropical pastures. CIAT, in many ways, was unique among international agricultural research centers in developing and adapting the model of the interdisciplinary crop research program within a multi-commodity Center.

This basic structure did not change for the 15 years of Nickel's tenure. However, the rapid developments in biotechnology, beginning with tissue culture in the late 1970s, forced a departure from interdisciplinary crop research programs, as the Biotechnology Research Unit (BRU) was created in 1985 to take advantage of the rapid progress being made in that field.

Although a lot of units were created and dismantled at CIAT, the BRU remained in operation.

### **Small farmers and the equity debate**

The intent of the Small Farm Systems Program created in 1973 was to “integrate the efforts of the commodity production systems programs in the context of the whole farm unit.”<sup>19</sup> There were two basic questions behind this initiative. The first was the technology design question, particularly whether agricultural technology could be specifically designed for small farmers. This in turn was linked to the second, i.e. the role of economists (and social scientists more generally) in international agricultural research and whether this role included ex-ante appraisal in the technology design process.

But the Small Farm Systems Program was closed in 1975. The three original economists left CIAT for various reasons at about the same time, and the next generation of economists continued to develop their role within the crop research programs.<sup>20, 21</sup>

There were two further dimensions to the equity debate in CIAT. First, both cassava and beans were essentially small farmer crops, and benefits of new technology would go mostly to

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19 Franklin D; Scobie G. 1974. The Small Farm Systems Program: A program document. CIAT, Cali, Colombia. p 10.

20 For a more detailed review of the factors that went into the closing of the Small Farm Systems Program, see: Holland D; Ashby J; Mejia M. 2002. Growing social research in CIAT, 1968-2002. Paper presented at the Social Research in the CGIAR Conference “Looking to the Future, Learning from the Past”, 11-14 September 2002, CIAT, Cali, Colombia.

21 The 1978 *Stripe Review of Farming Systems Research* had these observations on the Small Farm Systems Program: “The Small Farm Systems Program was discontinued in 1975. In the Review Team’s judgment, this became inevitable (with hindsight) because of the combined effect of four factors: it was too ambitious in scope; it overemphasized both formal systems methodology and computer modeling; and its focus was more that of a rural development program than of farming systems. In such terms, the Review Team sees CIAT’s decision as correct. Moreover, CIAT’s geographical area is so diverse in ecological, institutional, economic and social conditions as to make any widely relevant in-depth study of whole farm systems on small farms impossible within the scope of reasonable budget limitations. For a Center such as CIAT, the comparative advantage obviously lies with a commodity approach aimed at the production of components to be integrated into whole-farm systems via local institutions. This gives the advantages of a multidisciplinary approach within the frame of a focus that is both relevant and achievable. Moreover, it places the concern for small farmer impact within the commodity teams.” (Annex 2, p 4).

small farmers.<sup>22</sup> The second dimension was CIAT's philosophy of producing low-input technology and the recognition that on-farm testing is key in this kind of research, laying the base for CIAT's leadership in participatory on-farm research.<sup>23</sup>

In the end, farming systems research was incorporated into the Bean and Cassava Programs and agronomy and social sciences were recognized as an important component of commodity research teams.

### **Pursuing global mandates and expanding to Africa and Asia**

The 1980s were a period of significant shifts in global agendas, with a strong focus on poverty and the divide between the North and the South. The 1983–1985 famine in Ethiopia further put the focus on sub-Saharan Africa, where the issue of sustainable management of natural resources was also acute. These emerging issues were reflected in the CGIAR's new goal statement: "Through international agricultural research and related activities, to contribute to increasing sustainable food production in developing countries in such a way that the nutritional level and general economic well-being of low-income people are improved."<sup>24</sup>

CIAT was already responding to these emerging agendas. The 1981 Strategic Plan stated: "CIAT has identified limited resource producers and consumers, that is, the rural and urban poor, as

the principal beneficiaries of its work." Moreover, sustainable production goals were compatible with the low-input research orientation.

The 1980s also marked expansion into sub-Saharan Africa and Southeast Asia. CIAT started the process of developing a bean research network in Eastern and Southern Africa in 1983. The breeding work initially focused on bulk breeding at CIAT and varietal assessment in the region, but rapidly evolved to doing most of the breeding in Africa with pre-breeding for particular constraints being carried out at headquarters. An Asian regional liaison cassava scientist was based in Los Baños, the Philippines, in 1977 but the office was closed in 1979 as there was no strong cassava program to work with. An office was established in 1983 in Thailand instead, where the capacity of the national program had previously been developed through CIAT Cassava Program's training activities. The germplasm flow and breeding activities set the stage for the cassava yield take-off in Thailand, which spilled over into other countries in the region.

By 1990, in relation to the expanding set of CGIAR objectives, the CGIAR Technical Advisory Committee was beginning to question the longer range viability of the four-in-one commodity research program model of CIAT, as expressed in this comment: "TAC would welcome more information from CIAT as to the justification

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22 There was a question in cassava, however, of the effect of opening industrial markets, such as ethanol in Brazil, and the response of large-scale producers.

23 Nickel JL. 1987. Low-input, environmentally sensitive technologies for agriculture. Grant F. Walton International Lecture presented at Rutgers, The State University of New Jersey. 16 October 1984. CIAT, Cali, Colombia. p 16.

24 TAC (CGIAR Technical Advisory Committee). 1986. TAC review of CGIAR priorities and future strategies. TAC, Rome, Italy. p xvi.

for the retention of its ongoing programmes, and the exclusion of possible new initiatives.”<sup>25</sup> A change in Director General would in fact move CIAT into developing some very different initiatives in the next phase of its development.

## **Adapting to the sustainability agenda (1991–2008)**

The period 1991–2008 was a time of radical organizational and programmatic change at CIAT, induced by ongoing efforts to integrate natural resource management (NRM) research with commodities in regional programs, and by financial constraints.

In 1990, Gustavo Nores became the Director General and the eco-regional dimension of CIAT was strengthened, with the creation of integrated commodity and NRM programs. Nores’s 1991 strategic plan was a direct response to the emergence of sustainability on the global agenda and coincided with the United Nations Earth Summit in Rio in 1992. The response to this new agenda at the level of CGIAR was to expand the number of Centers, adding what have been characterized as the NRM Centers. The number of CGIAR strategic objectives also increased, adding sustainable management of natural resources to food security and an increasing emphasis on poverty alleviation.

But the integration of continued research on genetic improvement with increased research on the conservation and management of natural resources represented an important

organizational challenge for international agricultural research. In many respects, that challenge remains today, for CGIAR and for CIAT. For eco-regional Centers such as CIAT, there are core issues of how best to organize commodity and NRM research and how to balance and effectively integrate the two to achieve the expected synergies in terms of impact, or what has now been termed sustainable intensification.

CIAT focused on sustainable production systems through adapted, low-input technologies developed within the four commodity programs. Unfortunately, this major organizational restructuring impulse by Nores took place in a declining funding context. There was also a notable shift to project-based funding and concurrently a shift in that funding to sub-Saharan Africa. As a result, the established commodity programs had to be downsized while the NRM programs could not be fully staffed. The resulting tensions put such pressure on management that Nores had to step down in 1994. Former CIAT economist Grant Scobie was appointed Director General in 1995. Scobie maintained the 1991 strategic plan but implemented programmatic restructuring to accommodate the budget situation.

During this period of declining budgets, the host country, Colombia, became one of CIAT’s major partners. The Agreement of Technical and Scientific Cooperation was signed in 1993 with the Ministry of Agriculture and Rural Development (MADR) and would run through three phases of five years. A review of the results from 1994 to 2001 found that for every US\$1 million

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25 TAC (CGIAR Technical Advisory Committee). 1990. Report of the Fiftieth Meeting of the Technical Advisory Committee. TAC Secretariat, Rome, Italy. p 11.

invested, the return in the Eastern Plains was US\$74 million.<sup>26</sup> A further assessment found that in the 1994–2003 period, 1,618 Colombian researchers and technicians had been trained at CIAT under the Agreement.<sup>27</sup>

The 1990s also saw the beginning of the move from a set of autonomous international agricultural research centers to a more interactive CGIAR research system. Starting in 1993 inter-center eco-regional programs focusing on various NRM themes were formed, followed in 1996 by systemwide programs in other areas. By 2002, there were eight eco-regional and nine systemwide programs. CIAT participated in nine of them and was a convener or co-convener in three, making it the most “connected” Center within the CGIAR System.

CIAT’s “connectedness” in the 1990s positioned it well to participate fully in the CGIAR Challenge Programs that were launched in 2001. These were precursors to the CGIAR Research Programs (CRPs) that would come later in the decade. CIAT participated in all four Challenge Programs and was instrumental in developing HarvestPlus as well as the Challenge Program on Climate Change that evolved into the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Over this period, CIAT developed strategic research capacity in several areas, including biotechnology, geographic information systems (GIS), spatial analysis, integrated pest management, and farmer participatory research.

CIAT’s programs in Africa and Asia, which were originally built around its global crop mandates, particularly beans in Africa and cassava in Asia, had a focus on systems research. The African program was built around research networks that evolved into institutions that facilitated joint African-CIAT coordination. This institutional innovation is best expressed in the development of the Pan-Africa Bean Research Alliance (PABRA) which was launched in 1996 and which provided CIAT with the principal vehicle for undertaking bean research, testing, and delivery in the region. The Tropical Soil Biology and Fertility (TSBF) Program was developed in Africa outside of CGIAR but was integrated into CIAT in 2001. The addition of TSBF greatly enhanced CIAT’s research capacity in soils, augmenting the work done on the management of acid soils in Latin America.

The Asia program, while initially focused on cassava, developed as an integrated systems program for the poorer areas of Southeast Asia, such as Cambodia, Laos, and Vietnam. Besides adding significant elements of forages and NRM research, the Asia program integrated some of the elements of today’s value chain work in developing rural enterprises beyond cassava.

Joachim Voss was appointed the next Director General in 2000. He led the development of a new strategy in 2001, in which CIAT moved to a research-for-development (R4D) approach. But constant organizational changes led to unchecked growth and overspending. In 2002, CIAT adopted an unconventional

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26 Urrutia NE; Figueroa CE. 2002. Convenio Colombia-CIAT: Un negocio de amplios horizontes para el Llano, con ciencia y tecnología, esta región se convierte en la despensa agrícola del país. CIAT, Cali, Colombia. p 4.

27 Rivas Ríos L. 2004. Resultados, adopción e impacto en los Llanos Orientales de Colombia. CIAT, Cali, Colombia. p 9.

method of “full cost recovery” to balance its books at the end of each financial reporting period,<sup>28</sup> which was essentially based on borrowing from project funds to finance core costs.<sup>29</sup> The financial crisis, triggered by such practices and other drivers, led to Voss’s resignation at the end of 2007 and an unprecedented decision by the Executive Committee of CGIAR to replace the Board of Trustees. This proved to be a major crisis in the history of CIAT which threatened its very survival.

## **New directions and CIAT in a reformed CGIAR**

The Board was reconstituted in 2008 and a new Director General, Ruben Echeverría, then Executive Director of the CGIAR Science Council, was appointed in 2009 with the mandate to set CIAT on a new strategic course. In the same year, CGIAR undertook a major structural reform in which the alliance of 15 Centers would strengthen and operate more as an interdependent system focused around global strategic objectives. At the same time, donors’ interest in agriculture was stimulated by the prestigious World Bank’s *World Development Report 2008: Agriculture for development*, and by the global food price spike that same year. Significantly, the Bill & Melinda Gates Foundation became

a major donor for research on agricultural development in sub-Saharan Africa and South Asia.

Under Echeverría’s leadership, CIAT quickly put in place a new strategic direction called “eco-efficient agriculture for the poor.” However, it required another five years to build a program structure and strategy around that concept and a strategic plan was produced in 2014. This 2014–2020 Strategy built on capacities that the Center had developed over its history but adapted them to a very different global agenda.

Working within the new CGIAR Research Programs, commodity research continued to revolve around the three traditional crops – beans, cassava, and rice – and forages. Breeding progressed with modern technologies such as molecular methods, including marker-assisted selection and genetic transformation. Research on nutritional enhancement, for instance, based both on genetic transformation and marker-assisted selection, was developed through CIAT’s participation in HarvestPlus and is today a core component in CIAT’s new emphasis on developing sustainable food systems.

The NRM research evolved from being organized around agroecologies to a focus on soil and land management, while ecosystem services and the research on system characterization and spatial analysis evolved into a new research area known

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28 Field L; Özgediz S. 2008. CIAT’s institutional crisis – Lessons learned. Unpublished manuscript. CGIAR Secretariat, Washington, DC, USA.

29 The *ex post* assessment described the system this way: “CIAT’s FCR (full cost recovery) method consisted of: (a) transferring part of the excess expenditure that could not be met by unrestricted funding to special projects, to the extent that these costs could be legally covered in accordance with projects agreements; (b) “internal borrowing,” whereby the Finance Department and Project Leaders would “negotiate” passing certain expenditures which were not absorbed by unrestricted funding to special projects in one financial period with the understanding that these funds would be repaid to projects in the following year from unrestricted resources. The cumulative internal debt to special projects reached close to US\$4 million in 2005. In 2005, CIAT’s inability to pay its unconventional internal debt was compounded by the strength of the Colombian Peso against the US dollar, which resulted in increases in local costs, and by the cancellation of expected funding in 2005 from a major donor. This triggered the financial crisis.” Ibid. p 5.

as Decision and Policy Analysis (DAPA). DAPA now works on a range of topics across an expanding thematic agenda, including ecosystem services, climate change, gender mainstreaming, and equitable supply chains. Spatial analysis and modeling were the entry point into new areas such as climate change. DAPA also generated a range of regional and global economic, environmental and agricultural databases, which provided the basis for developing further capacity in precision agriculture, artificial intelligence, and data mining and analytics, thus paving the way for the CGIAR Platform for Big Data in Agriculture, launched in 2017 and jointly led by CIAT and its sister Center the International Food Policy Research Institute (IFPRI).

Soil and land management is divided between research on integrated soil fertility management at the farm scale and sustainable land management at landscape scale. This work builds on the long-standing research of TSBF in sub-Saharan Africa, but with an ecological approach to soil management. The land management component emphasizes rehabilitation of degraded lands and focuses on more marginal agricultural areas, particularly forests and hillsides, building on accumulated experience in these ecosystems.

The challenge for CIAT was how to programmatically link Agrobiodiversity (the prior work on commodities), DAPA, and Soils research areas to achieve the eco-efficiency objective, especially with impact on the poor. This was done through the identification in the 2014 Strategy of four initiatives: tropical forages for eco-efficient livestock production; sustainable food systems for a rapidly urbanizing world; reducing yield gaps for sustainable intensification of agriculture; and ecosystem services for human well-being. These initiatives aligned with the emerging

development agenda, which would be articulated in the United Nations' Sustainable Development Goals in 2015.

Under Echeverría, CIAT has also strengthened its relationship with Colombia, its host country for 50 years, and promoted close collaboration with the Colombian Corporation for Agricultural Research (CORPOICA) to implement joint research in the country. CIAT today also benefits from a stronger presence in Africa and Asia, with regional offices in Nairobi, Kenya, and Hanoi, Vietnam. The Center works in 53 countries and has 21 offices across the developing world, emphasizing a more decentralized, matrix-based model, with strong regional offices, that enables carefully crafted responses to major trends and challenges in each region.

The more fundamental change in CIAT's external environment was the major reform of the CGIAR System, especially from 2011, when the first phase of CGIAR Research Programs (CRPs) were approved and funded. CIAT's history and flexible program structure, coupled with a strong presence in the developing regions, were reflected in its participation in 12 of the 15 CRPs, again more than any other Center.

CIAT has aligned its research programs with the CGIAR System research portfolio. A major achievement was the award presented to CIAT for its leading role with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Evolving its research programs in relation to a changing external environment has been the hallmark of CIAT's history and surely will be the hallmark of CIAT's future.



Sustainable food systems is one of the four initiatives identified in CIAT's 2014–2020 Strategy, which would articulate in the United Nations' 2015 Sustainable Development Goals.



A network approach to bean varietal improvement has led to incorporation of CIAT-bred material into a wide range of countries, ecologies, and bean markets.

# The results of CIAT's Research Programs

## Beans

In Latin America and the Caribbean, CIAT's Bean Program has had varietal improvement at its core. The large number of traits and their heterogeneity across the countries in the region suggested a decentralized breeding strategy. Fortunately, this could be built on strong national bean breeding capacities, which provided the basis for a system where: "breeders and pathologists in CIAT would identify promising materials. Recombinations of these materials were made and then sent out in the early stages of selection (F3 and F4) to national programs to be selected in the regions where they would ultimately be released."<sup>30</sup>

Since CIAT does not supply finished varieties, a network approach to bean varietal improvement has led to the incorporation of CIAT-bred material into a wide range of countries, ecologies, and bean markets. Up to 2000, the number of bean varieties released annually in Latin America increased significantly, a high proportion of which was derived from CIAT's breeding program.

Following the strategic shift to natural resources management in the 1990s, the bean breeding program started to better target

agroecologies, with support from spatial analysis, and to respond increasingly to edaphic constraints.<sup>31</sup> Nutrition and culinary quality would receive increased emphasis over time too.

CIAT also focused on biotechnology approaches, particularly reinforcing pre-breeding. Most of the bean biotech focused on embryo rescue to develop inter-specific crosses to introduce novel traits from wild relatives. The development of molecular markers for disease-related traits, particularly viruses, was also a focus. Marker-assisted selection was as well used more recently in CIAT's biofortification work to increase the content of iron and zinc in selected beans.

In sub-Saharan Africa, varietal development faces similar problems to those in Latin America, namely a wide range of pest, disease and edaphic constraints and a diversity of sub-regional preferences in seed size and color. The Bean Program began to work in the region in 1985 and followed a similar strategy to that in Latin America i.e. decentralized breeding within a network approach, but with a significant institutional innovation in the creation of the Pan-Africa Bean Research Alliance (PABRA). This alliance was formed in 1996 as a collaborative mechanism with joint ownership for bean research between National Agricultural Research Systems (NARS), CIAT, and principal donors. Thanks to PABRA, capacity in bean research in the NARS has been developed and maintained over time in Africa.

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30 Johnson NL; Pachico D; Wortman CC. 2003. The impact of CIAT's genetic improvement research on beans. In: Evenson RE; Gollin D. (eds.). Crop variety improvement and its effect on productivity: The impact of international agricultural research. CABI Publishing, Wallingford, UK. p 260.

31 A 1991 workshop framed the shift in strategy: Voysest O. (ed.). 1998. An ecoregional framework for bean germplasm development and natural resources research. Working document, annex to a workshop on bean breeding held in October 1991. CIAT, Cali, Colombia. 371 p.

CIAT's research agenda in the region has also developed other innovative approaches. Realizing the importance of women in selecting next season's seed for planting, for instance, led to the development of participatory plant breeding in beans with a focus on the role of women. Another example is the introduction of climbing beans to Rwanda and eastern Democratic Republic of the Congo, where farms are generally small and climbing beans provided a means for significant yield intensification. This is unquestionably one of the initial program successes. A 2001 study suggested that "by 1998 Rwanda and the eastern areas of the DR Congo were estimated to have 16 and 48%, respectively, of their bean area planted to climbing bean varieties."<sup>32</sup>

The combination of a large and diverse germplasm collection, a trait-based pre-breeding capacity, and a set of networks that undertook breeding and adaptive research for local conditions has been central to preserving beans in farming systems in Latin America and Africa, when the area planted to grain legumes in many parts of the world has been declining. Although nutritional deficits in protein are no longer a major problem in Latin America, it continues to be an issue in sub-Saharan Africa. Beans are still a major source of protein in the region, and research on the crop is still a priority. More recent breeding efforts for improving iron content have extended the nutritional dimension to micronutrients.

## Cassava

Unlike other programs, the Cassava Program did not have its roots in the Rockefeller Foundation's Colombia program, but began instead when CIAT received financial support for a major international germplasm collection in 1970.

In a world then focused on increasing agricultural productivity, CIAT scientists were working on one of the largest existing yield gaps. Average farm-level yields were around 8 tonnes (t) per hectare, while studies suggested possible yields of 80 to 90 t.<sup>33</sup>

Due to the limited research history on cassava, fundamental research was needed. The Cassava Program during the 1970s and 1980s developed a profound understanding of entomology, pathology, plant nutrition, and physiology.

Breeding activities focused on germplasm adapted to specific ecologies. Instead of providing finished varieties, CIAT provided sexual seed from which national programs would select the most appropriate varieties for their own local conditions.

Through the 1990s and into the following decade, CIAT cassava breeding at headquarters increasingly used molecular methods. But cassava research did not receive the same kind of investments as other crops such as maize and soybeans, and the Cassava Biotechnology Network (CBN) was formed in 1988 to take advantage of latest advances in molecular biology. The CBN transitioned into the Global Cassava Partnership for the 21<sup>st</sup> Century (GCP21) in 2002.

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32 Johnson et al. 2003. op. cit. p 270.

33 CIAT Staff. 1972. CIAT Cassava Review Conference: Notes and Observations. CIAT, Cali, Colombia. p 25.

CIAT cassava team focused on increasing rural income as their goal, which required cassava's entry into the broader market economy. A recent example is the identification of a mutant that produced waxy starch. This moved the technology into the area of food processing and the development of an exclusive commercialization agreement with the company Ingredion. This example of innovation at the upper end of the value chain was a transition from where the program started, which was how market diversification would impact on the small farmer.

The program recognized quite early that to benefit small farmers in Latin America, access to growth markets was essential. The program was probably the first in CGIAR to use what has since become known as a value chain approach, i.e. identifying potential new markets and then organizing the production, processing, aggregation, and delivery along the value chain. The question was how to diversify markets and at the same time direct benefits to small farmers.

The Latin American and Caribbean Consortium for Support of Cassava Research and Development (CLAYUCA) was created in 1999 with support from CIAT. Like the Latin American Fund for Irrigated Rice (FLAR), CLAYUCA is membership based, with annual contribution by participants from both the public and private sector.

But the principal impact of CIAT's cassava research appeared in Asia and was market led, first through cassava pellet exports from Thailand and then through the growth in the cassava starch



industry in most of Southeast Asia.<sup>34</sup> This was when CIAT made major decisions to reduce its program in Colombia and transfer resources to Asia.

A regional office was opened in Bangkok, Thailand, in 1983. Thailand was chosen because of its strong cassava research

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<sup>34</sup> IITA's research strategy in sub-Saharan Africa would also shift to an understanding of market potential as critical to driving cassava development and technology adoption, primarily based on the results of the COSCA study. See Nweke F; Spencer D; Lynam J. 2001. The cassava transformation: Africa's best-kept secret. Michigan State University Press, East Lansing, MI, USA.

programs and a promise of support from the Thai Government. A feature of CIAT's Cassava Program in Asia from 1983 was its seamless integration into local programs and institutions, with CIAT breeders working within the framework of the national programs. The program was also interdisciplinary, working on soil and land conservation, farmer participatory research, networking of national programs, and pests and diseases. Significantly, cassava yields increased in Thailand from about 12 t per hectare in the mid-1990s to close to 25 t in mid-2000.

The program in Asia focused on meeting the needs of an industrial market, with CIAT headquarters continually sending cassava crosses. Notably, a variety with significantly higher starch content and yield potential, KU50, was introduced in 1992 in Thailand and in 1995 in Vietnam.

KU50 was the basis for a yield take-off in both countries. A 2013 impact study calculated a net present value of an economic surplus of US\$243 million in Thailand and US\$150 million in Vietnam.<sup>35</sup> KU50 has been disseminated to five other countries in the region and is now grown on 47% of the total area under improved varieties.

Fifty years of cassava research have moved the crop from its role as a neglected subsistence crop to an important commodity that contributes to the economic growth of countries in the tropics.

CIAT and IITA in Africa have led this process and contributed to the development of a system of strong national research programs working on the crop. Cassava still does not receive the same level of research funding as maize, but it is price competitive with maize starch in some segments of Asian starch and feed markets.

## Rice

The CIAT Rice Program has focused exclusively on Latin America and the Caribbean (LAC). It had its origins in the Rockefeller Foundation Colombian Agricultural Program and was by design closely linked to IRRI.

Initial efforts focused on transferring the highly successful IR8 variety released by IRRI in 1966 to Latin America. A strong partnership with the Colombian Rice Producers Association (FEDEARROZ) led to CIAT's first big success when modern varieties were adopted on practically the whole irrigated rice area of Colombia by 1975, causing yields to increase from 3.5 to 5.4 t per hectare or a 50% increase.<sup>36</sup>

The early success in irrigated rice and the large share of area under upland rice in Latin America of over 70% naturally encouraged CIAT to focus more on upland rice.<sup>37</sup> The breeding

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35 Robinson J; Srinivasan CS. 2013. Case studies on the impact of germplasm collection, conservation, characterization and evaluation (GCCCE) in the CGIAR. Standing Panel on Impact Assessment. CGIAR, Washington, DC, USA.

36 Dalrymple DG. 1986. Development and spread of high-yielding rice varieties in developing countries. Bureau for Science and Technology. USAID, Washington, DC, USA.

\_\_\_Scobie GM; Posada R. 1978. The impact of technical change on income distribution: The case of rice in Colombia. *American Journal of Agricultural Economics* 60(1):85-92.

37 TAC (CGIAR Technical Advisory Committee). 1985. Report of the Second External Review of the Centro Internacional de Agricultura Tropical. TAC, Rome, Italy.

work targeted blast resistance and tolerance to acid soils, and resulted in the release of at least seven cultivars.<sup>38</sup>

But the CGIAR-wide budget downturn and the shift of resources within CIAT to NRM in the early 1990s hit the Rice Program especially hard. The core budget for rice fell from US\$4 million in 1990 to US\$1 million in 1998.<sup>39</sup> In addition and in part due to CIAT's success, by 1986–88, an estimated 70% of rice production in Latin America was irrigated, and CIAT changed its emphasis from upland to irrigated rice.

The funding crisis and the shift back to irrigated rice led to an innovative partnership, the Latin American Fund for Irrigated Rice (FLAR), established in 1995 by CIAT and public and private rice stakeholders in the region.

Since 2000, the Rice Program has emphasized eco-efficiency and has used new tools such as molecular markers and the sequencing of major genotypes coupled with phenomics for gene discovery. Partly because of the generic biosafety approval granted to CIAT in 2007 by the Government of Colombia, CIAT has become a leader within CGIAR in rice transformation, with a focus on improved nitrogen- and water-use efficiency and, more recently, on increased zinc content.



Over the past 50 years, on-farm rice yields in Latin America have increased at 2.3% annually, significantly above the global average of 1.5%.

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38 Martínez CP; Torres EA; Chatel M; Mosquera G; Duitama J; Ishitani M; Selvaraj M; Dedicova B; Tohme J; Grenier C; Lorieux M. 2014. Rice breeding in Latin America. *Plant Breeding Reviews* 38:187–278.

—Bresseghele F; de Moraes OP; Pinheiro PV; Silva ACS; Da Maia de Castro E; Guimarães EP; de Castro AP; Pereira JA; de Matos Lopes A; Utumi MM. de Oliveira JP. 2011. Results of 25 years of upland rice breeding in Brazil. *Crop Science* 51(3):914–923.

39 Beintema N; Raitzer D; Dobermann A; Pray C; Sanint L; Wopereis M. 2010. Positioning rice research globally: Investments, institutional arrangements, and emerging challenges. In: Pandey S; Byerlee DR; Dawe D; Dobermann A; Mohanty S; Rozelle S; Hardy B. (eds.). *Rice in the global economy: Strategic research and policy issues for food security*. IRRI, Los Baños, the Philippines.

Linkages with IRRI, AfricaRice, and advanced research institutes were strengthened from 2011 through participation in the CGIAR Global Rice Science Partnership (GRiSP), now called the Rice AgriFood Systems Program.

The early success with semi-dwarf varieties related to IR8 was followed by the release of nearly 300 varieties based on CIAT crosses or a parent.<sup>40</sup> Under FLAR, 48 varieties were released through the network, mainly based on crosses made at CIAT.<sup>41</sup> Practically all irrigated and favorable rain-fed rice area is now sown to modern varieties based on CIAT or IRRI parentage. The most recent estimate from eight Andean and Central American countries is that 63% of the rice area in those countries is sown to varieties based on CIAT crosses.<sup>42</sup> Over the past 50 years, on-farm rice yields in Latin America have increased by 2.3% annually, which is significantly above the global average of 1.5%.

The benefits of investment in rice improvement have been placed at between US\$0.85 billion and US\$2 billion per year.<sup>43</sup> An assessment in the early 1990s concluded that benefits from

investment in rice research were higher than for any other crop researched by CGIAR in Latin America.<sup>44</sup> Most of the benefits have gone to consumers, especially poor consumers, due to lower prices.<sup>45</sup>

But CIAT's public investment in rice research must be justified by objectives that go beyond food security and equity. Higher yields in irrigated areas and lower prices also helped save land and forests as some of the upland rice was sown on fragile forest margins.<sup>46</sup> The Rice Program continues to contribute to global sustainability goals such as saving forests, reducing greenhouse gases, restoring degraded land, and improving global rice knowledge, including for instance on rice production systems based on direct seeding.

CIAT's contribution to building rice research capacity in Latin America is equally important. CIAT has trained over 1,300 rice scientists, most of whom have subsequently transformed rice research in their countries and have constituted the core of national rice programs to date.<sup>47</sup>

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40 CIAT. 2017. CIAT Rice Program: Outcome and next steps. Powerpoint presentation.

41 Martínez et al. 2014. op. cit.

42 Yamano T; Arouna A; Labarta RA; Huelgas ZM; Mohanty S. 2016. Adoption and impacts of international rice research technologies. *Global Food Security* 8:1-8.

43 Sanint LR; Wood S. 1998. Impact of rice research in Latin America and the Caribbean during the past three decades. In: Pingali PL; Hossain M. (eds.). *Impact of rice research*. pp 405-428.

—TAC of the CGIAR. 1990. op. cit.

44 Janssen WG; Crissman C; Henry G; López Pereira MA; Sanint LR; Walker T. 1992. CIAT, CIMMYT and CIP: Their role in the agricultural research in Latin America and the Caribbean. CIAT Publication No. 213. CIAT, Cali, Colombia. p 49. <http://hdl.handle.net/10568/69585>

45 e.g. Sanint and Wood. 1998. op. cit.

46 Ibid.

47 Martínez et al. 2014. op. cit.

The challenge for CIAT's Rice Program today is how to finance the full cost of rice research from regional stakeholders, especially the private sector, while ensuring that it contributes to global public goods.

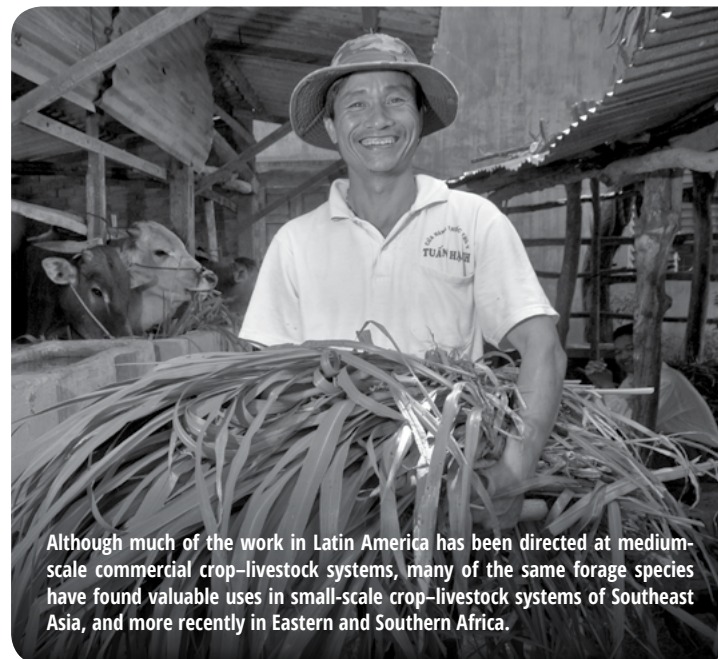
## Tropical Forages

At its inception, CIAT recognized that exploiting the huge potential of the tropical lowlands of Latin America would require a strong focus on beef production. Priority was initially given to improving the productivity and sustainability of cattle production for beef and later that of dual-purpose meat–milk systems. The initial plan for CIAT contemplated both a beef production and a forages unit but, by 1980, the program was squarely focused on pastures.

An important step in this process was the founding of the International Tropical Pastures Evaluation Network (RIEPT) in 1979 to help test forage species and cultivars in a wide range of environments. This effort generated unique data from 100 sites in 15 countries, which eventually fed into the database and software *Tropical Forages*, which was released in 2005.

From the early 1980s, grass and legume cultivars were released by national programs mainly through RIEPT. In total, national programs have released 64 tropical grass and legume cultivars based on germplasm accessions provided by CIAT.<sup>48</sup>

Much of CIAT's research has been to establish fundamental knowledge on tropical forages, especially testing options for pasture establishment and management that would be



Although much of the work in Latin America has been directed at medium-scale commercial crop–livestock systems, many of the same forage species have found valuable uses in small-scale crop–livestock systems of Southeast Asia, and more recently in Eastern and Southern Africa.

sustainable over the long term. The program also demonstrated the benefits of crop–pasture systems.

Although much of the work in Latin America has been directed at medium-scale commercial crop–livestock systems, many of the same forage species have shown valuable uses in small-scale crop–livestock systems in other regions. The program started modest research efforts in Southeast Asia in 1991, and Eastern

48 Peters M. 2011. Tropical Forages Program [brief]. CIAT, Cali, Colombia. 2 p. <http://bit.ly/2xlxZvs>

and Southern Africa in 2009,<sup>49</sup> and studied other methods of forage management beyond pastures, especially cut-and-carry practices in crop-livestock systems.

New types of concerns emerged in the 2000s, with the global livestock industry coming under growing criticism for its role in climate change. CIAT then increasingly turned its attention to livestock and landscape issues, such as restoration of degraded lands, reduced greenhouse gas emissions, and conservation of biodiversity, as reflected in the LivestockPlus initiative launched in 2015.<sup>50</sup>

With the growing emphasis on global environmental services, CIAT's strategic research has shown that well-managed *Brachiaria* grasses are particularly effective in sequestering soil carbon relative to natural pastures, and that *Brachiaria humidicola* inhibits biological nitrification. Both these findings offer opportunities to reduce greenhouse gas emissions.<sup>51</sup> These positive impacts on the environment have already been used to justify and pilot payments for environmental services in pasture systems in several countries.<sup>52</sup>

In 2012, CGIAR launched the CGIAR Research Program on Livestock and Fish, and much of the Tropical Forages Program of CIAT was incorporated into it, while it also logically linked to the work of CCAFS on climate change. Since January 2017, CIAT is also coordinating the *Feeds and Forages* flagship of the CGIAR Livestock Research Program.

The major success is that of *Brachiaria* grasses developed by the Brazilian Agricultural Research Corporation (EMBRAPA) from the germplasm shared by CIAT and which fostered a partnership with the private seed sector (31 seed companies associated as UNIPASTO). The partnership pivoted on extensive adoption, estimated to cover around 10 million hectares in Brazil since 2003.<sup>53</sup> Likewise, surveys carried in 2017 in the Eastern Plains in Colombia suggest that about one-third of improved pastures is sown using *Brachiaria* cultivars selected or bred by CIAT.

*Brachiaria* cultivars were also released in Mexico in 2002, and adoption was documented on over 3 million hectares in Mexico and Central America by the early 2000s.<sup>54</sup> The development of *Brachiaria* hybrids in 2002 and a partnership with a private seed

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49 Spain JM; Ayarza MA. 1992. Tropical pastures target environments. In: CIAT (ed.). Pastures for the tropical lowlands: CIAT's contribution. CIAT, Cali, Colombia. pp 1-8.

50 Rao IM; Peters M; Castro A; Schultze-Kraft R; White D; Fisher M; Miles J; Lascano CE; Blümmel M; Bungenstab DJ; Tapasco J. 2015. LivestockPlus: The sustainable intensification of forage-based agricultural systems to improve livelihoods and ecosystem services in the tropics. *Tropical Grasslands-Forrajes Tropicales* 3:59-82.

51 Fisher MJ; Rao IM; Ayarza MA; Lascano CE; Sanz JI; Thomas RJ; Vera RR. 1994. Carbon storage by introduced deep-rooted grasses in the South American savannas. *Nature (United Kingdom)* 371(6494):236-238.

\_\_Subbarao GV; Nakahara K; Hurtado MDP; Ono H; Moreta DE; Salcedo AF; Yoshihashi AT; Ishikawa T; Ishitani M; Ohnishi-Kameyama M; Yoshida M. 2009. Evidence for biological nitrification inhibition in *Brachiaria* pastures. *Proceedings of the National Academy of Sciences of the United States of America* 106(41):17302-17307.

52 Interview with Cees De Haan.

53 Cacilda Borges do Valle (pers. comm.).

54 Holmann F; Rivas L; Argel PJ; Pérez E. 2004. Impact of the adoption of *Brachiaria* grasses: Central America and Mexico. *Livestock Research for Rural Development* 16(12):1-6.

company Grupo Papalotla helped overcome the problem of seed production and distribution. The partnership was further expanded through licensing by Dow Agrosociencias in 2011. Today, enough seed of *Brachiaria* hybrids has been produced to sow an estimated 0.7–0.8 million hectares in Latin America.<sup>55</sup>

Throughout the first two decades, until budgets were slashed in the 1990s, CIAT made major contributions by training pasture scientists. In the period 1977–83 alone, some 255 scientists received training at CIAT, most of them through in-service training and including 32 postgraduates and 18 postdocs.<sup>56</sup>

## Genetic Resources

A major task from 1967 through the early 1970s was to assemble and organize existing bean collections, including the collection of the United States Department of Agriculture (USDA) and that of the Rockefeller Foundation Colombian Agricultural Program, as well as mount new collections. Thirty-six explorations since 1978 by Daniel Debouck, the longtime leader of CIAT's Genetic Resources Unit, yielded 3,944 accessions of 41 wild bean species and new species as recently as January 2017. The CIAT genebank currently keeps over 38,000 accessions of beans from 110 countries.

Investment in collection was especially important for cassava as there had been little research on the crop to date and even its biological origin was unknown in 1967. CIAT quickly proceeded

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<sup>55</sup> Michael Peters (pers. comm.).

<sup>56</sup> TAC (CGIAR Technical Advisory Committee). 1985. Report of the Second External Program Review of Centro Internacional de Agricultura Tropical (CIAT). TAC Secretariat, Rome, Italy.

<sup>57</sup> Gulick, P; Hershey C; Esquinas-Alcazar J. 1983. Genetic resources of cassava and wild relatives. International Board for Plant Genetic Resources. FAO, Rome, Italy. 56 p.



Today the CIAT genebank keeps in trust the biological heritage of 141 countries, and the collections of beans, cassava, and forage legumes are the largest in the world by size and diversity.

to assemble a collection from remote areas of tropical South America, including Colombia.<sup>57</sup> From a genebank of 2,218 accessions in 1973, the cassava collection increased to 6,643 accessions from 28 countries by the end of December 2016.

The first collections of forages were donated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the University of Florida, among others. This was greatly increased by 9,410 accessions of forage legumes, mostly collected by 1979 in South America from acid soil savannas.<sup>58</sup> In the 1980s, numerous collecting trips in Brazil, Venezuela, and several Southeast Asian countries yielded thousands of accessions that make up the largest part of today's tropical legume collection.<sup>59</sup> The tropical forages collection kept at CIAT's genebank consists of 23,140 accessions of 734 taxa, mostly of the legume family, from 75 countries.

Initially, CIAT bean breeders logically chose to use landraces (domesticated, locally adapted, traditional varieties) stored in the genebank to deliver rapidly improved varieties that could be accepted by farmers and markets in the developing world. But over time, breeders have increasingly turned to stored wild relatives for new sources of traits. Resistance to diseases (e.g. bacterial blight, common bean mosaic virus, white mold), insects (e.g. bruchids, leafhoppers), and tolerance to salinity and frost are traits that have been progressively discovered in the wild materials of beans. As many accessions in the genebank are now extinct in the wild or in farmers' fields, it's easy to measure the importance of the conservation service that CIAT's genebank provides.

The growing size of the different collections then managed by each program and the challenges of characterizing and

distributing germplasm led to the establishment of the Genetic Resources Unit in 1977. Another important development by the mid-1970s was the establishment of a germplasm health lab for checking the health status of each sample being exported or imported.

Cassava as a clonal crop required the development of specific methods for the safe transfer of vegetative materials across international borders. These included the *in vitro* conservation technology, which allowed the entire collection occupying more than 6 ha in the field to be moved into an *in vitro* genebank in the early 1980s. Using *in vitro* technology, the genebank has distributed samples of nearly all the cassava collection to users in 84 countries.

The Convention on Biological Diversity agreed in December 1993 changed the prevailing norms and placed control of crop genetic resources under national laws. In 1994, CGIAR concluded an agreement with FAO to keep the germplasm collections of the countries in trust for the development of agriculture, particularly in the tropics. Material transfer agreements were implemented and were made common to all the CGIAR genebanks. In 2008, CIAT genebank staff attended the opening of the Svalbard Global Seed Vault in the Norwegian Arctic and, by 2016, 90% of CIAT's accessions of the in-trust collections of beans and tropical forages were safely backed up at Svalbard.

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58 Schultze-Kraft R; Giacometti DC. 1979. Genetic resources of forage legumes for the acid, infertile savannas of tropical America. Pasture production in acid soils of the tropics. CIAT, Cali, Colombia. pp 55-65.

59 Maass BL; Hanson J; Robertson LD; Kerridge PC; Abd El Moneim AM. 1997. Forages. In: Fuccillo D; Sears L; Stapleton P. (eds.). Biodiversity in trust: Conservation and use of plant genetic resources in CGIAR centres. Cambridge University Press, Cambridge, UK. p 321-348.

Today the CIAT genebank keeps in trust the biological heritage of 141 countries, and the collections of beans, cassava, and forage legumes are the largest in the world in terms of size and diversity.

Since 1973, CIAT has distributed 576,002 samples to users in 164 countries.

A total of 323 professionals have received hands-on training and 68 graduate theses have been supervised. Yet to ensure conservation of genetic resources into the future a new generation of genebank curators and professionals in conservation science will need to be trained.

## Biotechnology Unit

CIAT has always been at the forefront of biotechnology research within CGIAR. Over the past three decades, it has created a state-of-the-art bioscience platform – consisting of laboratories and field facilities – where advanced techniques are used in germplasm conservation, genomics and phenomics applications, and genetic transformation.

CIAT established the Biotechnology Research Unit (BRU) in 1985 to include biotechnology tools in the development, characterization, and conservation of germplasm in the crop improvement programs. The strategy of the BRU is to target biological constraints that are difficult to solve through traditional approaches.

Early work focused on the development and use of cell and tissue culture technologies, especially for cassava. CIAT created the Cassava Biotechnology Network (CBN) in 1988 and was also a



main actor from 1991 in the Latin American and Caribbean Agricultural and Forestry Biotechnology Network (REDBIO), which moved its secretariat to CIAT in 2013.

By 1995, CIAT's capacity in molecular biology was also well established and CIAT researchers developed the first cassava molecular map, the first one that was done entirely in a CGIAR

Center.<sup>60</sup> In cassava, and especially in beans, there was a focus on developing capacity in marker-assisted selection in the breeding programs and the molecular fingerprinting of the germplasm collections.<sup>61</sup> A good example is the use of markers for a dominant gene (*CMD2*) for cassava mosaic virus (CMV) resistance to develop resistant varieties in CIAT, where CMV does not occur. This allowed the introduction of Latin American germplasm into African breeding programs where CMV was a major problem. Markers are also used in the HarvestPlus program for the biofortification of beans and cassava.

Genetic transformation is a potentially important part of any crop improvement program, and CIAT has developed its capacity and products in both cassava and rice. With the focus on eco-efficiency, more emphasis was placed on abiotic stresses and water, nitrogen, and phosphorus efficiency, which are primarily multigenic. Transgenic approaches have been used in rice to introduce genes already present in the rice genome more efficiently than could be done through conventional breeding.

In 2007, CIAT received generic permission from the Government of Colombia to evaluate new gene technologies under confined field conditions that comply with national biosafety regulations.

CIAT's biotechnology facilities have become a central focus for training of young scientists from the developing world. In the period 2009–2016, 30 PhD students, 47 MS and 22 BS students conducted their thesis work at the BRU along with many others who received specialized in-service training.

## Natural resource management research

Natural resource management (NRM) research is quite broad in scope, and the research challenge varies depending on the scale, usually either plot, farm, landscape, or agroecology. In the mid-1970s, CIAT focused on its four commodities and at the plot and farm scales.<sup>62</sup>

For the three crop programs, this primarily meant soil and nutrient management and adaptation to edaphic constraints. The Tropical Pastures Program targeted two of the three major lowland tropical ecologies identified by Roberts and Hardin,<sup>63</sup> the savannas and the tropical forest of the Amazon and the Orinoquia.

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60 Fregene MA; Ángel F; Gómez R; Rodríguez F; Chavarriaga P; Roca W; Tohme J; Bonierbale M. 1997. A molecular genetic map of cassava. *Theoretical and Applied Genetics* 95:431–441.

61 Blair MW; Fregene MA; Beebe SE; Ceballos H. 2007. Marker-assisted selection in common beans and cassava. In: Guimarães EP. (ed.). *Marker-assisted selection: Current status and future perspectives in crops, livestock, forestry and fish*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. p 107.

62 CGIAR ISPC (Independent Science and Partnership Council). 2012. *A stripe review of natural resources management research in the CGIAR*. Independent Science and Partnership Council Secretariat, Rome, Italy. p 2.

63 The proposal classified as favorable the coastal areas and the high selvas of the Andes. The Cerrados and Llanos were classified as of unknown potential at the time of the report. The potential of the humid tropics was defined as unfavorable.

However, challenges were emerging on the horizon for pastures. Deforestation had just started with the opening of the Trans-Amazonian Highway in 1972. The 1980s were a period when a consensus among scientists was only beginning to develop around the impact of increasing CO<sub>2</sub> on climate change. Pasture establishment and the area under degraded pastures in the Amazon were rapidly expanding. All of this pointed to a more holistic approach to NRM than just tropical forages, at least in the rain forest of Latin America, which would become part of the rationale for the shift to a NRM research agenda in 1991.

The 1991 strategy marked a turning point in CIAT's approach to NRM research as it gave primary focus to NRM over commodities in the design of its program structure. The research was organized around three agroecologies: the savannas, the rain forest margins, and the mid-altitude hillsides. CIAT entered into this program restructuring when overall funding for CGIAR was declining, and simultaneously the needs were increasing with the creation of new Centers. CIAT used the strategy as an organizing template throughout the decade of the 1990s but was severely financially constrained in fully staffing and implementing the strategy.

To manage the decline in budget over the 1991–1996 period, the Center experimented with a range of organizational models, with a continuing vision of integrating crop improvement and NRM research. This led to organization around more disciplinary research, which culminated in 1996 in a structure based on 16 project areas and the complete closing of the research programs. There were five NRM projects: integrated pest

management, soils, sustainable systems, hillsides, and land use. Research lost its systems orientation to a significant extent, but achieved more flexibility in competing for project funding. During this period, CIAT became an important participant in the CGIAR systemwide and eco-regional programs.

The impacts of this research during the 1990s can only be framed in terms of the products or research outputs that were produced. Some of these found applications in unexpected areas, such as the characterization work by the Agroecological Studies Unit (AESU), which generated an atlas of Honduras that helped in targeting the relief effort after Hurricane Mitch in 1998.

At the turn of the century, CIAT's NRM research, supported by a new strategy in 2001, increasingly shifted its focus to sub-Saharan Africa, particularly Eastern, Central, and Southern Africa. This was motivated in part by the increasing NRM research being done within the PABRA network and the integration of the Tropical Soil Biology and Fertility (TSBF) Program into CIAT. TSBF was incorporated within CIAT in 2001 and at a stroke added a well-developed soils research program based in Nairobi and with a principal focus on Africa.<sup>64</sup>

TSBF in many ways defined the soils research agenda for sub-Saharan Africa. The early research focus was on understanding the biological management of tropical soils. In joining CIAT, this was translated into an applied and adaptive research agenda under the banner of integrated soil fertility management (ISFM). Given the high rates of nutrient depletion in African farming systems plus the high cost and variable access

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64 TSBF (Tropical Soil Biology and Fertility Institute of CIAT). 2006. Integrated soil fertility management in the tropics: TSBF-CIAT's achievements and reflections. CIAT Publication No. 350. TSBF-CIAT, Cali, Colombia. p 3.

to fertilizer, and the general inability to maintain traditional land fallowing systems, the efficient use of limited nutrients was critical in developing effective soil management strategies.

CIAT, during the first decade of the century, seemed well positioned to develop a program for implementing integrated natural resource management (INRM), turning theory into practice. The Africa program participated in three multi-Center initiatives that had INRM at their core, i.e. the African Highlands Initiative, the African Challenge Program, and the Consortium for Improving Agriculture-Based Livelihoods in Central Africa (CIALCA).

Since 2010 and due to the focus on eco-efficient agriculture, NRM research at CIAT has encompassed two broad lines of work: soils and landscape management, and ecosystem services. CIAT's research on land restoration, soil health, and soil carbon sequestration is contributing to major ongoing global and regional initiatives for large-scale land restoration, especially 4pou1000, 20x20 in Latin America, and AFR100 in Africa, as well as CGIAR Research Programs. The work on ecosystem services has contributed to the development of policies for the equitable sharing of benefits from ecosystem services and for determining the level of investment and incentives required to protect them, such as in the case of the Tana-Nairobi Water Fund in Kenya<sup>65</sup> and the Payment for Ecosystem Services law in Peru,<sup>66</sup> both in 2014.

## Decision and Policy Analysis (DAPA)

The Decision and Policy Analysis (DAPA) Research Area was created after the 2008 External Program and Management Review and the program restructuring that followed. As a component of the resulting 2014 strategic plan framed around eco-efficiency, it subsequently became one of the three research areas of CIAT: DAPA, Agrobiodiversity, and Soils. Over the course of the years, DAPA has developed into an important research area in CIAT.

DAPA today consists of three main research themes: (1) climate change adaptation and mitigation, (2) ecosystem services, and (3) sustainable food systems; and five cross-cutting research groups: (1) gender analysis, (2) policy analysis, (3) impact and strategic studies, (4) spatial and agricultural modelling, and (5) big data.<sup>67</sup>

DAPA is in many ways a product of CIAT's history of program recombination to respond to changing global agendas as well as to opportunities within the CGIAR CRP process. It is a recent research area but builds on several research lines that go back through much of CIAT's history, including: (1) data and spatial analysis, evolving from the early work in the Agroecological Studies Unit (AESU); (2) value chains, evolving from early postharvest research and then agroenterprise development; (3) soil, land, and water management work that provided an entry point into ecosystem services; and (4) social sciences which

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65 Africa's first water fund to combat rising threats to food security, water and energy supplies. [press release]. 20 March 2015. <http://bit.ly/1t5WYNL>

66 CIAT. (n.d.). First Peruvian law established for ecosystem services - Update 2016. <http://bit.ly/2xLinkG>

67 CIAT. 2013. DAPA general strategy 2013-2020. Unpublished paper. CIAT, Cali, Colombia. p 2.

have been integrated to varying degrees in major program areas over its history.

### **Data and spatial analysis**

Data and spatial analysis is a central foundation to the work of DAPA, and CIAT's involvement in this area started in the mid-1970s with Thomas Cochrane's agroecological characterization of the land systems in the Amazon Basin. This study led to the creation of the AESU and the extension of agroecological characterization to the commodity programs. This work was the first venture into what has now become known as knowledge management – information and analysis which supported decision making and research design within the commodity programs. This tracks very closely to DAPA's current mission: "To facilitate and improve decision making in the private and public sectors (i.e. agricultural and environmental sectors) by ensuring that decision makers are well informed and engaged."

To undertake this work at a continental scale, AESU engaged from the beginning in the development of critical databases. This formed the inception of CIAT's work on what is now termed big data. In particular, Peter Jones built a climate database of thousands of weather stations across the tropics with the aim of constructing spatial climate surfaces for targeting of agricultural technologies. After a decade of data collection, Jones's research generated decades of research outputs in support of CGIAR's mission. This helped CGIAR and its partners identify priorities, set crop improvement targets geographically, and better understand how to tailor solutions to site-specific problems. Jones's data sets eventually fed into WorldClim, a suite of global gridded climate

surfaces, which was made freely available online and has been downloaded by hundreds of thousands of users, paving the way for open-access culture within CGIAR. The paper published on WorldClim is the second most-cited paper in CGIAR's history, according to a citation analysis commissioned by the CGIAR Consortium Office in 2013.

### **Agro-processing and value chains**

CIAT was an early leader in CGIAR in using a value chain methodology. The value chain work was formalized in the creation of the Rural Agroenterprise Development project in 1996, building on experience in the Cassava Program, where effective demand and uncertain markets were major issues, and in seed enterprise development. By 1998 the research scope had broadened to high-value products such as horticulture and dairy as they often presented better opportunities for poverty reduction.

CIAT developed some innovative approaches in the emergence of equitable "local innovation ecologies" in value chain governance, including collective action to empower communities and entrepreneurs, especially women and learning alliances, to share experiences across communities and value chains.

The most recent of these value chain tools is the LINK Methodology,<sup>68</sup> which aims to enhance smallholder access to markets within private-sector-led market development and which has recently been extended to work on nutrition.

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68 Lundy M; Amrein A; Hurtado JJ; Becx G; Zamierowski N; Rodríguez F; Mosquera EE. 2014. LINK Methodology: A participatory guide to business models that link smallholders to markets. CIAT Publication No. 398. CIAT, Cali, Colombia. Available at: <http://hdl.handle.net/10568/49606>

## **Ecosystem services**

Ecosystem services is a relatively new area of research for CIAT. The work has initially been biophysical in nature and has assessed changes in the “stocks” of water and soil organic carbon (SOC), principally in relation to land-use change from community to landscape levels.

At the same time, there is an obvious interface with the research on climate change in both assessing the impacts of climate change on the provision of ecosystem services and the impact of sequestration of SOC on climate change mitigation.

Ecosystem services such as water and SOC are provided at a landscape level but depend on the decisions of individual land users. Improvements in the provision of ecosystem services depend essentially on improvements in crop and natural resource management practices. The payment for ecosystem services (PES) framework provides incentives for land users by creating a market for ecosystem services. PES potentially provides a vehicle for that long sought-after goal at CIAT of integrating commodity and NRM research.

## **Social sciences**

Social sciences, including agricultural economics, have been a principal component of CIAT research but, except for an early agricultural economics program, there has never been a social science program. Social scientists have been integrated into multidisciplinary teams, apart from the Impact Assessment Unit formed in 1993, which included primarily agricultural economists,

and were distributed both across programs and outposted within regions.

CIAT has had in its history more non-economist social scientists than most other CGIAR Centers. This has partly been due to CIAT’s leadership in the area of participatory research and the work it has done in gender analysis.

Currently, social science at CIAT is essentially located in DAPA, with an emphasis on agricultural economics, particularly in the work on impact assessment, valuation of ecosystem services, value chains, gender, and policy. This is very close to an economics and geography research agenda although it is done within a multidisciplinary team approach, and reflects CIAT’s historical systems approach and the recent strategic frame of eco-efficiency.

## **Institutional innovation**

CIAT is not only associated with a 50-year record of technological innovation. Given its broad and flexible mandate, it has also been at the forefront of a number of institutional innovations.

## **Commodity networks**

The importance of regional networks in sharing germplasm and information was recognized at the outset, and all the commodity programs quickly developed networks at the regional level. The creation of effective networks was recognized as one of CIAT’s major achievements.<sup>69</sup>

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<sup>69</sup> TAC of the CGIAR. 1985. op. cit.

The Bean Program has been consistently commended by external reviews for the quality and innovation in its partnerships. The networks increasingly brought in non-traditional partners from the private sector and civil society, as well as end users. Participatory approaches such as participatory varietal selection and participatory plant breeding became routine practice to meet the diversity of farmer and consumer demands. New disciplines were added especially in nutrition, gender, and value chains.

By 1996, a consortia approach had emerged with the Pan-Africa Bean Research Alliance (PABRA), which by 2016 included 570 partners in 30 countries, reaching an estimated 27 million farmers.<sup>70</sup> A recent favorable review of the achievements of PABRA noted that “CIAT is the mainstay of the PABRA network and will continue to be so in the future.”<sup>71</sup>

Financial sustainability and the orientation to users were further strengthened in rice and cassava networks where members pay the cost of the network and in return set the agenda. FLAR, the Latin American Fund for Rice established in 1995, finances most of the regional breeding work on rice through annual membership contributions from over 30 public and private sector members from 18 countries; annual membership fees are based on the size of the rice sector in the country.

The Latin American and Caribbean Consortium for Support of Cassava Research and Development (CLAYUCA), created in 1999 with support from CIAT, follows a similar model involving nine

countries in LAC and three in Africa, and in fact has gone further in establishing a legal entity, Clayuca Corporation, to share costs, risks, and benefits.

### **Participatory research**

Given its early emphasis on small farmers and low-input approaches to improving productivity, CIAT instinctively developed a strong multidisciplinary orientation to working closely with small farmers. When moving to the four commodity programs in the 1980s, CIAT became a leader in on-farm research with a farming systems perspective, built around the commodity of interest and involving breeders, agronomists, and social scientists.

Training of national program scientists in on-farm research methods was a major focus with nearly 200 participants in 1989 alone. By the end of the decade, CIAT had achieved a “worldwide reputation among professional peers for its innovative approach to on-farm research methodologies.”<sup>72</sup>

The next logical stage in participatory approaches was to empower farmers in decision making about experimental priorities and choice of technology. Two long-term social scientists, Louise Sperling and Jacqueline Ashby, led these institutional innovations in participatory research.

Sperling was a pioneer in participatory varietal selection and breeding. Her classic study of farmers selection of bean varieties

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70 PABRA (Pan-Africa Bean Research Alliance). 2017. Annual Report 2016. CIAT.

71 Robinson J. 2015. The role of CIAT in the Pan-Africa Bean Research Alliance. Independent External Review, CIAT.

72 TAC of the CGIAR. 1990. op. cit.

in Rwanda showed that farmers were more efficient in selecting bean varieties for their diverse environments and tastes than breeders were.<sup>73</sup>

Ashby established the idea of CIALs, Local Agricultural Research Committees, by empowering communities to run their own on-farm research programs. This not only enhanced demand perspectives for technologies but offered a way to greatly reduce costs and to integrate technology delivery mechanisms through the development of community seed enterprises. By 2000, there were 250 CIALs in eight countries with significant spillovers to neighbor communities.<sup>74</sup> The Tropical Forages Program used a similar approach to successfully introduce forages into upland farming systems of Asia.<sup>75</sup>

By 2000, CIAT was recognized as playing “a crucial role in putting participatory research methods on the intellectual map.”<sup>76</sup> This recognition was evident when CIAT was asked to lead the systemwide program on Participatory Research and Gender Analysis (PRGA) from 1996. CIAT, through its strong record on participatory approaches, was already a leader in gender analysis, especially in the Bean Program in Africa where most farmers were women. The PRGA provided a strong conceptual

and methodological basis for gender analysis, but progress in mainstreaming gender in a transformative way in the research programs was much slower.<sup>77</sup>

## Capacity development

Capacity development has been a central element of CIAT’s strategy over the half century but, in many ways, it has had to continuously adapt to changing financial, institutional, and development contexts.

When CIAT was created, there were no universities in Latin America offering a PhD in agricultural sciences and only a few offering an MSc. The constraint was having enough qualified personnel to staff national research programs.

Only a year after becoming operational, the *1969 Annual Report* reported that 11 postgraduate interns, 17 production specialists, and 7 MSc candidates were being trained at CIAT.

With the reorganization into four commodity programs, training was integrated into the different programs and differentiated into: i) multidisciplinary production of in-country short courses

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73 Sperling L; Loevinsohn ME; Ntabomvura B. 1993. Rethinking the farmer’s role in plant breeding: Local bean experts and on-station selection in Rwanda. *Experimental Agriculture* 29(4):509-519.

74 Ashby J; Braun AR; Gracia T; Guerrero MDP; Hernández LA; Quirós CA; Roa JI. 2000. Investing in farmers as researchers. Experience with local agricultural research committees in Latin America. CIAT, Cali, Colombia.

75 Connell J; Stür W; Horne P. 2010. Forages and farmers: Case studies from South-East Asia. Canberra, ACT: Australian Centre for International Agricultural Research.

76 TAC (CGIAR Technical Advisory Committee). 2001. Report of the Fifth External Programme and Management Review of the Centro Internacional de Agricultura Tropical (CIAT) - 2000. TAC Secretariat. p 69.

77 Walker TS; Rathgeber EM; Dhillon BS. 2007. Report of the First External Review of the System-wide Program on Participatory Research and Gender Analysis (PRGA), CGIAR Science Council, Rome, Italy.

covering all aspects of research in a specific crop, and ii) longer term discipline-specific research training where the trainee was assigned to a CIAT scientist.

This approach to capacity development of targeting crop research programs was strengthened by the development of commodity research networks, based on germplasm exchange and developing breeding capacity. This was particularly striking in the bean research networks in both Latin America and Africa. Cassava, however, was limited by the difficulty of germplasm exchange of a vegetative crop. An indication of the investment in human capital development during the 1980s is the training of 2,551 scientists and 72 MScs, counting only those from Latin America.<sup>78</sup>

With the shift in the 1990s to NRM, both the content and the target of capacity development changed quite significantly, although the capacities needed to carry out this emerging research agenda were not clearly known. At the same time, the budget cuts dramatically affected the training program; it was closed in 1995 and reopened in 1996 with a focus on training in research methodologies and developing training tools for training of trainers. Although the limitations of this approach were recognized in the importance to “move from a focus on

training to one of capacity development, from short-term, one-off actions to long-term relations based on dialogue and collaboration,”<sup>79</sup> unfortunately, the reliance on project-based funding did not allow such a pathway.

An initial innovation in terms of knowledge management was the development of learning alliances, “a process undertaken jointly by R&D agencies through which research outputs are shared, adapted, used, and innovated upon. This is done to strengthen local capacities, improve research outputs, generate and document development outcomes, and identify future research needs and potential areas of collaboration.”<sup>80</sup> Learning alliances eventually folded into the broader approaches to integrated natural resource management.

The approach to capacity development at CIAT today combines a number of elements which the Center has developed over the years, including: “(1) partnership strategies, (2) participatory research, (3) learning alliances, (4) monitoring and evaluation, and (5) knowledge management and sharing.”<sup>81</sup>

The challenge is to develop organizational and management capacity in national research institutes that in turn supports the development of systems research and rural innovation capacity.

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78 Janssen et al. 1992. op cit. p 49.

79 Lundy M. 2004. Learning alliances with development partners: A framework for scaling out research results. In: Pachico D; Fujisaka S. (eds). Scaling up and out: Achieving widespread impact through agricultural research. Volume 3 of CIAT Economic and Impact Series. CIAT, Cali, Colombia. p 229.

80 Ibid. p 229.

81 Staiger-Rivas S; Álvarez S; Ashby J; Lundy M; Muthoni R; Victoria PA; Quirós CA; Sette C, Rajasekharan M; Russell N. 2013. Strengthening capacity to achieve eco-efficiency through agricultural research for development. In: Hershey CH; Neate P. (eds.). Eco-efficiency: From vision to reality. Issues in Tropical Agriculture series. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. p 228.



Capacity development has been a central plank of CIAT's strategy over the half century.

# Looking forward

## The past as a prologue: CIAT's evolving R4D program

CIAT's 50-year history has been one of adaptation to both a dynamic external environment and emerging internal constraints in CGIAR.

Among CGIAR Centers, CIAT has had one of the broadest mandates, which it has reinterpreted at various points in this history. However, CIAT's work has to date been built around a foundational core of commodity programs, while maintaining an innovative "leading edge" to address emerging issues.

Global agendas, which have direct relevance for agricultural research, have increased in number and complexity over the course of the last 50 years. Today, over half of the land used for agriculture is moderately to severely degraded; millions of people have an abundance of calories but suffer from poor nutrition; vital ecosystem services are undervalued and at risk; and climate change threatens many of the world's most vulnerable people. The complexity of these issues cuts across scientific disciplines and requires a flexible research program structure.

These global challenges require global action and are now enshrined in the United Nations' Sustainable Development Goals (SDGs) and the Paris Agreement on climate change. These have far-reaching implications for agricultural research and CIAT. They show that the agricultural research-for-development (R4D) agenda has shifted from the idea of "more, better, faster, cheaper" to "more, better, fairer, cleaner." The global community

is asking the agriculture sector to do more than just produce; it is asking it to be a steward of the landscapes in which it generates economic returns.

CIAT and its partners have never been in a stronger position to help achieve the SDGs. That's partly because, in the 50 years since CIAT was established, science has been revolutionized by new tools, techniques, and technologies that have helped research keep pace with the challenges. But critically, there is another reason why CIAT is well placed to play a part in the new development agenda: as documented in this book, it has always been a "systems Center." Over the years, it hasn't just focused on improving key crops, but also on the ways in which they are produced, bought, sold, and how these activities affect the environment, different social groups, and human health.

This multidisciplinary, systems approach has seen CIAT's work evolve from research on crops adapted to particular agroecologies (1967–1990) to the integration of NRM and commodity research in target agroecologies (1991–2007), to the unifying concept of eco-efficient agriculture, which has been its guiding principle for the last decade or so.

Building on this diverse research base, it's now time to further expand CIAT's vision, to one focusing on sustainable food systems. That's because the global development agenda requires integrated responses: food security or nutritious diets, for example, are no longer simply about agricultural productivity or even the availability or affordability of food. They are also about quality, utilization, and distribution of food; about rural and urban consumers' behaviors and preferences; about the incentives and disincentives that food processors and sellers respond to; and about the stability and resilience of food supply

chains in both cities and rural areas. These in turn are closely linked to – and affect – the way we manage our natural capital: soils, water resources, and landscapes more broadly. One of the central challenges for the coming decades will be to deliver healthy diets and to ensure the sustainability of the systems that deliver those diets.

CIAT's expertise (in areas ranging from genetics, soil sciences, and nutrition, to economics, policy analysis, social sciences, and ecology) will play a key role in meeting the growing demand for food and boosting incomes, while reducing agriculture's environmental footprint and achieving greater social equity. The objective for CIAT will be to make it a reality in all the regions in which it operates.

In the coming years, CIAT will aim to strengthen its capacity in social and environmental sciences, and it may consider expanding its crop research portfolio to move beyond its traditional focus on rice, beans, cassava, and tropical forages.

The Center's continued involvement in many CGIAR programs, platforms, and initiatives reflects its unequivocal commitment to collective action at the CGIAR System level as well as the unique character of its individual contribution. CIAT has evolved in step with CGIAR over the years, supporting its transition to become one of the world's largest networks of agricultural research-for-development organizations. CIAT's innovative work in areas such as participatory gender research, biofortification, genotyping and phenotyping, geographic information systems, public-private partnerships, linking farmers to markets, ecosystem services, climate change, and big data – to name a few – have significantly influenced CGIAR research and helped expand its development impact.

To further strengthen its global presence in recent years, CIAT has focused strongly on broadening its partnership strategy and its multiple spheres of collaboration at the national, regional, and international level. At the same time, there are important shifts taking place in the way CIAT's partners and donors operate, which the Center is already responding to. For example, some "traditional" donors would like to become partners; some traditional partners would like to become donors; and there is now a stronger focus on impact at the regional and national levels than ever before. As a result, CIAT will see the emergence of more bilateral partnerships, new relationships with national agricultural research organizations, universities and other advanced research institutions, new agreements with governments and development agencies, and new public-private partnerships.

CIAT will find the best ways to translate donors' investments into tangible benefits. It will aim to balance the need for near-term impacts, while ensuring sufficient expertise is dedicated to issues that require longer term research and engagement.

One strategic undertaking to which CIAT is giving special attention, and which combines global, regional and local dimensions, involves the creation of *Future Seeds*, a new plant genetic resources hub at its headquarters in Colombia. For decades, CIAT's genebank has been at the heart of its efforts to make tropical agriculture more productive and resilient. By creating a new state-of-the-art facility, CIAT will continue to conserve, study, and share valuable seeds for crop improvement work, while looking to expand this work into new areas. In addition, it will share digital genetic information that researchers around the world can use to help them unlock the value of crop diversity – the biological foundation of tropical food systems. Colombia,

the second most biodiverse country in the world after Brazil, stands to gain significantly from the new facility and is actively involved in its planning.

## Staying the course

These are all exciting new developments that will help ensure that as CIAT celebrates its 50<sup>th</sup> anniversary, it maintains a youthful vigor. CIAT has strong organizational, scientific, and financial foundations upon which to pursue these new research directions and partnerships over the next decade, and it is well prepared to carry out its mission of reducing hunger and poverty and sustainably improving human nutrition in the tropics.

In addition, as we look to the future, the benefit of five decades of experience tells us that some things certainly won't change. Agriculture will continue to be an important driver of economic and social development in many parts of the world, and this will continue to have profound implications for the environment, equity, and human health. That means CIAT will remain committed to producing independent scientific research that policy makers can use to boost the productivity, competitiveness, and sustainability of farming. It will also remain committed to innovative research that is targeted, inclusive, long lasting, and that improves both lives and landscapes. In short, the Center will continue to demonstrate the enormous potential of its science in helping achieve a sustainable food future for all.

As the current Director General Ruben Echeverría noted:

*I'm immensely proud to look back at five decades of CIAT research, and equally excited about the emerging opportunities. CIAT's achievements are a great testament to the dedication, ingenuity, and perseverance of its research and administrative staff, and its partners all over the world. I would personally like to thank everyone who has contributed to CIAT's success, and join the global development community in looking forward to the work ahead.*

*This is a summary of the book*

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