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CIAT IN THE 1990s

A Strategic Plan



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Centro Internacional de Agricultura Tropical (CIAT)
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WHO ARE WE?

CIAT is a development-oriented, agricultural research institution dedicated to the application of science toward lasting alleviation of hunger and poverty in developing countries.

WHAT IS OUR MISSION?

CIAT contributes to economic development and poverty reduction in developing countries by applying modern science to the generation of new technology that will increase food production and productivity. This mission can be accomplished only by working in partnership with various institutions, especially national agricultural research organizations.

WHAT WILL OUR BUSINESS BE IN THE 1990s?

CIAT will concentrate its efforts on common beans, cassava, rice, tropical pastures and land use management. These research efforts will be supported by specialized research, training, communications, germplasm, seed, and research services units and programs. The products of these efforts are knowledge, technology, methodology, stronger national and regional research programs, and improved intranational cooperation.

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FOREWORD

We are pleased and proud to present this Strategic Plan for CIAT in the 1990s. It describes the enduring values and new strategic directions that will guide the Center as it approaches the 21st century. It will also serve as the road map for the development of medium-term operational strategies and annual work plans as CIAT enters its third decade.

In its first decade of operations, the 1970s, CIAT developed its facilities and programs. This was a period of rapid expansion. At the same time, it was one of circumspection as the Center moved from a broad initial base to a lesser number of more sharply focused programs. By the end of the decade its efforts in rice improvement, built on the technological base and materials from IRRI and a close partnership with the Colombian national rice program, had already achieved a major impact on national rice production statistics in Latin America.

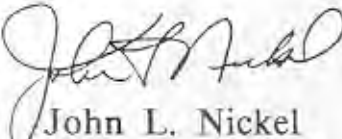
During its second decade, the 1980s, CIAT consolidated its efforts in Latin America, building stronger ties with national research and development systems, and decentralizing a growing share of its operations. During this period it also expanded its activities to include selected areas of Africa and Asia. By the end of the decade, measurable impact was already seen for all its programs in farmers' fields and in national production figures of various Latin American countries.

In the decade of the 1990s we expect that the many emerging technologies already in the pipeline will have growing impact in the Americas, Africa and Asia. We also expect that CIAT's long-standing sustainability and equity perspectives will ensure that these gains are lasting and environmentally sensitive. We plan to expand our efforts in this area to make sure that badly needed improvements in productivity are based on practices that preserve the natural resource base on which future progress will depend. We also plan to further accelerate the incorporation of advances in science into our efforts and to respond to the changing needs of our national program partners.


This strategic plan is the product of a two-year effort, involving the entire staff of CIAT, its Board of Trustees and many people from outside the Center. Extensive consultation with developing country research leaders and individual scientists, through task forces and workshops, has characterized this process. We acknowledge with gratitude the contribution of the many highly qualified individuals that have given their valuable time to help us in the development and review of the various components of this plan. We also acknowledge the assistance of Dr. Jeffrey Watson, who helped us transform a much longer draft of this plan into a more readable document.

This is a strategic plan. It describes the Center's overall philosophy and the trends, directions and changes in emphasis that will characterize it in the years ahead. While the issue of financial and human resources is approached in a general way, the plan addresses neither budgetary details nor specific changes in resource allocation. These will be dealt with in the five-year operational plans which will be developed for each half of the decade. Ideally, the first operational plan would accompany the strategic plan. This has not been done in this case because the leadership of the Center will change in early 1990. The CIAT Board considered it best to allow the newly appointed Director General to take the lead in translating this plan into operational terms. This will be done, and the operational plan presented to TAC, in early 1991.

We are confident that the strategy elucidated here, implemented in a flexible manner by a dedicated staff, supported by committed donors, and executed in partnership with national and international research and development institutions, will contribute to a brighter 21st century for those we serve. By working together in the urgent task of alleviating poverty and hunger we will contribute to achieving a more just, secure and prosperous future.



John L. Nickel
Director General



Frederick E. Hutchinson
Chairman, Board of Trustees

EXECUTIVE SUMMARY

This plan is the result of an intensive, interactive process involving CIAT's Board of Trustees, internal task forces and consultation with many national programs leaders. The planning horizon chosen is ten years. Results from the planning process show that change in the environment in which CIAT operates is rapid and continuous. Although it was concluded that CIAT has the appropriate commodity mix, some adjustment of priorities is needed. It is clear that the Center must respond to four particular trends:

- Evolution of national programs; they will vary greatly in their strength and rate of development, challenging CIAT to respond flexibly to their needs. This will gradually modify our respective roles.
- Projected trends in production and consumption of CIAT commodities; demand will exceed supply unless new production technology is generated and adopted.
- A changing scientific and technological base; rapid advances in biotechnology-based solutions to agricultural problems and the information and communications revolution will offer powerful alternatives to the way CIAT does its business.
- Concern for sustainability of production; while lasting solutions have always been a fundamental cornerstone of CIAT's philosophy, there is a growing worldwide recognition of the need for environmentally sound approaches to all aspects of development. We will need to intensify our efforts in this area and join with others to work for sustainability in all production systems.

These strategic issues arose from careful evaluation of how CIAT's external

environment will change. We also looked at CIAT's internal environment, reaffirming CIAT's mission and the institutional culture needed to carry it out. It was recognized that our goals of poverty and hunger alleviation would not only require continued concern for both poor consumers and low-resource farmers, but entail greater attention to income generation and maximization of social returns to research investments. Partnership with national programs and linkages with advanced research institutions, development entities and other international organizations will be necessary to achieve these objectives.

Looking ahead to see how these considerations will affect our interface with the NARDS, we anticipate that increased emphasis will be given to specialized research support; to methodology development and training; to selection and characterization of parental materials for use by NARI partners; to facilitating horizontal technology transfer; and to serve as a bridge between advanced institutions and NARS. There will be a parallel decrease in production training and on-farm production research at headquarters and in the development of finished varieties.

To meet sustainability objectives CIAT will increase its activities on characterizing genetic resources, assessing long-term impact of component production technology on soil properties, and the fostering of integrated pest management. Programs will give greater emphasis to a sustainability perspective; the Agroecological Studies Unit will be strengthened to support them in these endeavors. A special task force will undertake a study to determine what CIAT's role should be in a possible broader ecosystem-focused approach to agricultural development that goes beyond specific commodity program activities.

CIAT will move upstream in the 1990s with a gradual shift from applied to strategic research. In addition to using new biological tools to solve important production constraints, strategic research will obtain a better understanding of biological processes, nutrient utilization and rhizosphere interactions. This work will be facilitated by development of cooperative upstream networks. Continued downstream activities will be required as well in areas such as product utilization and marketing, seed supply and the training of trainers for national programs' efforts to improve technology transfer.

This plan will be implemented through multidisciplinary programs supported by specialized research units. Some of the ways in which program emphases will change are:

- The Bean Program will give greater attention to nutrient and water-use efficiency, yield potential and a better understanding of *Phaseolus* germplasm. Emphasis in research on biotic constraints will shift to broadening the genetic base of resistances and developing integrated control strategies, principally in decentralized programs.
- The Cassava Program will increase emphasis on agronomic, physiological and biochemical characterization of germplasm and pre-breeding to provide improved gene combinations to national programs. Emphasis will be devoted to developing technology for commercial cassava production from true seed. Agronomic research will have a strong focus on the conservation of natural resources. National program strengthening will be accompanied by further devolution of research and development activities, especially in integrated production and marketing projects.
- The Rice Program will devote an increasing share of its resources toward agronomic and integrated pest management practices and at reducing production costs in both irrigated and

upland systems. During the decade the trend will be toward balancing the research effort between irrigated and upland rice. In breeding, it will concentrate more on exporting the germplasm base and providing good parental materials and early breeding lines to national programs.

- The Tropical Pastures Program will give greater attention to documenting the commercial feasibility of grass-legume pastures and their role in maintaining or recovering soil quality in marginal lands. It will cooperate with other commodity programs in developing integrated crop-pasture farming systems.

All the commodity programs have included among their objectives the strengthening of national programs in their ability to work as effective partners in conducting complementary research to adapt technology to local production systems and ecological conditions. The Training and Communications Support Program will assist these research- and institution-strengthening roles through the training of NARDS' staff, provision of scientific and technical information, promotion of cooperation both among NARDS and between them and CIAT, and by fostering a favorable policy environment for agricultural research through public information.

The research support units will focus their specialized efforts on those areas of highest priority to the commodity programs. Collaborative research with advanced scientific institutions will enhance the work of these units, particularly in the fast-paced field of biotechnology.

Criteria for arriving at an appropriate balance among commodity programs and between different types of activities within programs include the comparative advantages of CIAT, the present and potential contributions of different commodities to economic development, and equity and sustainability considerations. These criteria will

be further refined in the allocation of resources when the five-year operational plan that will follow this strategic planning exercise is developed. The Center has committed itself to a policy of highly restricted growth that will demand the phasing down or out of selected

activities in order to carry out the increased emphases described in this plan. Adoption of new technology will be monitored to ensure that it has the desired social and environmental impact.

Chapter I

THE EXTERNAL ENVIRONMENT

The environment external to CIAT is changing and will continue to change. Determining strategic shifts necessary to cope with this changing world requires an analysis of the probability and degree of adjustment that may be needed over the next ten years. This chapter examines projected trends in food and agriculture, with specific reference to CIAT's commodities; the physical environment; the institutional environment; and the scientific base. It also analyzes the challenges and opportunities arising from these trends.

Trends in Food and Agriculture

CIAT programs represent an appropriate commodity mix. With beans and cassava as chiefly small-farmer crops and rice and pastures important for frontier expansion, and all contributing to production of important basic food commodities, a good balance has been achieved. Previous plans have confirmed the suitability of the current commodity mix in relation to the needs of poor consumers and small farmers and the complementary actions of other international centers. The task force charged with looking at future trends concluded that there will be a strong need for international attention to the CIAT crops for the next decade; that we should continue to focus on these and not add new ones. Details are available in Appendix C of the accompanying document. This chapter will limit itself to a brief overview of the outlook in the 1990s for regions where CIAT's mandated commodities are most important.

Latin America

General outlook. Although undernutrition is milder in Latin America (13%) than in other regions, average caloric intake is below

recommended levels in many countries. Daily caloric intake ranges from 1905 in Haiti to 3380 in Argentina. These national figures mask serious problems, resulting from skewed income distribution, even in countries that appear to have adequate food supplies. Risk groups are very susceptible in periods of recession.

The debt crisis in the region will continue to cause severe curtailment of government services and leave limited public funds for investment. In spite of the recognition that an efficient agricultural sector is key to a new development strategy, fundamental changes in the research and technology strategies are not expected. Thus, we predict continued underinvestment in agricultural research, in spite of its proven high payoff. Commercial production on medium-sized farms is becoming more important and many small farmers are integrating themselves into the market economy. The gap will widen between those who respond to new opportunities and technologies and those who do not. Many of the marginal poor will form a class of landless and urban laborers.

Lack of public resources will limit infrastructure at the agricultural frontier over the next decade. Thus, intensifying use of land already farmed, not area expansion, will have to be the source of agricultural growth. Use of extensive pasture land for crop production and development of integrated crop-livestock systems will facilitate this intensification.

Agricultural growth will have significant multiplying effects outside the sector. With the new economic policies of austerity, technology development is among the few feasible options for stimulating agricultural growth. An increased market orientation will ensure that such technology improves the welfare of poor

consumers and enhances the livelihood of small farmers. Technology for favorable production conditions offers great potential to realize such growth.

Pressure on the fragile frontiers can be partially relieved by increasing the sustainable production capacity of less fragile land.

Beans. Beans are an important small-farmer crop and the most important food legume for low and middle-income rural and urban populations of Latin America. Availability of beans at an affordable price is important to many people, and thus to policy makers. Increases in production in the past decade resulted mainly from increases in area cultivated, often in marginal areas, and not from increases in productivity. To stop further use of marginal lands, profitability increases and risk reduction are critical. Beans are often grown in highly complex production systems where they face competition from other crops. Strategic crop management research to complement genetic improvement will be needed.

For the region as a whole, projections of production and consumption trends point to self-sufficiency in bean supplies in the year 2000 in Latin America as a region. These, however, mask strong subregional differences: Brazil and the Andean region are projected to have deficits.

It is likely that improved varieties and improved management will increase productivity and allow total production to grow more rapidly than the population, thereby diminishing pressure on prices.

Cassava. Cassava is a small-farmer crop grown in marginal areas where low-fertility soils and water availability limit other crops. It is also very reliable, producing a harvest when other crops fail during periodic drought. Because of their bulkiness and perishability, urban consumption of fresh roots is less than in rural areas. The major areas for market expansion are seen to be in conserved fresh cassava, animal feed and refined flours.

New technology that extends fresh cassava shelf life has high levels of consumer acceptance, resulting in increased demand. Cassava is used increasingly in animal and shrimp feeds. This demand, coupled with the deficit of cereals in tropical Latin America, indicates great potential for dried cassava in animal feeds at existing costs of production. The animal feed industry effectively guarantees a stable minimum floor price if the product is dried. The modern urban dweller consumes large quantities of flour. Cassava, suitably processed, is a good partial substitute for wheat, which is mostly imported. Therefore, considerable demand for cassava flour is predicted and may be a major growth area in the coming decade.

With increasing market alternatives, farmers are now demanding new production technology. The rate of return on cassava research is likely to be high and progress rapid. The prognosis for cassava in Latin America is therefore very good.

Rice. Rice is a relatively new staple in the Latin American diet, averaging an annual per capita consumption of 30 kg. Among the poor of many countries, it now represents 25% of caloric intake and 15% of food expenditures. The rice economy of Latin America is characterized by two dichotomies: about 70% of planted area is upland rice, but 70% of production comes from irrigated areas; most farmers have 20 hectares or less, but most production comes from larger farms.

The overall current deficit of 1.2 million metric tons is expected to remain at about the same level until the year 2000, because of offsetting trends in the deficitary position of tropical Latin America and the increased surpluses of the Southern Cone. Crop management practices are a major limitation to further productivity increases, especially since new varieties have been adopted by most farmers in the irrigated sector. The genetic and cytoplasmic base of modern varieties in the region is disturbingly narrow. One parent, IR 8, predominates and all modern semidwarves share a common cytoplasm.

Improving harvest and postharvest technology and cultural practices is an area of high potential impact. Waste reduction, for example, can increase food availability without intensifying pressure on the resource base.

There will be a tendency for rice to be displaced toward more marginal areas by crops that are more efficient both in the use of water and producing higher incomes. This points to the need to improve the biological efficiency of irrigated rice and at the same time to develop new technology for growing rice in upland systems.

Tropical pastures. Beef and milk are staple foods in Latin American diets. Average annual per capita beef consumption is 16 kg. The combined food budget share is over 20%, even for the lowest income groups of the urban population, ensuring high priority in food policies. Although cattle surpass 250 million head (about 20% of the world total), trends show decreasing self-sufficiency in beef, with projected imports of about 360,000 metric tons in year 2000. The Andean region is expected to be self-sufficient and Central America to continue being a net exporter.

The area will continue being a net importer of milk and dairy products, with decreasing self-sufficiency levels. Technical change in pastures could reduce domestic milk prices and generate income for small- to medium-sized dairy farms.

Of 800 million hectares of savannas and forests, a large proportion have acid, low-fertility soils. The 250 million hectares of tropical savanna have great agricultural potential because favorable solar radiation, rainfall and temperature allow extended growing seasons. While the soil structure and topography of the savannas are generally favorable, the soil chemistry dictates high inputs for intensive crop production. Although parts of the forest area (100-150 million hectares) have potential for cropping and livestock production, they are at high environmental risk with current production practices.

There is a clear need for the stable, more highly productive technology of legume-based pastures. The rate of expansion of land for cattle will diminish because of distant markets, fragile ecosystems and lack of public funding. Production growth can be achieved by increasing land-use intensity on present marginal and frontier lands. The relative attractiveness for improving pastures will therefore increase. As subsidies to fertilizers are removed, nitrogen-fixing legumes will become more important. Because of increased cropping in prime lands, cattle are being pushed increasingly into marginal areas where, in some instances, the proportion of the national herd of cattle has doubled. Contrast this with reductions of 50% in many fertile areas. The resulting lower productivity of cattle on these marginal lands, coupled with environmental fragility and the lack of sustainability, are major concerns.

The new technology based on adapted grass-legume pastures has great potential for increasing cattle productivity and improving sustainability of pasture-based production systems in the acid-soil regions of tropical America.

Africa

General outlook. The key to economic development in sub-Saharan Africa is agriculture: it is the only sector in which future employment opportunities can be readily created; it offers the best opportunity for earning foreign exchange; it can provide for a nation's food security needs; and 75% of the population already earn their living in agricultural production.

Growth in income levels are insufficient to stimulate increase in demand for food commodities. Growth in demand will mainly be population based. Developing technologies that are adoptable in this economic climate is a challenging task. Only those technologies that are low cost with minimal risk are suitable for most farmers.

Beans. Beans are the principal source of protein for over 70 million people in sub-Saharan Africa. Consumption reaches 50 kg per capita annually in Burundi and Rwanda. Production is by small farmers, mostly women, and is primarily subsistence. Production is concentrated in the highlands of eastern and southern Africa—in some of Africa's most densely populated regions. Continuing intensification of land use often threatens the natural resource base.

Increases in bean production from area expansion are occurring at a decreasing rate—a disturbing trend. A 750,000 metric ton deficit in Africa is projected if trends continue, equalling 18% of expected consumption by the year 2000.

Demand growth for beans in Africa will outstrip that of Latin America. The total demand by the year 2000 will have increased 70% over 1985 figures and will then be equal to that of Latin America. Meeting this demand will be critical for human nutrition. In the past, growth in bean production has lagged behind that of population growth. The demand for new technology will therefore be strong among farmers. Nonetheless, through the next decade and beyond, most production will occur in a subsistence setting where cash is scarce and the use of purchased inputs will be low.

Cassava. After maize, cassava is the most important caloric staple in sub-Saharan Africa. It provides over 200 calories per day for 200 million people. Cassava's central role in the African diet takes on special importance as it is in Africa where food production has declined most rapidly. In the short term, increased cassava production will help reverse declining food availability. The long-term contributions cassava can make to the overall development of the African agricultural sector need study, as data on these issues are virtually nonexistent.

Cassava's future in Africa rests upon its income generation potential. This potential is linked to developing market surpluses and identifying and developing markets. These issues in turn lead to questions about the type

of product and associated interventions needed in processing technology and marketing channels, and the effect of pricing policies on substitutes. Cassava has a potential role as a farm income source in current production areas if marketing channels to growing urban areas can be opened. It could also be a stabilizing component for farming systems in marginal, food-deficient areas. To develop strategies to foster these roles, it is necessary to consider the foregoing issues. The joint IITA/CIAT agro-economic study of cassava in Africa (COSCA), now underway, was initiated to shed further light on those issues.

Tropical pastures. The West African countries have important subhumid and semiarid savanna land resources. These are under increasing ecological threat because of growing cattle numbers made possible by reduced trypanosomiasis incidence, which, in turn, is caused by deforestation brought about by increasing human population. Desertification of the Sahel is also contributing to higher stocking rates on the grasslands. Overgrazing, together with short-fallow shifting cultivation, are causing soil erosion and degradation of both vegetation and land. Incorporation of improved, legume-based pastures in the farming systems can make an important contribution to sustainable production in these areas by increasing carrying capacity and improving soil quality.

Asia

Cassava. Rice is the dominant calorie source in Asia. Cassava's main role has been to provide a cheap food source to augment the calorie intake of the poor, particularly in Indonesia and India.

Cassava production in the region has more than doubled in the past twenty years to about 47 million metric tons. The largest producer is Thailand (38%). A multiple-use cassava market system is already well developed in Asia, with cassava uses spanning a range from basic food source, through dried pellets for animal feed,

to high fructose syrup. Cassava is the second most important starchy staple produced in tropical Asia and is a major cash crop in the upland areas. It has achieved this prominence because of the diversity of investments, mostly in small-scale processing capacity and because of the versatility of cassava as an upland crop. Its high-yielding ability makes it suitable for the needs of very intensive systems, as reflected in yields of 30 tons per hectare in Tamil-Nadu, India. Moreover, cassava is also well adapted to the more extensive systems on the agricultural frontier of tropical Asia and to the spectrum of upland areas with major rainfall or soil constraints. Nevertheless, because it is often grown on fragile soils with little or no fertilizer, and its relatively slow growth leaves soils exposed to erosive forces, there is a need to develop more sustainable production systems for this crop.

Certain Southeast Asian countries have fallen out of the mainstream of the Pacific economic miracle. Annual growth rates in cassava production have been very high in these countries over the last two decades: Burma (13%), Kampuchea (10%), Laos (12%), and Vietnam (8%). These countries indicate the fundamental role that cassava plays in maintaining food supplies under crisis conditions and when economies revert to near-subsistence levels. Cassava will continue to play this role. What is new, however, is the realization that cassava has an increasing role to play in the rapidly developing economies such as those of Indonesia and China.

Market diversification in Asia, particularly in Thailand, over the last two decades has been heavily influenced by the export market for cassava. Export prices are set by special tariff for cassava pellets in the EEC. In general, some Asian countries have found it more profitable to export cassava and use domestic or imported maize in their animal feed industries. The challenge is to make cassava fully competitive with coarse grains in an open, integrated market. There is good reason to believe that new production

technology can sufficiently reduce costs to achieve this goal.

Markets for cassava in Asia are growing to the point that production is not keeping up with demand. The market structure already in place has the capacity to absorb significant increases in production without drastic declines in prices. In the coming years, it is expected that cassava will continue to move into new markets and that native Asian ingenuity will find new uses for cassava as it has in the past. In addition, the poultry feed market is growing very rapidly in Asian countries, further increasing the potential demand for cassava pellets. New cassava technology could bring benefits to those farmers who were bypassed by the Green Revolution, especially those who have a much poorer resource base than those who benefited from the new rice and wheat technology.

Tropical pastures. Per capita incomes are growing rapidly in many countries of Southeast Asia and populations are growing at 1.4% to 2.5%. These factors, together with the high income elasticity of meats and dairy products, are triggering growth in demand for animal products. However, the ruminant animal/human population ratio is only about 20% of that of Latin America. The land is mostly used for food and industrial crop production and ruminant production is therefore integrated with mixed farming systems.

The large, predominately rain forest areas of the Philippines, Thailand, south China, Sri Lanka, Malaysia and Indonesia have been disturbed. Two situations can be identified in relation to CIAT's contributions.

- First, on poor acid soils, short-fallow shifting cultivation and unsuccessful plantations have left large areas of *Imperata cylindrica* grassland which have low productivity and palatability.
- Second, cover crops and native grasslands under successful plantations on

moderately acid soils are being used to supply the growing regional demand for beef and dairy products. Shade-tolerant grasses and legumes, as well as management strategies, are required for integrating pastures and grazing.

Preliminary evaluation of CIAT germplasm has identified a number of grasses and legumes which show great potential for improving pastures, both in the open and under trees.

Beans. In West Asia, some 400,000 tons of dry beans are being produced annually, with Turkey and Iran being the major producers. Beans complement many other food legumes such as chickpeas, lentils, and broad beans. The competition between these crops indicates that relative prices and product quality will be the determining factors for the future of beans in the region. Beans are often produced in West Asia and North Africa as a spring or autumn crop under irrigation. The close interaction with other crops, the present labor costs, and growing salinity problems justify future research on beans in this region.

Snap beans (string beans) are produced in South and East Asia, particularly in China, and in West Asia. Estimated production in China and Turkey alone is 3.4 million tons per year. Snap beans are a high-value vegetable crop. Their production is under intensive management and creates considerable employment. Snap bean production suffers from pests and diseases, largely because of inappropriate varieties.

With increased incomes in many Asian countries, people are diversifying their diets and demand for more vegetable crops is increasing rapidly. This ensures that an increased supply of snap beans will be readily absorbed and will effectively contribute to improved availability of minerals and vitamins in the diet. At the same time, increased snap bean production will increase the incomes of many Asian small-farm families. Development of resistant varieties will help reduce the very high current usage of pesticides on this crop.

Changes in the Physical Environment

We assume that, during the coming decade, concern about environmental changes will continue growing. Global concerns about environmental degradation include global warming, depletion of the ozone layer, reduction of floral and faunal diversity, species extinction, depletion of nonrenewable resources, soil erosion, declining soil fertility, silting of water catchments and environmental pollution. Most relevant to CIAT's strategies are those activities that contribute to these processes and that are directly related to agricultural development. These are deforestation in fragile ecosystems, misuse of chemical inputs, inappropriate land use and cultural practices that deplete natural resources, soil erosion, loss of soil fertility, reduction of genetic variability and pollution.

Currently the loudest and most strident voices on these issues are heard from industrialized countries. But sustainability issues in the developed world, resulting mainly from excessive use of external inputs in a surplus-producing agricultural sector, are certainly different from those in the developing world. In developing countries, environmental degradation is mainly caused by increasing demographic pressure on fragile lands, motivated by deficits in internal food production. Challenges are therefore different: in the developed world, they are to decrease chemical pollution and meet a growing demand for "natural," albeit more expensive, food; whereas in the developing world, they are to use external inputs judiciously and efficiently without degrading the natural resources.

Leaders of developing countries are recognizing that the very resource base on which future development rests is being threatened. We expect this trend to continue, resulting in changing national policies. An important change will include the elimination of incentives for large-scale clearing of tropical forests. This will move the focus from tropical deforestation to small-scale settlers.

Increasing population pressure will continue to contribute to these problems. World population is projected to reach 6 billion by the year 2000. Urbanization is increasing greatly in Latin America, creating an urban poor that has a poorer quality of life than the rural poor. Almost 75% of the population will be urban dwellers by the year 2000. Population migration will also continue. Settlement at the frontier will continue, especially in the rain forests, as people are attracted by low-cost land, abundant water and potential income from timber. Although these fragile environments are initially productive, they are not sustainable with existing technology.

Poverty, economic development and natural resources exploitation are intimately intertwined. Population pressures force farmers to abandon long established practices that conserve the soil, to farm marginal land unsuitable for cultivation, and to overgraze their pastures. As natural resources are depleted, productivity declines and poverty becomes more intense. Thus, people desperate to provide a livelihood for their families impoverish both the environment and themselves. The depletion of natural resources will, therefore, be intimately linked to the erosion of social resources in rural life.

Family support systems and community structures that otherwise discouraged wasteful resource use are undermined by population pressures, outmigration of the young, and the increased burden of semisubsistence farming carried by women. Ensuring an equitable distribution of benefits within the household will be integral to achieving social as well as technically sustainable production.

Just as poor farming households are trapped between the imperatives of current survival and the need to conserve natural resources, the nations in which they live are caught in the web of ecological and economic adversity. Their limited economic resources will continue to seriously constrain their ability to stimulate economic development. Likewise, there will be constraints on developing institutions,

infrastructure, and policies that will make feasible the rational exploitation of their natural resources in a manner consistent with the needs of future generations.

A scientific research institution cannot solve all these problems. The policies of governments, institutions and international bodies are critical. Global environmental issues will have to be addressed by major international efforts and CIAT will add its talents to provide solutions where possible. The acceleration of colonization of the humid tropics is a socioeconomic issue that is difficult to stop but one that must not be ignored. The need to provide alternative stable production systems is critical.

Technology development is a powerful tool to enhance food availability to consumers and at the same time improve income to producers, enabling them to use practices less destructive to the environment. A summary of the implications of the changing scene in food and agriculture and the growing environmental concerns for technology generation in CIAT programs is given in the following Box.

Evolution of the National Programs

National agricultural research and development systems (NARDS) are expected to change over time in two basic ways: in the quantity and quality of human, physical and financial resources available to them; and in their research and development priorities. Both factors will significantly affect the "derived demand" for CIAT's services and the nature of the partnership. We consulted extensively with NARDS leaders to obtain their views on how their institutions would change during the next decade (see Appendices B, D and E for details on the nature and results of these consultations). The main conclusion reached from these consultations was that the current status of the NARDS is highly variable and will probably become even more so in the coming decade, with some growing stronger and others remaining weak or becoming

Technology and Research Implications of Socioeconomic and Environmental Trends

All CIAT Programs

- Increase food availability
- Emphasize income generation
- Expand sustainability perspective
- Develop low external input technology
- Understand plant and soil relationships

Bean Program

- Improve yield potential
- Improve nitrogen-fixing capacity
- Improve tolerance to poor soils and water stress

Cassava Program

- Expand work on root quality
- Emphasize adaptation to drier climates
- Improve yield potential

Rice Program

- Broaden genetic diversity
- Improve biological efficiency and stabilize yields under irrigation
- Expand rice-growing alternatives for upland systems

Tropical Pastures Program

- Emphasize grass-legume associations
- Develop crop-pasture farming and silvopastoral systems
- Improve nutrient recycling

weaker. There has been a general improvement in the level of training and experience of scientists (largely related to CIAT's training efforts). This trend is expected to continue, but will often be offset by defections from agricultural research because of continuing lack of operational support and poor pay.

From the key issues that emerged regarding changes in the NARDS, we can construct this future scenario:

- National partners are more complex: those that are predominately technology generators emphasize technology transfer; private sector is larger; IARC-NARDS interface is more complex.
- Some national agricultural research institutions (NARIs) are better funded but still short of operational support.
- Human resources improve in quality and experience; low levels of operational support erode and underutilize them.
- Gap between research and extension narrows because of greater efforts in on-farm research (OFR), but much less than desirable because of the OFR's high operational costs.
- National research emphasizes sustainability, income generation, export crops, biological forms of pest control and fertilization. More emphasis is placed on policy research for agroindustrial development, especially for increasing aggregate values and employment generation.
- Smaller NARDS consolidate nationally oriented expertise; regionally oriented

division of labor increases with closer country integration and better use of scarce resources. Networks are a more important tool for integrated scientific and technological capability at regional levels.

- Some more advanced NARIs continue to strengthen plant breeding capacity, taking over some activities previously performed by IARCs.
- Many national agricultural research systems (NARS) move upstream to remain at the cutting edge of science and to solve, at country level, problems requiring considerable sophistication. Greater demands for methodological support are placed on IARCs and partnerships are formed with new research organizations in the NARS.

In general, NARS see their relationships with IARCs as evolving into a much more collaborative partnership mode, based on complementarity, with "comparative advantage" replacing "gap filling" by the IARCs. There will be countries where the current research capacity and resource levels are low and a significant increase in research capability cannot be envisioned. Such countries will continue to rely on regional cooperation and international efforts for research results and applied technology, which, with increasingly efficient communication networks, will be more easily transferred.

Trends in Science and Technology

Rapid advances in the biophysical and social sciences will make new tools available for our research, and the fast-moving scene in communications technologies will affect how CIAT does its research and disseminates its results.

The great advances made recently in biotechnology are expected to continue. Laboratories in industrialized countries carry out a great deal of research that is beyond the

capacity or mandate of CIAT. Yet the application of the results of this research is of fundamental importance to problems affecting poor farmers and consumers. We expect that research linkages with laboratories in both industrialized and developing countries will provide CIAT with advanced techniques that will help solve some of the more critical problems facing us. In particular, biotechnology should be able to assist in achieving breakthroughs. Techniques such as protoplast fusion, hold promise for improving yields in beans, especially in areas of drought and where soils have poor water-holding capacity. Increasing the photosynthetic efficiency and yield of cassava, especially under stress, will need the expertise of physiologists and biotechnologists from advanced laboratories. Stabilized disease resistance is critical for all species at CIAT.

There is no place for isolationism in the international community of agricultural commodity research. In addition to integrated planning, the results of research must be freely shared to assist one another achieve mutually similar goals. This can be done through the development and maintenance of standardized, compatible information transfer systems. The 1980s ushered in the Information Age in most industrialized countries. Advances in telecommunications technology and information processing, and storage and retrieval have forever altered the way knowledge is created and applied to problems. The 1990s may see the developing countries make as great a leap forward as from the oxcart to the airplane in adopting information technology which is becoming cheaper and easier to use.

The challenge for CIAT in the coming decade is to be vigilant in monitoring developments in its external environment, adapt those that show promise, and be assertive in linking with those who, through collaborative research or by contract, can most cost-effectively lead CIAT faster toward its goal of lasting alleviation of hunger and poverty.

CIAT IN PERSPECTIVE

Planning is influenced not only by the external environment of an organization, but also by the nature of the organization itself. Here we describe the basic purposes of CIAT and its enduring culture, answering in turn what CIAT is, what it does, and what its achievements have been in relation to its strengths and constraints, thereby setting the scene for strategic issues to be considered for the 1990s.

The CIAT Culture

The basic purpose of CIAT's existence has not changed since its creation. During two decades of work an institutional culture has evolved. This culture embodies basic values which translate into a set of operating principles. These values form the philosophical foundation upon which the Strategic Plan for the 1990s was developed.

CIAT is:

a development-oriented, agricultural research institution dedicated to the application of science toward lasting alleviation of hunger and poverty in developing countries.

Over 700 million people suffer from malnutrition, causing great reduction in human capacity as well as increased mortality and susceptibility to disease. The basic cause is poverty, that is, the lack of sufficient income to purchase food for an adequate diet. Some other causes are inadequate food production and resources to import food. Any solution to the world food problem, although dependent on sufficient quantities of food staples, ultimately boils down to raising the income levels of the poorer segments of the population.

The essence then of CIAT's values is a concern for human dignity and welfare. The

alleviation of poverty and hunger is a prerequisite for the betterment of the human condition. CIAT also believes in a more equitable society and actively seeks that the benefits of its work favor the underprivileged. CIAT staff hold themselves accountable to those they serve as well as to those who provide the resources that make these efforts possible. These cultural values determine the operational principles we follow to achieve our mission.

Mission and Operational Principles

In line with its culture and basic values, CIAT's mission is:

to contribute to economic development and poverty reduction in developing countries by applying modern science to the generation of new technology that will increase food production and productivity. This mission can be accomplished only by working in partnership with various institutions, especially national agricultural research organizations.

In carrying out this mission the Center will adhere to operational principles centered around the following: outcomes and beneficiaries; modes of cooperation; scientific focus; and management and administration. These principles form the basis for CIAT's policy-setting mechanism.

Outcomes and beneficiaries

To ensure that the outcomes of our work have positive effects on the greatest number of our beneficiaries we will put into practice the following operational principles:

- Assist in alleviating hunger and poverty

- Strive for a more equitable society
- Contribute to sustainable economic development
- Pay special attention to low-resource farmers and consumers

Poverty, hunger and malnutrition cannot be divorced from issues such as food costs, income generation and economic development. The poor and hungry are found in both rural and rapidly expanding urban populations. The beneficiaries of CIAT's efforts to alleviate hunger and poverty must therefore include consumers. Moreover, the different needs of men, women and children as producers and consumers alike must be taken into account when researching food security improvement.

Many of the poorest people live in countries with grossly inadequate resources to meet the many competing needs for a reasonable quality of life. Equity is an important underlying value. The technology produced by CIAT and its partners must not exacerbate existing income disparities but should help alleviate them. We try to generate technologies that sustain or improve the capacity of the poor to earn income and provide food for the household.

The poor must receive a larger portion of a growing pie. The mere redistribution of wealth cannot satisfy these enormous needs. Thus, overall economic development is an essential component of CIAT's goals. Agricultural development is one key to economic development, and improved technology is the most powerful tool available to achieve this, benefiting producers and consumers alike. The orientation of such technological development must be such that the needs of the present are met without compromising the ability of future generations to meet their needs. Sustainable natural resource management is therefore an important outcome of the execution of CIAT's mission.

CIAT's concern for poverty and equity motivate it to focus special attention on low-resource farmers, both men and women. Rural

income can be improved by increasing productivity and reducing production costs. Postharvest processing in rural areas is an important activity because value-added processes can contribute significantly to the total income of the household, thereby benefiting all members of the family unit. Raising higher value crops is another way. The highest population pressures are often found in more favored regions. Thus, CIAT's concerns for poor producers should not be interpreted as concentrating excessively on farmers in the most marginal areas.

While continuing to focus attention on the needs of low-resource farmers, more attention will be given to those farmers in this category who are located in medium to high potential areas and are capable of producing market surpluses. This group has greater likelihood of achieving a better life and is in a position to be more responsive to adopting modern technologies which can increase productivity in a sustainable way. Beneficial impact on their welfare is ensured by the commodity mix at CIAT and our emphasis on low-risk technologies.

The consumers benefit most from agricultural research as increased productivity and reduced production costs lower food prices. Such a positive social benefit is maximized when research results are applied where they will achieve greatest impact. It is for this reason that CIAT's strategy cannot aim exclusively at increasing production by low-resource farmers. The highest social return on research investment must be an important criterion in the formulation of the Center's strategies and its programs.

Modes of cooperation

The world of agricultural research is large and CIAT is a small, but important part of this world. In reaching for our goals we foster a symbiotic relationship with our partners and others with similar objectives by:

- Emphasizing partnership

- Developing linkages
- Fostering each other's strengths
- Specifying a clear geographic focus

The chief performers in agricultural research and development are the national agricultural research institutions (NARIs). Together with others in the public and private sectors, the NARIs constitute the national agricultural research systems (NARS). They and the agricultural development and technology transfer institutions comprise the national agricultural research and development systems (NARDS).

Relations with each of these is on the basis of partnership and mutual respect. The Center works most closely with the NARIs. It assists them build their capacity through training programs, and by strengthening their linkages with CIAT and among themselves through workshops and networking. CIAT acts more as a catalyst than as an advocate in fostering appropriate policies and by providing an opportunity to exchange views through consultation, conferences and seminars.

It is essential that CIAT's activities complement those of other institutions, particularly the NARDS, related international centers, other international and regional agricultural research and development organizations, and advanced research institutions. The division of labor in such complementary relationships must be based on the principle of comparative advantage, each partner doing what it does best.

Among the IARCs we also look at complementarity. This influences our geographic focus which combines knowledge, technological information and germplasm of selected species (those that have, potentially, a worldwide impact) with existing regional competence and institutional relationships in the American tropics. Within the CGIAR family, CIAT has been assigned global responsibilities for certain commodities and a

regional responsibility for others. Close working relationships with related IARCs are maintained.

CIAT also operates on the principle of hosting scientists from other international centers whose work is of relevance to the region, but in which CIAT has no assigned responsibilities.

Scientific focus

Three major operational principles emerge in the operation of our research function:

- Conducting relevant research
- Emphasizing germplasm
- Avoiding chemical solutions

CIAT is an applied research institution, applying the principle of relevance to all it does. It focuses on problem-solving, mission-oriented research, at whatever level of sophistication necessary to overcome constraints.

Through systematic planning, evaluation, monitoring and coaching, the Center ensures that its scientists concentrate on the important rather than the merely interesting, and follow clearly defined priorities with a sense of urgency. Through its training program, CIAT encourages its partners to do the same.

Emphasizing germplasm is a fundamental principle. The vast germplasm collection at the Center gives it a comparative advantage in the application of genetics to solving production problems. Maintenance of the collection preserves an important heritage for future generations.

To reinforce the values of equity and sustainability, a low-input philosophy pervades all CIAT programs. This does not mean that farmers should not use purchased fertilizers. Indeed, they should use them as necessary, but judiciously, where they will increase their incomes and soil fertility. It means, however,

that CIAT strives to find genetic rather than chemical solutions to production problems and seeks ways of using external inputs most efficiently. This low external input philosophy is particularly applicable in pest and disease control. CIAT also stresses technology that uses internal inputs such as organic materials and household labor, most effectively.

Management and administration

Research is a creative process and requires especially sensitive management approaches to ensure that the creative flame is nurtured while, at the same time, results are achieved to help alleviate poverty and hunger. The philosophy of CIAT's management and administration is based on these operational principles:

- Having a dynamic and flexible approach
- Creating multidisciplinary teams
- Emphasizing excellence and fairness
- Providing efficient and cost-effective management

Research is a venture into the unknown. Results from one set of experiments lead to changes in another and many lines of inquiry lead to dead ends. This does not negate the need for sound planning, on the contrary. However, good planning provides only the framework. If CIAT is to maintain a dynamic edge, a flexible approach is needed so that programs and needs can be modified as indicated by research results. This flexibility of approach applies equally well to program and collaborative strategies as to management style.

CIAT is organized along interdisciplinary lines for the generation of new technologies. Disciplines representing both the biophysical and social sciences are allocated to programs according to need. Service units which cut across commodities support the program needs with specialized assistance. Seminars, task forces and sharing of facilities and equipment serve to keep scientists from each discipline in touch with areas of common interest and to reduce costs.

People represent CIAT's most valuable resource. The task of developing improved agricultural production technology is too great to tolerate mediocrity. We therefore insist on high standards of performance from our staff. At the same time, consistent with our strong people orientation, our personnel policies are designed to foster a team spirit and to motivate our highly qualified and creative staff to strive for these expected levels of productivity and quality of work. Quality need not be synonymous with high costs. CIAT carefully administers donor resources to ensure efficiency and cost-effectiveness.

Management and administrative policies are therefore designed to maintain a nonbureaucratic environment of creativity and innovation, supported by the underlying values of fairness, trust and responsibility. As we enter our third decade, we look forward to building higher on the solid foundation already established.

CIAT in the 1980s

Here we briefly outline CIAT's broad achievements in the 1980s with an overview of strengths and constraints. This analysis will then lead us naturally to the next chapter—strategic issues and their resolution.

Through training, networking and decentralization CIAT has achieved an effective relationship with its national partners. Many people have been able to apply their training to local problems and the commodity-based networks established along with the location of CIAT staff on-site in regional programs have led to a fruitful partnership in many instances.

The important function of monitoring the impact of CIAT-developed technology at farm and national levels has revealed that significant production increases have been achieved for beans and rice in Latin America; pastures in South America; and cassava in Colombia, Cuba and Thailand. Cassava-based agroindustries have been established in

Colombia and Ecuador. Agroclimatic databases have been established and are being used to revise research priorities. A strong problem-oriented effort in biotechnology research has been mounted. We have also contributed to stronger on-farm, client-oriented research through training and methodological development.

Program activities were expanded beyond Latin America for beans (Africa) and cassava (Asia). In Latin America, rice research was expanded to include upland areas. A modus operandi for regional programs has been successfully implemented in these regions.

Technology for integrated pest management was successfully developed and promoted and a Seed Unit was established to expedite production impact of CIAT programs.

Lastly, fiscal management was improved and leadership and management skills of key staff were strengthened.

Strengths and Constraints

The success of CIAT's programs over the past decade must largely be attributed to a highly motivated staff. Assisting them has been the strong institutional culture, with interdisciplinary teamwork, excellent facilities and support to conduct research, excellent relations with the host country, Colombia, and a strong Spanish-language facility. The strength offered by an apolitical neutrality facilitates convening meetings of scientists, training activities and our coordination function. Finally, our large germplasm collection and the international mobility of people, ideas and genetic material considerably strengthens our broad spectrum of research-based activities.

A number of constraints limit our ability to achieve as much as we would like. Chief among these is the lack of operational funds for our NARS partners and generally weak linkages in NARDS between research and development. Another problem, common to all IARCs, is our general inability to deal with location-specific problems.

THE WAY AHEAD

Emerging out of the long process of consultation, discussion and analysis that is inherent in strategic planning are the key strategic issues. These issues must be weighed in conjunction with the Center's mandate, the needs of the people served by the Center, potential resources, and the capabilities of others in the same business. Decisions must then be made on the strategic shifts that are both necessary and feasible in the next ten years. This chapter addresses the issues that arose from the many discussion papers and task force reports mentioned earlier and sets the scene for CIAT's priorities and mandate for the 1990s.

Strategic issues of most critical importance to the Center in the future are relations with NARDS, sustainability, and commodity and activity balance. Each of these will be dealt with in turn, followed by the CIAT mandate for the 1990s.

Relations with NARDS

Partnership with the NARDS is a fundamental aspect of CIAT's culture. In the broadest sense this means that CIAT shares with them the responsibility for generating and transferring improved technology, with a division of labor based on comparative advantage. There are a number of activities performed together.

In addition to being partners, NARDS are also the most important "customers" for CIAT's products and services. Like any other enterprise, therefore, knowing how the demand for its products and services will change is an essential part of developing a CIAT vision for the future. Thus a key component throughout the process of strategic planning has been consultation with the NARDS to ascertain their views on how the nature of the partnership and the type of support they desire

from CIAT will change during the next decade. How the NARDS are expected to change has been summarized in Chapter I; how their expectations from CIAT will evolve is presented in the following Box.

NARDS' Expectations of CIAT for the 1990s

The NARDS expect CIAT to *increase* its research efforts on:

- Genetic resources characterization (including "hi-tech" areas such as gene mapping) and documentation
- Nonconventional breeding
- Methodology development
- Natural resource management
- Integrated pest management
- Postharvest technology
- Policy research and promotion
- Training in research management

and its institution-strengthening efforts in:

- Specialized and advanced degree training
- Training of trainers
- Training methodology and materials development
- Providing leadership in integrating regional cooperation

At the same time NARDS believe that CIAT should *decrease* its research efforts (at headquarters) on:

- Conventional breeding
- On-farm research
- Cultural practices

and its institution-strengthening efforts (except in regional programs) in:

- Production training
- In-country training

(This information was obtained through extensive consultation with the NARS. See Appendix D for details.)

Clearly, CIAT must continue to respond flexibly to the challenge of highly varied and changing NARDS partners by making available a variety of goods and services from which they can select what they need. One of the challenges is to maintain the appropriate balance in what it has to offer. CIAT will also need to expand the current trend to work closely with other IARCs, especially where crops dealt with by different IARCs are grown in the same farming systems, and in Africa, where many centers cooperate with the same NARI.

The Center will also have to respond flexibly to a wider array of participants in its working environment. The semiprivate sector such as growers' organizations, commodity research institutions and private foundations will play an increasing role as continued budgetary problems and lack of good management combine to reduce the effectiveness of public sector NARS in some countries. At the same time, some public sectors are diversifying, with special emphasis on upstream technology. The increased sophistication of research within both sectors will stress the importance of CIAT's serving as a link between agricultural research in developed and developing countries, and as a facilitator of scientific cooperation both between and within developing countries.

CIAT's direction

In the 1990s CIAT will continue to respond flexibly to the varying needs of the NARDS, acting as a catalyst to promote regional cooperation and working in regional programs with NARDS in on-farm, client-oriented research. The spectrum of NARDS partners will also be broadened. Increased emphasis will be given to specialized research support, methodology development and training, to selection and characterization of parental material for use by NARI partners, to facilitation of horizontal technology transfer, and to serving as a bridge between advanced

institutions and NARDS. There will be a parallel decrease in production training and in on-farm production research out of headquarters and in the development of finished varieties.

Sustainability

Maintaining agricultural production at current levels will not be enough. The goal must be to develop sustainable technology that makes possible the required production increases without degrading the environment. The key question for CIAT is "what role is appropriate for an IARC to have when dealing with the related issues of sustainability and environment?" Several obvious points come to mind:

- Developing appropriate technology
- Being a role model by introducing long-term productivity and environmental perspectives into the evaluation of production technology components
- Providing the databases and leadership to promote sustainable alternatives in land-use management

CIAT commodity programs already make a major contribution to sustainability through their efforts to increase crop productivity (see the following Box). These will continue to be given high priority even as other approaches are considered. In addition to their pivotal role in enhancing productivity through germplasm improvement, the commodity programs are making major contributions by developing component technology for cultural practices which make possible more sustainable systems. This work will become more focused by specifically incorporating into their evaluation criteria cropping systems parameters linked to soil quality, nutrient cycling and pest management.

Natural resources management is critical to sustainability and environmental concerns. A key CIAT activity in this area is germplasm conservation and management; this contributes

CIAT Commodity Program Activities Related to Sustainability Issues

Bean Program

Major long-term activities:

- Incorporation of resistance to major pests and diseases into new lines
- Enhancement of nitrogen-fixation capacity
- Selection for drought tolerance
- Selection for efficiency in nutrient utilization and tolerance to acid, infertile soils
- Research on total productivity of bean-based cropping systems

Recent initiatives:

- Research on varietal mixtures to reduce disease and insect damage
- Efforts to incorporate agroforestry methods in soil erosion terraces in Africa
- Studies of traditional soil conservation practices used by bean farmers in Africa
- Promotion of an Africa-wide network on soil fertility work for bean production systems

Cassava Program

Major long-term activities:

- Development of biological control components for cassava hornworm and mealybug
- Incorporation of resistance to major diseases and insects into new cassava lines
- Research on drought-tolerance mechanisms

Recent initiatives:

- Work on soil fertility maintenance and erosion control in cassava production systems in Asia and Latin America
- Collection, biological studies and shipment to Africa of natural enemies of cassava mealybug and green mite
- Studies on the effect of mycorrhizal associations on nutrient use efficiency

Rice Program

Major long-term activities:

- Incorporation of resistance to major pests and diseases into new rice lines

Recent initiatives:

- Development and promotion of integrated pest management practices for rice in Latin America
- Development and promotion of integrated crop management practices in Latin America
- Development of new generation of rice lines with deep-rooting systems and acid-soil tolerance for savanna regions

Tropical Pastures Program

Major long-term activities:

- Development of pasture grasses and legumes tolerant to acid, infertile soils in order to enhance and make more rational use of savanna regions of Latin America, thus providing a viable alternative to deforestation in frontier expansion
- Incorporation of legumes into pastures to eliminate the need for nitrogen fertilization of pastures
- Development of low-energy, low-input, soil-conserving methods of pasture establishment
- Selection of pasture legumes and grasses resistant to major insects and diseases

Recent initiatives:

- Anthropological studies of land use practices of settlers in the Amazon Basin and the social benefits of using better-adapted pastures to reclaim degraded, abandoned land areas
- Selection of well-adapted, deep-rooted grasses and legumes for the reclamation of degraded, deforested lands in the humid tropics region
- Studies on plant, soil and animal interrelationships in nutrient recycling
- Selection of shade-tolerant pasture species as potential components of silvopastoral systems

to combating genetic erosion. This work will be emphasized in the 1990s. Maintenance of genetic diversity in beans, cassava and selected tropical forages and better germplasm characterization will be allocated significantly increased resources.

CIAT has concluded that concerns such as genetic diversity, cultural practices, misuse of chemicals and intensification of production, can be best dealt with by the commodity programs. These programs develop component technology for use in existing farming systems. They do not have a comparative advantage in developing new farming systems, nor are they equipped to work effectively on broader issues at the ecosystem level. Serious consideration should be therefore be given to developing a research program dedicated to one or more major ecosystems. The Center may have a comparative advantage for conducting research and coordinating an interinstitutional effort in land resource management for one or more of the following ecosystems in Latin America: the American tropical forests; the South American savannas; and/or the Andean hillsides.

American tropical forests

Land and resource poor farmers are drawn to this fragile environment by land availability and the ability to produce crops on the nutrients released by the burning of the forest cover. This fertility depletes rapidly and the colonists move on. Population pressures create the immediate imperative of containing further deforestation by making more productive and sustainable use of land already cleared. In the longer term, an appropriate land use system must be developed to ensure sustainable use of the resources. This task is complicated by the fact that the tropical forest ecosystem is heterogeneous. It contains subecosystems with highly varied climate and soils ranging from those suited for agrosilvicultural or silvopastoral production systems to those that should be left untouched. These subecosystems must be delineated. The new acid-tolerant pastures developed by CIAT have potential, particularly for reclaiming already degraded

areas. CIAT alone cannot meet all of the challenges of deforestation, but it may play a significant role by catalyzing and participating in an international effort together with institutions with expertise in forestry, agroforestry, tropical ecology and policy development.

South American savannas

This vast, underutilized land resource has adequate rainfall for crop or livestock production. There are few settlers, largely because the characteristic acid, infertile soils are not sufficiently enhanced by burning. Crops are poor without significant inputs; therefore, livestock predominates. CIAT has collected and evaluated many grasses and legumes that are acid-tolerant and perform well without fertilizers. This offers the possibility of more intensive livestock and crop production where soils are improved by grass-legume associations. Both cassava and acid-tolerant rice lines grow well under these conditions. An interprogram working group will develop integrated schemes which combine crops and improved pastures in rotation to produce low-input, sustainable systems. Substantial contributions can be made in developing sound crop and livestock rotation alternatives within CIAT's present program structure. A new research program would facilitate an even broader ecosystem approach.

Andean hillsides

Severe environmental deterioration resulting from inappropriate cropping or overgrazing of hillsides is exacerbated by high population pressure. Much of the region should be reforested. However, pressure on the land and the lack of economic alternatives make this option unlikely. CIAT commodity programs are contributing to anti-erosion cropping systems where their crops are grown and improving pastures to reduce overgrazing. The major obstacles are political and economic, making CIAT's comparative advantage less readily apparent.

In addition to exploring the possibility of developing a new research program, CIAT will expand the ongoing efforts of the Agroecological Studies Unit (AESU) to support the sustainability efforts of all of CIAT's programs. Long-term climatic data from over 16,200 meteorological stations and soil data according to land-use classification are computer accessible. Information will soon be available on microregions so that data on cropping system, culture, economy and society can be incorporated. Expertise in the area of soil management needs to be added.

CIAT's direction

In the 1990s CIAT will continue to emphasize low external input technology and seek genetic solutions to production constraints. An increasing emphasis will be devoted to research on characterizing genetic resources, long-term impact of component production technology on soil quality, integrated pest management, and efforts of the AESU to support programs in their sustainability activities. We will also actively consider the creation of a new program to deal with natural resource issues for one or more ecosystems. A special task force, formed by external consultants and scientists from relevant disciplines in the commodity programs and expanded AESU, will undertake a study to determine what CIAT's role should be in an ecosystem-focused approach to agricultural development; on which ecosystem(s) it should focus; and whether a new program should be created to deal with sustainability issues. If the decision is made to go ahead, the program will be defined early in the decade.

Commodity Balance

In the strategic plan "CIAT in the 1980s," the following set of qualitative criteria and external considerations were analyzed in setting priorities for that decade:

- Close gaps between growth in demand and supply for foods in Latin America
- Focus on foods of nutritional importance to poor consumers
- Develop frontier lands in Latin America
- Improve small-farm productivity
- Mandates of other IARCS

When the plan was revised in the mid-1980s, considerations were extended to cover CIAT's role for cassava and beans in Africa and Asia. In selecting the commodity mix for the 1990s, consideration was given to a range of criteria, including comparative advantages, economic development, equity and sustainability. These are further elaborated below.

1. Comparative advantage

- Coherence with CGIAR and NARS' priorities
- CIAT's existing stock of germplasm and expertise
- Technical feasibility and probability of success
- Institutional complementarity

2. Economic development

- Importance of the commodity
- Demand for growth
- Potential for production increase

3. Equity

- Nutrition for poor consumers
- Income for the rural poor
- Targeting economically deprived regions

4. Sustainability

- Reduce pressure on fragile ecosystems
- Husband genetic resources
- Lessen dependency on agrochemicals

The above set of criteria will be an integral part of the decision-making process for resource allocation in the upcoming operational plan. The possibility of changing

the commodity portfolio at CIAT will be part of the ongoing strategic planning process over the next decade.

CIAT's direction

In developing its five-year operational plans, CIAT will carefully reassess the balance of resource allocations among different commodities that has evolved to date on the basis of socioeconomic indicators and other factors. Criteria for this exercise will include comparative advantages of CIAT; the present and potential contributions of the respective commodities to economic development; and equity and sustainability consideration.

Activity Balance

Responding to changing circumstances sometimes means phasing out one activity in favor of another. This is particularly true of research organizations and CIAT has done this when warranted. More often though, it means shifting emphasis on activities or approach. As we approach the 1990s some important issues related to the relative emphasis along the research-development spectrum have been evaluated. These center around the relative allocation of resources to research versus institution building or strengthening; the possible role of future development activities; and the degree to which activities should be decentralized.

Research spectrum

For purposes of discussion we classify research as either basic, strategic, applied or adaptive. "Upstream" refers to work toward the basic end; "downstream" to the adaptive end. Downstream may also refer to activities that fall outside of research as such, but involve development activities such as technology transfer, seed production, farm credit, farmer organization or rural development. This aspect will be addressed separately.

Basic or fundamental research with no other purpose than the advancement of knowledge is excluded from CIAT's activities and will remain so. However, such knowledge is used by CIAT and we must therefore be aware of new findings and techniques, particularly in the biological sciences. This is why we maintain close ties to advanced research laboratories.

There is no doubt that CIAT should move upstream in the 1990s. This conclusion is based on three primary factors arising from many consultations:

- The greater opportunities offered by recent developments, particularly in tissue culture, molecular biology and genetic engineering
- The growing ability of some national programs to assume more responsibility for certain aspects of component production technology
- The accomplishments to date in applied research, making possible a diversion of efforts (usually within disciplines) to more strategic research

Moving upstream presents the danger of CIAT becoming involved in specialized research in which it has no comparative advantage in terms of scientific expertise, equipment or facilities. Clearly, it is now even more important than in the past to collaborate with advanced research institutions.

CIAT's direction

CIAT's move upstream in the 1990s will be accompanied by a gradual shift in emphasis from applied to strategic research, thereby obtaining a better understanding of genetic characterization of germplasm; the causal organisms of the most important diseases and pests of CIAT's crops; plant mechanisms related to yield, photosynthetic efficiency, drought tolerance, and nutrient utilization; and of plant-soil-microorganism relationships. Biotechnology research will be expanded considerably and will be targeted

to problems in the commodity programs more effectively tackled by nontraditional methods. Advanced methods such as use of monoclonal antibodies, nuclear hybridization, and transgenic methods of inducing resistance will be applied to virus detection and control. Coupled with this move upstream will be a shift to contracting appropriate research projects to advanced institutions; an increase in the monitoring program to evaluate the social and environmental impact of our work; the development of upstream networks in the areas of highest priority for the commodity programs; and an increase in the research component of regional programs.

National research and institutional strengthening

About one-third of the Center's budget is allocated to training, network coordination, communications and technical assistance to the NARS. Our consultations with national partners indicate that the nature of training should be more intensive and specialized to reflect the greater capability of national programs to do some of the production and in-country training formerly carried out by CIAT and to reflect the upstream nature of most CIAT activities (see Box, p. 17 for details on NARDS' expectations). As national programs become stronger they need less technical assistance and more workshops and coordination and networking activities to strengthen horizontal cooperation and build upstream links. A reduction in overall institution strengthening will allow regional program staff to devote less time to in-service training and more time to research of regional importance. In moving upstream in these areas a balance has to be made between the number of trainees and the availability of program staff. Increasing the number of trainees too much has a negative impact on the research program scientists' time; decreasing the number too much would deny the NARS one of the types of support they most value and feel will be needed in the future.

Consultations with NARDS' leaders revealed that they consider that CIAT's scientific credibility and institutional neutrality give it a comparative advantage in regional networking activities and fostering the sharing of responsibilities among national programs.

CIAT's direction

CIAT will decrease its efforts in institution strengthening through bilateral technical assistance and increase its efforts to promote the integration of regional research activities. By doing so, CIAT will foster sharing among national programs, and so will go beyond the current emphasis on research projects directly related to CIAT regional activities to one of greater integration of all research in the respective commodities. The Center has concluded that the proportion of resources budgeted under the Training and Communications Support Program will be maintained at the same level in the 1990s, although the activities classified as institution strengthening will diminish to allow for more specialized training and support, including training of trainers.

Development activities

CIAT is deeply concerned that the technology it develops is not only applied rapidly but also produces a positive social impact. Often, however, there are impediments to achieving this objective at the local level. Thus CIAT works with and through various international, regional and local development institutions and projects to speed up the validation and delivery of such technology. Direct involvement in bilateral development projects is limited, recognizing that they divert scarce resources from research efforts. Nevertheless, those in which CIAT has been involved have demonstrated the benefits of feedback to its programs and have produced a very positive impact. Other areas that need to be expanded include: seed production for small farmers, pilot projects on integrated utilization and marketing, and conceptual research on farmer participatory methods.

On-farm research, including new initiatives in farmer participatory research, is an essential component of technology generation. This is location-specific work more appropriate to local research institutions than an IARC. However, this is an important component of decentralized regional programs and there is a great need for the development of training materials.

CIAT's direction

CIAT will continue to expend some effort in the development side of R & D activities with an emphasis on developing technology transfer mechanisms and institutional

models that can be broadly adopted. Operational on-farm research activities will remain an important component of the regional programs and the headquarters role will be development of methodology and training materials. Linkages with development organizations will be further developed to facilitate the impact of technology generated by CIAT and NARDS partners. The manner in which CIAT will respond to the challenges of the strategic issues described above is summarized in the following Box. These responses collectively form the material from which CIAT's mandate for the 1990s has been developed.

Issues and Challenges Facing CIAT in the 1990s					
Topic	Issue	Challenge	Topic	Issue	Challenge
Relations with NARDS	Complementarity	Adjust flexibly to increasing complexity	Sustainability	Genetic diversity	Expand efforts to collect, maintain and distribute materials for selected species
	Regional approach to technology generation	Promote networks based on sharing responsibilities		Germplasm improvement	Develop databases of characterized germplasm
Activity Balance	Research spectrum	Increase emphasis on strategic research		Cropping systems	Expand evaluation criteria to include long-term productivity
	Institutional strengthening	Provide more specialized training based on changing needs		Land systems	Develop framework for interinstitutional cooperation for the design and testing of alternative models
	On-farm research	Develop methodologies and training materials; serve as role model through incorporation of farmers' perspectives in regional activities			

CIAT's Mandate for the 1990s

Taking into account the Center's mission and incorporating the conclusions on strategic issues discussed above, the following mandate for the 1990s has been crafted.

CIAT will concentrate its efforts on common beans, cassava, rice, tropical pastures and land-use management. These research efforts will be supported by specialized research, training, communications, germplasm, seed, and research services units and programs. The products of these efforts are knowledge, technology, methodology, stronger national and regional research programs, and improved international and intranational cooperation.

The geographical responsibilities for the crop species covered by this mandate are:

Common beans

Global

Cassava

Global (in Africa, in cooperation with IITA)

Rice

Regional for Latin America and the Caribbean (in cooperation with IRRI)

Tropical Pastures

Global (focused on acid, infertile soils of Latin America, with modest germplasm distribution and evaluation activities in Africa with the cooperation of ILCA, and in Asia).

The nature of any new activities dealing directly with natural resources management on an ecosystem basis will be defined early in the decade, but will be restricted to the American tropics.

PROGRAM STRATEGIES

CIAT's mandate is carried out by the commodity-based research programs which are supported by specialized research units and the Training and Communications Support Program. This chapter outlines how these programs and units will operate in the next decade and the strategies they will pursue. Strategies for the proposed new program on land-use management await the recommendations of the task force.

The Commodity-Based Programs

These programs for CIAT's four target crops (common beans, cassava, tropical pastures and rice) will conduct their work through multidisciplinary teams supported by six specialized units: Genetic Resources, Biotechnology, Virology, Agroecological Studies, Seed, and Data Services. Research priorities have been, and will continue to be, determined through extensive consultation with national partners and through discussion among advanced research networks relevant to each commodity.

Bean Program

Beans are the most important food legume for over 500 million people in Latin America and the highlands of eastern and southern Africa. Beans are the leading source of protein for over 100 million poor consumers whose diets otherwise consist principally of low-protein starchy staples. Demand for beans is growing fastest in Africa where production growth is lagging behind population increase.

Small farmers in Latin America are producing dry beans and snap beans principally for the urban market and are increasingly using chemical inputs which are

often abused. In contrast, the bulk of production in Africa is by women in a subsistence setting without the use of purchased inputs. As much as 75% of beans are grown in association or in relay with other crops. The relation between beans and the environment has to be seen from the viewpoint of a cropping system rather than of an isolated commodity.

As diseases, pests, drought and nutritional deficiencies are major constraints to the realization of high yields in existing varieties, the Bean Program has emphasized improving resistance over yield potential. Substantial progress has been achieved in improving resistance to many diseases and insects, but now the priority is to diversify the genetic base to avoid the breakdown of resistances. Moreover, there is still much research needed on insects and diseases occurring in Africa but not in Latin America. Overcoming drought and nutritional stresses remain major challenges. Significant opportunities exist for the application of biotechnology to beans for more efficient identification and transfer of useful genes. The key, however, to the development and transfer of improved technology to farmers is the strength of national programs.

Goal

To increase food availability and incomes of the poor by improving the productivity of beans through the development of technology in collaboration with national institutions

Strategic objectives

1. **Strengthen national capacity to improve productivity in diverse cropping systems**

2. Reduce losses from pests and diseases
3. Improve efficiency of nutrient and water use
4. Increase yield potential of beans
5. Improve methods for utilizing *Phaseolus* genetic resources

Each strategic objective is subsequently discussed, emphasizing the challenges involved and the proposed strategies to tackle them.

1. Strengthen national capacity to improve productivity in diverse cropping systems

Accomplishments to date have been significant. Because of the collaborative effects of CIAT's Bean Program and national programs, more than 50 improved varieties are now grown by farmers on more than 350,000 hectares. The value of this increased production is about US\$50 million annually. Figure 1 illustrates the effect of technical change on bean production in Costa Rica.

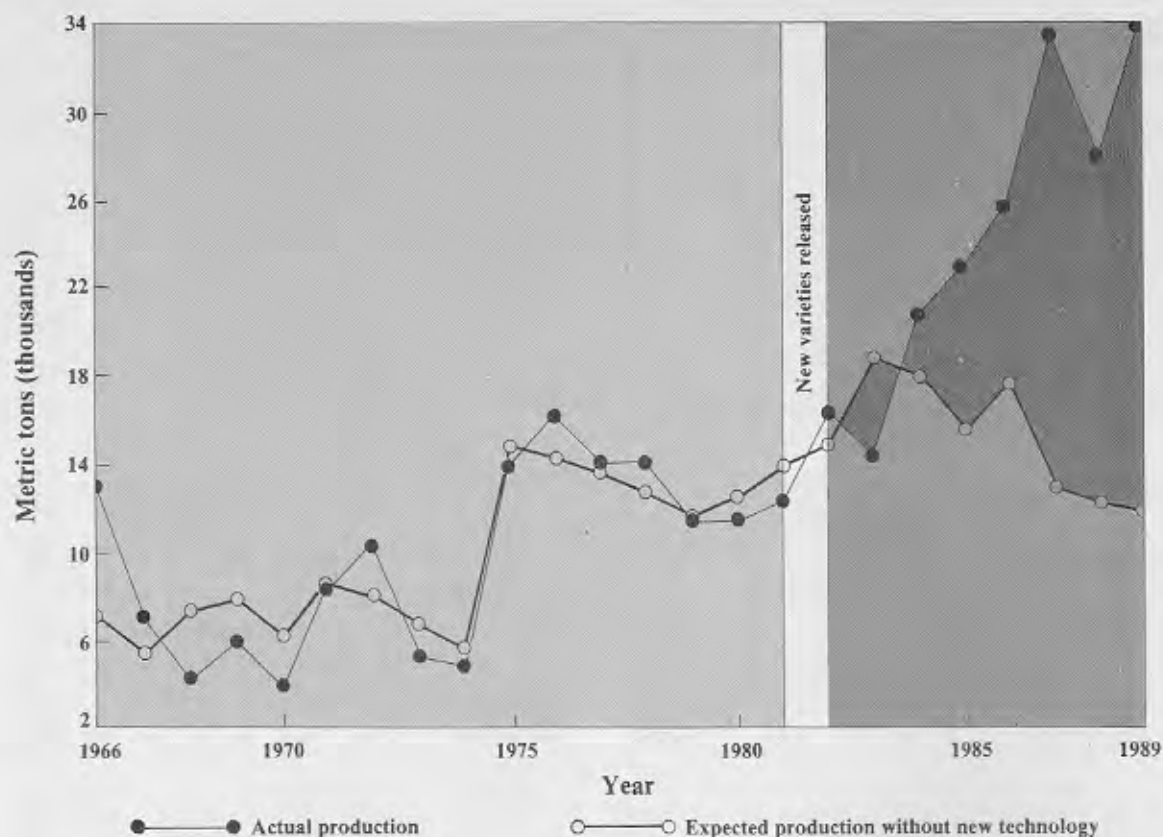


Figure 1. Costa Rica bean production: the effect of technical change. Before 1986, Costa Rica imported an average of 10,000 tons of beans per year. By 1989, however, bean production reached 34,000 tons, allowing exports of 10,000 tons. New technology was largely responsible for the difference, shown here as the shaded area between the two lines in the graph. The total value of the extra beans has

been over US\$40 million since 1984. Costa Rica, Argentina, Bolivia, Guatemala and Nicaragua have all released improved bean varieties which are now grown on 44% of the total bean area in those countries. Their production growth averaged 8%, compared with 0.8% in other countries of Latin America where newly released varieties have not yet gained wide acceptance.

Most national programs now have trained breeders, plant protectionists and agronomists. On-farm research training has increased national program capacity to set priorities and evaluate new technologies. National program scientists of different countries can now collaborate with each other through regional research networks in Latin America and Africa.

The challenges are highly heterogeneous national programs with different capacities and needs; a great diversity of production problems compared with limited national program resources; weak articulation between research, extension and farmers; and little attention paid to the long-term effects of current cultural practices.

Strategies to deal with these problems are:

- Deliver to national programs genetic materials as parents, segregating populations or finished lines according to their needs
- Link national programs more strongly in research networks to solve common problems and exchange results
- Strengthen national program capacity to involve farmers in setting research priorities and technology evaluation
- Stimulate national programs to develop sustainable and productive crop management systems

2. Reduce losses from pests and diseases

Reliable screening methods for most major diseases and pests have been developed and resistant or tolerant germplasm have been identified. However, resistance can break down in the face of highly variable pathogens. Sources of tolerance or resistance for some of the major diseases and insects are also inadequate. The increasing use of pesticides by small farmers in Latin America is a growing problem both economically and environmentally.

The following strategies to overcome these problems are:

- Broaden the genetic base of resistance sources, including increased use of genes from wild ancestors and other cultivated species of *Phaseolus*
- Identify resistance sources where lacking and incorporate the genes conditioning resistance into acceptable cultivars
- Develop integrated control strategies to complement genetic resistance while reducing pesticide applications

3. Improve efficiency of nutrient and water use

Some 60% of the area planted to beans is subject to drought stress, while about half consists of acid soils with low phosphorus availability. Genetic variability has been observed for increased nitrogen fixation, tolerance to low soil phosphorus and root systems with better adaptation to drought stress. Although a start has been made in incorporating these characters into improved cultivars, significant challenges remain.

The overall soil fertility in bean-based systems is declining because of expansion of beans into marginal soils, shortened fallow periods, soil erosion, and high costs and/or limited availability of inorganic fertilizers, especially in Africa. Biological nitrogen fixation in beans is low compared with other legumes and can be improved. The mechanisms of adaptation of beans to low phosphorus or acid soils have yet to be determined. Water stress is the most important cause of production instability, but little is known about drought tolerance.

Four major strategies will be pursued to relieve nutrient and drought constraints:

- Breed bean genotypes with improved ability to fix nitrogen
- Identify mechanisms and develop efficient screening methods for tolerance to low phosphorus and to acid soils

- Generate bean genotypes with improved adaptation to water stress
- Stimulate national program research in fertility management for bean-based cropping systems

4. Increase yield potential of beans

CIAT-bred bean lines have exceeded the yields of the best commercial cultivars and the relationship between yield, maturity, seed size, growth habit and leaf area is now better understood. The combining ability for yield was found to be increased by crossing between gene pools. Visual estimation of yield has been found to be unreliable as a selection criteria, so methodologies have been developed for early generation yield testing to facilitate the selection process.

There are a number of serious problems to solve. Recent efforts in improving yield potential have as yet made little progress when compared with achievements in cereals. In particular, there is very low yield potential in the highly preferred medium-sized and large seed types. Finally, neither the physiology nor the genetics of improving yield potential is fully understood.

Strategies for the next decade to help resolve these problems are:

- Emphasize selection for yield
- Exploit variation across gene pools to increase yield potential
- Modify growth habits of medium- to large-sized seed types to increase yield potential
- Identify yield-maximizing optima for physiological traits such as canopy morphology and patterns of nitrogen uptake and partitioning

5. Improve methods for utilizing *Phaseolus* genetic resources

Progress in molecular biology offers the opportunity for more efficient identification and transfer of useful genes, both within common beans and from related species. With the world's largest collection of *Phaseolus* genetic resources, CIAT has a comparative advantage in exploiting new biotechnology methods for genetic improvement. For example, biochemical markers are already being used at CIAT to improve the efficiency of conventional breeding, and genes found only in wild bean ancestors have been successfully transferred to commercial bean types to confer resistance to storage weevils.

The Genetic Resources Unit (GRU) has the responsibility of conserving *Phaseolus* germplasm and setting priorities for limited acquisitions in the future. A major challenge is to apply biotechnology techniques to solving many of the problems mentioned above.

Five major strategies will be followed:

- Study patterns of genetic diversity to prioritize genetic resource acquisition
- Utilize biochemical markers to increase the efficiency of conventional breeding
- Evaluate the potential for increased utilization of wild ancestors and related species for common bean improvement
- Apply new methods for gene transfer
- Link biotechnology research institutes in developed countries to priority problems of beans in the tropics through an advanced research network on beans

The projections in resource allocation to accomplish the strategies are summarized in Figure 2.

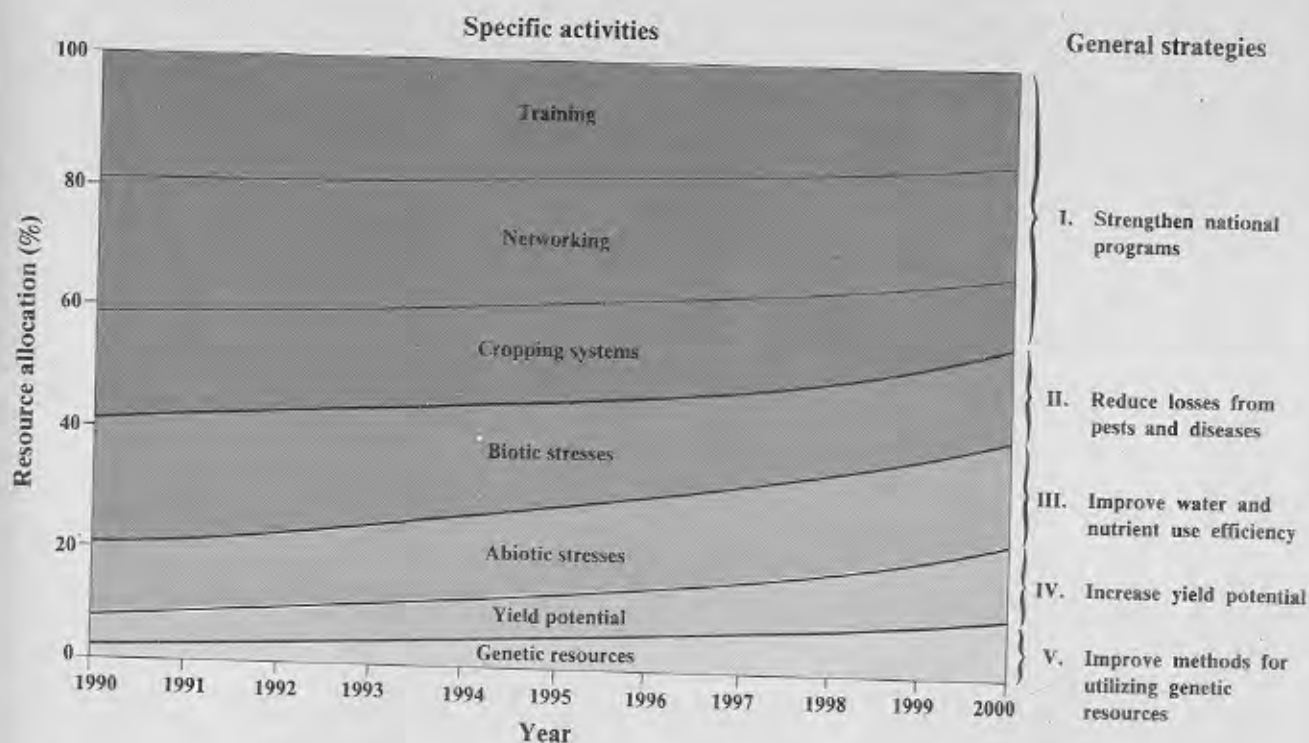


Figure 2. Projected Bean Program resource allocation for the 1990s.

Cassava Program

The Cassava Program has made significant progress in the last decade and is positioned to make greater impact in the next decade on the livelihood of the rural poor, its main target.

Most of the research results on the characteristics of the crop are now in the pipeline, and demand studies have shown that cassava can compete in many markets and can play a strong role in the marginal agroclimatic zones largely untouched by the Green Revolution. In these areas, it is one of the few alternatives resource-poor farmers have.

Cassava is also one of the few crops that can have research targeted for the direct benefit of the poor.

Because of the low resource base of the producers and the poor infrastructure in marginal areas, the improved production and processing systems must be simple, low cost

and self-sustainable. Under these circumstances, better varieties, biological control, erosion control and artisanal seed production are key components of the improved technology. In addition, development efforts based on improved cassava production depend largely on the integration of production processing and marketing. The research strategy to support rural development must therefore deal simultaneously with the complete system of the commodity. In addition, care must be taken to choose appropriate regions for these rural development efforts to ensure that benefits do reach the target population and that results can be later extrapolated to similar conditions elsewhere. Figure 3 shows an example of the benefits of such an activity in the north coast of Colombia.

Cassava is unique to the tropics. This has had an effect on the organization of the

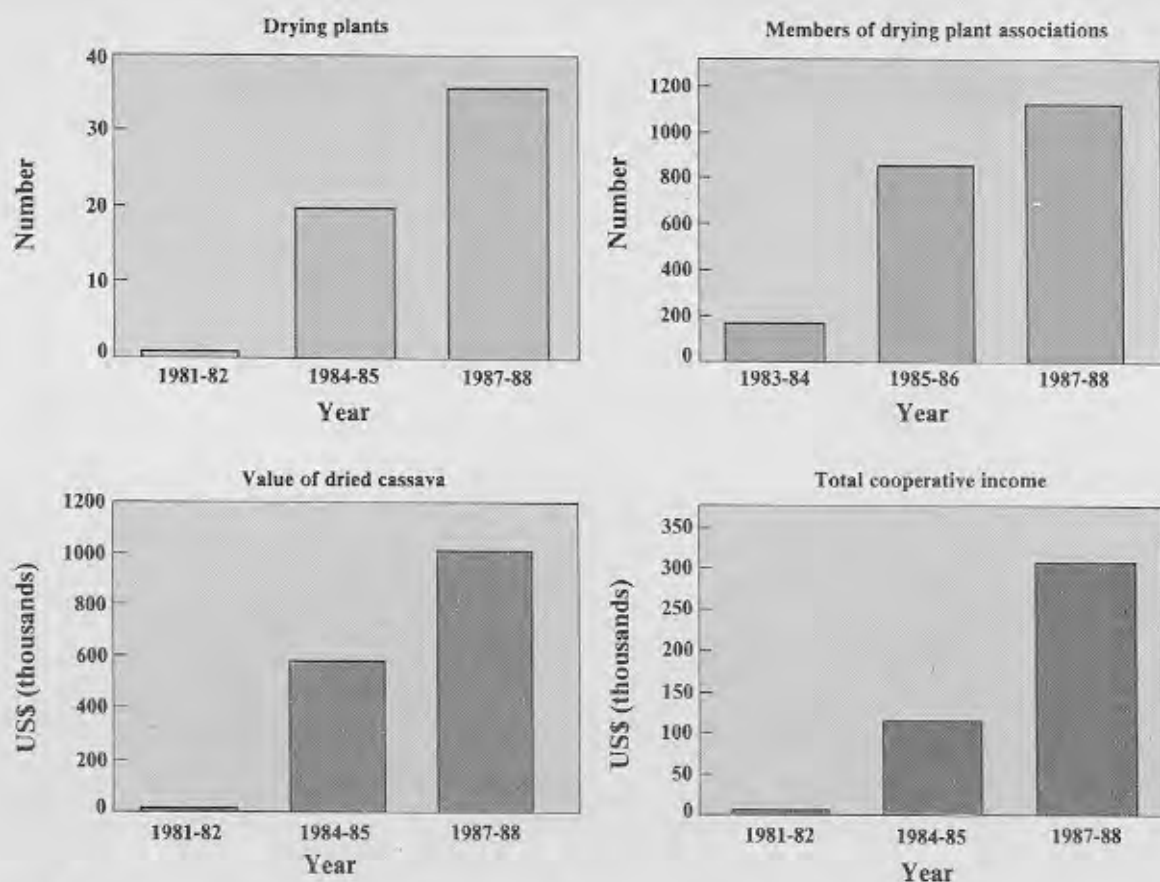


Figure 3. Achievements of the Dried Cassava Project on the north coast of Colombia. The Integrated Cassava Project has opened the market for dried cassava in northern Colombia. In 1988-89, national production was 13,000 tons, 5500 tons of which were produced by DRI-assisted cooperatives. Expansion of the dried cassava industry is currently occurring in many Colombian departments with increased

benefits to farmers with limited resources, especially in the marginal areas of the country. This new industry has resulted in the stabilization of the fresh cassava price by providing a floor price in the north coastal region, bringing benefits of more than US\$4 million per year to consumers in the city of Barranquilla alone by lowering the real price of this staple.

research effort. In developed countries, research on cassava has been very modest and most has been the result of collaborative projects developed with the IARCs. Basic research, essential for sound applied research on the crop, has begun only recently in comparison with grain crops, and is largely the result of IARC efforts to have research done by others so that production improvements could be gained more rapidly.

An important step in this process is to identify key constraints in cassava production

and processing that cannot be met through traditional research approaches, but are manageable through a multidisciplinary, interrelated network approach. It is essential that the link between basic research in advanced research institutions and the more applied research being done by international and national institutions in the developing world be designed and strengthened. It is critical that these links be formed to effectively utilize the limited resources available so to accelerate advances in cassava research, which will ultimately benefit the rural and urban poor.

Goal

To increase incomes, particularly in the less-favored sectors of the rural population, and improve overall availability and quality of cassava in the tropics

It is the Program's conviction that improved living conditions and employment opportunities in the rural sector can slow migration to the urban sector, thereby mitigating the abject misery often associated with rapid increases in urban population. The Program also believes that its efforts will reach and help the urban poor by improving the availability and quality of traditional cassava-based products and by the development of new products based on improved root quality and new processing technologies.

Strategic objectives

1. **Augment and characterize the *Manihot* germplasm collection for more effective utilization**
2. **Develop and make available production systems for sustainable and improved cassava production in different agroecosystems**
3. **Improve the quality of cassava products for human consumption and animal feed**
4. **Facilitate the movement and adoption of new production and postharvest technologies to stabilize and increase the production of high quality roots and leaves**
5. **Strengthen and improve the research and technology transfer capabilities of national research and development systems**

A brief discussion of each objective follows.

1. **Augment and characterize the *Manihot* germplasm collection for more effective utilization**

CIAT has accepted the world mandate for cassava germplasm conservation, and the corollary activities which this entails such as collection, characterization and documentation. The collection now consists of more than 4000 landraces collected from the diverse ecosystems where cassava is cultivated. In the next decade a major effort will be given to complementing the cultivated cassava collection with a collection of wild *Manihot* species. These will be characterized for their potential contribution to cassava improvement and crossability with cultivated species.

Few landraces meet the full range of criteria required for modern production systems, and the major challenge is to extract and recombine the positive attributes of the germplasm accessions to develop productive, stable and high quality new varieties. The world germplasm collection will be more thoroughly characterized, improving our knowledge of cassava evolution and breeding potential.

The following strategies will be used:

- Molecular fingerprinting and mapping of the cassava genome
- More efficient screening and genetic transformation techniques, especially for pest and disease resistance, physiological traits and quality factors
- Applying dihaploid techniques to uncover rare recessive genes

2. **Develop and make available production systems for sustainable and improved cassava production in different agroecosystems**

The target ecosystems for cassava production have been defined and emphasis has been given to those agroecosystems in which cassava is an important crop. The challenges for the future are in those marginal ecosystems such as the semiarid areas of Africa, Asia and north coastal Brazil; the African highland areas; and subtropical Latin America and Asia.

Cassava has traditionally been grown on marginal lands where low soil fertility and erosion have restricted yields. A major challenge to the Program is to make these soils more productive for cassava through fertility improvement and erosion control, as well as developing germplasm which responds favorably to these marginal conditions.

Emphasis will be given to the following strategies:

- Improving the knowledge of complex interactions of physical and biological environments with plant growth and development
- Developing appropriate germplasm which is tolerant to biotic and abiotic stresses, especially drought
- Designing appropriate crop and pest management practices for the target ecosystems to achieve sustainable cassava production
- Designing production systems based on the use of botanical seed
- Maintaining the biodiversity within the target agroecosystems to establish long-term, sustainable production systems

3. Improve the quality of cassava products for human consumption and animal feed

Research to date has shown that the cassava root is extremely sensitive to changes in the preharvest environment, making the eating quality of fresh cassava highly unpredictable and affecting the quality of cassava flour. Major challenges are to determine and understand which plant growth characteristics and environmental factors affect root and leaf quality, and to identify critical stages during processing which affect product quality.

The high hydrocyanic acid (HCN) content of many African and Brazilian cultivars can result in toxicity problems for consumers, especially during prolonged drought. The Cassava Program will give increased attention to the HCN issue.

Research strategies will include:

- Determining the plant growth factors that affect the quality of starch and other root constituents
- Developing processing techniques that will improve the quality of cassava flour and other products
- Defining starch and other root and leaf constituent properties required for various processing techniques and end uses
- Developing acyanogenic varieties

4. Facilitate the movement and adoption of new production and postharvest technologies to stabilize and increase the production of high quality roots and leaves

The decade of the 1980s has seen an emphasis on the improvement of cassava germplasm, resulting in the release of numerous varieties in many cassava-growing countries. The Cassava Program anticipates a rapidly expanding area planted to improved cassava varieties over the next decade. In addition, new uses for cassava-based products are continually being developed.

A major challenge to national and international institutions will be to make these new varieties and technologies available to the traditionally low-resource cassava farmers who are often located at considerable distances from a resource base.

Strategies to be followed will include:

- Utilize applied social sciences to ensure proper analysis and feedback of acceptability and value of production and processing techniques
- Define market opportunities and potential for cassava-based products
- Promote rural development efforts based on the integration of production, processing and marketing

5. Strengthen and improve the research and technology transfer capabilities of national research and development systems

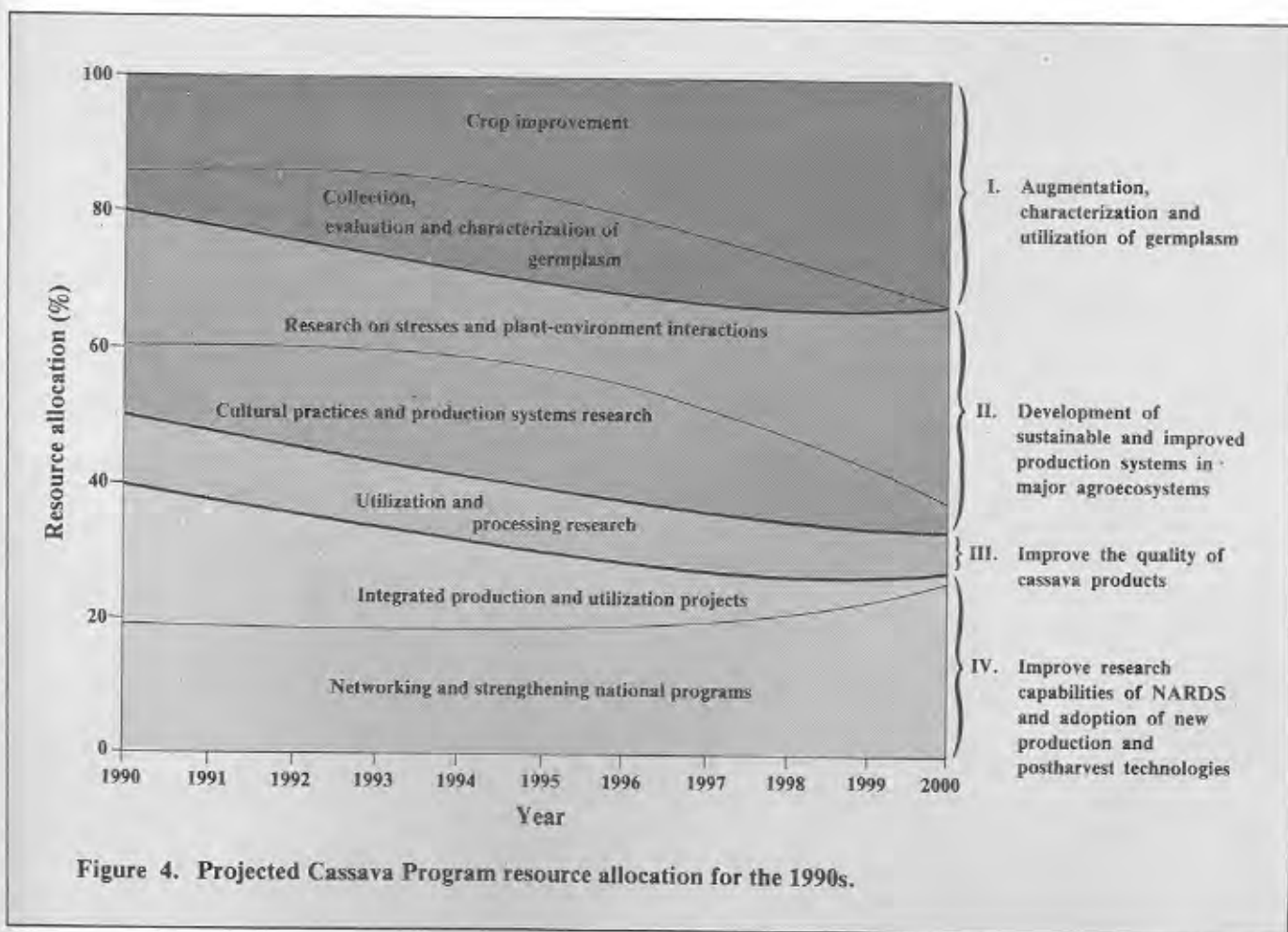
CIAT has played a major role in the development of national cassava research programs, especially in Latin America and Asia. There were no national programs in Latin America working on cassava when the CIAT Cassava Program was initiated; now at least eight countries have research capabilities in cassava. However, several of these programs are underfinanced and understaffed to meet the increasing demand for improved cassava technology.

With the limited resources available, the CIAT Cassava Program faces major challenges to involve and strengthen these programs in the rapidly advancing research and development technologies.

This can be accomplished by the following strategies:

- Establish germplasm improvement programs for defined ecosystems within national institutions
- Provide advanced and selective training to national research and development personnel
- Define appropriate linkages with research and development institutions in developing and developed countries
- Establish regional networks among research and/or development institutions
- Devolve selected research activities to national systems

Projected resource allocations to accomplish the Program's strategies in the 1990s are presented in Figure 4.



Rice Program

The Program's mandate is to generate and disseminate improved rice technology for increased and stable production in Latin America and the Caribbean. It originated from a collaborative rice-breeding effort initiated in the 1950s between the Colombian Ministry of Agriculture and the Rockefeller Foundation. Having a regional mandate, it is the smallest of the Center's commodity programs and is able to draw upon considerable research resources available from other centers with global (IRRI) and regional (WARDA, IITA and IRAT/CIRAD) mandates. The Program continues to place heavy emphasis on germplasm development. However, it is moving into areas of integrated crop management and socioeconomics. Adjustment is therefore needed to move from what has been solely a program focusing on irrigated germplasm to one that covers a broader range of ecosystems and issues.

Being small and confronting heterogeneous rice-growing environments, the Program has concentrated on a limited number of topics which promised large impact in the short term. To maintain its high level of effectiveness, the Program has concentrated its research on irrigated rice topics which could be handled in or from Colombia. Thus, research on other important problems has had to be deferred.

This approach has resulted in germplasm-based technology for irrigated rice being generated and widely disseminated, with about 75% of irrigated production coming from material generated from CIAT/IRRI germplasm. Functional germplasm exchange networks of national programs have been established (Figure 5). Researchers can share research results and methodologies and can jointly plan research projects. The Program has also contributed significantly to strengthening national rice programs in Latin America. Most rice programs in the region are now well staffed, particularly in the field of breeding,

It should be emphasized that increased rice production requires more than technological

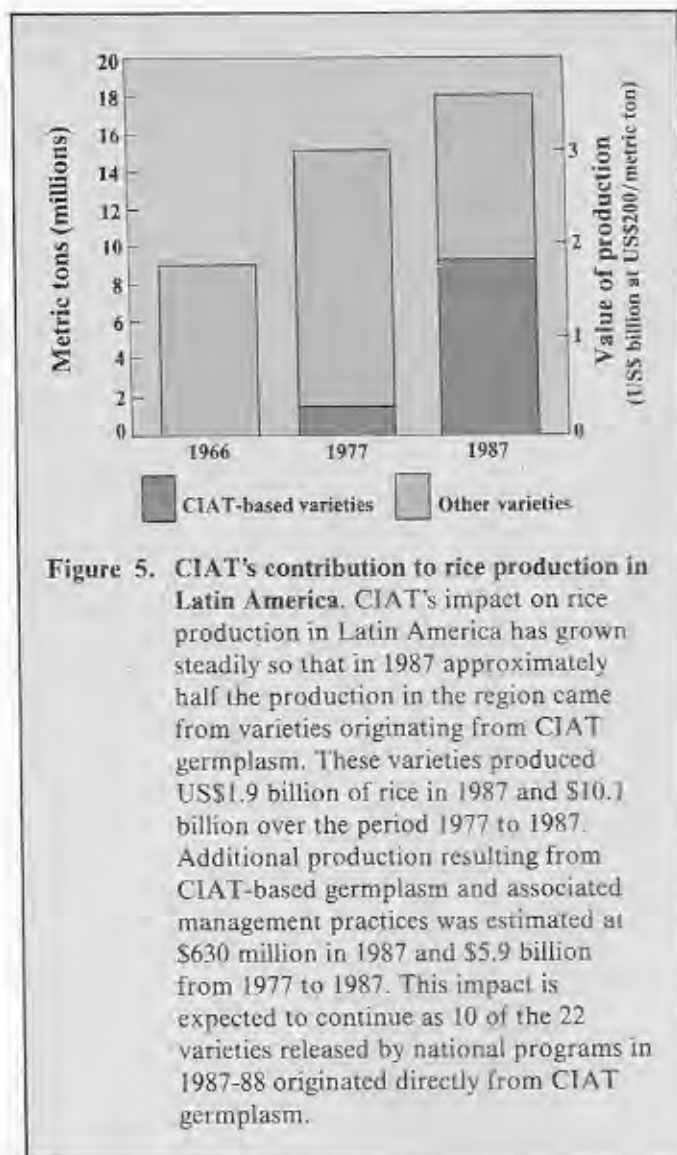


Figure 5. CIAT's contribution to rice production in Latin America. CIAT's impact on rice production in Latin America has grown steadily so that in 1987 approximately half the production in the region came from varieties originating from CIAT germplasm. These varieties produced US\$1.9 billion of rice in 1987 and \$10.1 billion over the period 1977 to 1987. Additional production resulting from CIAT-based germplasm and associated management practices was estimated at \$630 million in 1987 and \$5.9 billion from 1977 to 1987. This impact is expected to continue as 10 of the 22 varieties released by national programs in 1987-88 originated directly from CIAT germplasm.

improvements. Political and administrative support is needed if the potential benefits of technology are to be realized.

The challenges to be faced in the next decade are:

- Develop technologies for maintaining yields of the most productive systems and for opening new opportunities in less favored areas through production systems with long-term stability
- Continue interaction with NARDS to develop national rice research plans, to identify research and training priorities, to define areas for collaborative activities, and to facilitate communications with regional partners

- Understand the mechanisms governing plant response and interaction with pests under environmental conditions relevant to Latin America and the Caribbean

Goal

To contribute to the improvement of the nutritional and economic well-being of rice growers and consumers in Latin America and the Caribbean by supporting NARDS' efforts to increase rice production and productivity

Strategic objectives

1. **Contribute to achieving and sustaining the genetic yield potential in irrigated systems while reducing external inputs, and expanding rice-growing alternatives in the upland systems**
2. **Improve the knowledge base of crop-environment and socioeconomic relationships for rice in Latin America and the Caribbean**
3. **Strengthen the capabilities of NARDS to design and implement national research and training plans**
4. **Promote the development of effective information systems to improve communications within and among NARDS**

Each strategic objective is subsequently discussed.

1. **Contribute to achieving and sustaining the genetic yield potential in irrigated systems while reducing external inputs, and expanding rice-growing alternatives in the upland systems**

The diffusion of genetically-related, modern, high-yielding germplasm over most of the irrigated area, even though such germplasm still lacks tolerance to many regional stresses, indicates that breeding to incorporate such tolerance and increase genetic diversity will

continue to be a high priority. Since farmers also rely on toxic agrochemicals, a shift in emphasis toward integrated crop and pest management is needed.

The 2.2 million hectares of high rainfall savanna and cerrado upland rice which have not benefited from germplasm with high-yield potential offer great opportunities. Since lines have been developed by the Program with good yield potential and which tolerate the harsh soils and biotic stresses, there is an opportunity to achieve substantial production increases in these areas. However, the systems are fragile and careful development of sustainable agronomic practices, rotations and associations will be needed.

To accomplish these objectives some work currently conducted by CIAT will have to be passed on to those NARDS which have the capability. Many of the national programs are conducting varietal development activities relevant to the needs of other countries. Where possible, these programs may assume greater responsibility for providing advanced materials for areas with similar requirements. Fixed lines will no longer be developed at CIAT with the principal objective that they serve as potential varieties. This implies a fundamental shift in CIAT's breeding strategies toward providing good parental material and developing different breeding strategies for different targets.

The strategies to be followed are:

- Broaden the genetic base of commercially suitable rice varieties in Latin America
- Develop screening and evaluation methods relevant to NARDS' needs
- Provide good parental material to national partners
- Generate integrated crop management technologies for a more judicious use of agrochemicals
- Develop germplasm and cropping system alternatives for the acid, high-rainfall savannas

2. Improve the knowledge base of crop-environment and socioeconomic relationships for rice in Latin America and the Caribbean

Developing effective integrated crop and pest management technologies requires a sound understanding of the relative importance of production constraints and their interactions with the rice plant and the environment. Similarly, because socioeconomic factors such as land tenure, farm size, or alternative markets can significantly influence the suitability of a particular technology, these must be addressed as well.

Given the environmental diversity in which rice is grown in Latin America and the Caribbean, the following strategic issues should be understood:

- Factors mediating the importance, variability and interaction of key biotic constraints of regional importance such as the *hoja blanca* virus and the blast fungus
- Mechanisms of varietal tolerance to the *hoja blanca* virus
- Mechanisms governing varietal tolerance to acid soils
- Factors controlling rice grain quality components and their implications for alternative uses of rice
- Implications that socioeconomic issues have for technology relevance, transfer and adoption

3. Strengthen the capabilities of NARDS to design and implement national research and training plans

Over the next several years, the Rice Program will cooperate with selected NARDS in the identification of constraints to assign research and transfer priorities based on diagnosis of the rice environment. These will indicate specific training requirements for both in-country courses and inservice training at CIAT.

Inservice training will increase in importance, and will include small courses with specific topics. The Program will also become a center for advanced training in rice research, having graduate students from the region who will conduct postgraduate projects in collaboration with Program scientists. Postdoctoral fellowships will address specific issues of regional importance.

In summary, the Program will carry out the following strategies:

- Meet the needs currently addressed by the general training course by developing national training capabilities that will replace it with more specialized and intensive training opportunities
- Explore the possibility of strong national programs assuming some regional training responsibilities
- Link specific research activities of the Program with advanced educational and research needs of NARDS' scientists

4. Promote the development of effective information systems to improve communications within and among NARDS

While the region's germplasm exchange needs can be adequately met through the existing International Rice Testing Program (IRTP), there is no structure within which interactions among other national program scientists can be supported. Horizontal contacts among the NARDS will be enhanced through the development of informal relevant research networks. An important part of this emerging interaction will be the establishment of effective information exchange by specialized newsletters and regional conferences dedicated to relevant research and development issues. A cornerstone of the Program's strategies will be to develop strong databases that will facilitate both the Program and its NARDS' partners in developing complementary plans. These databases will concentrate on:

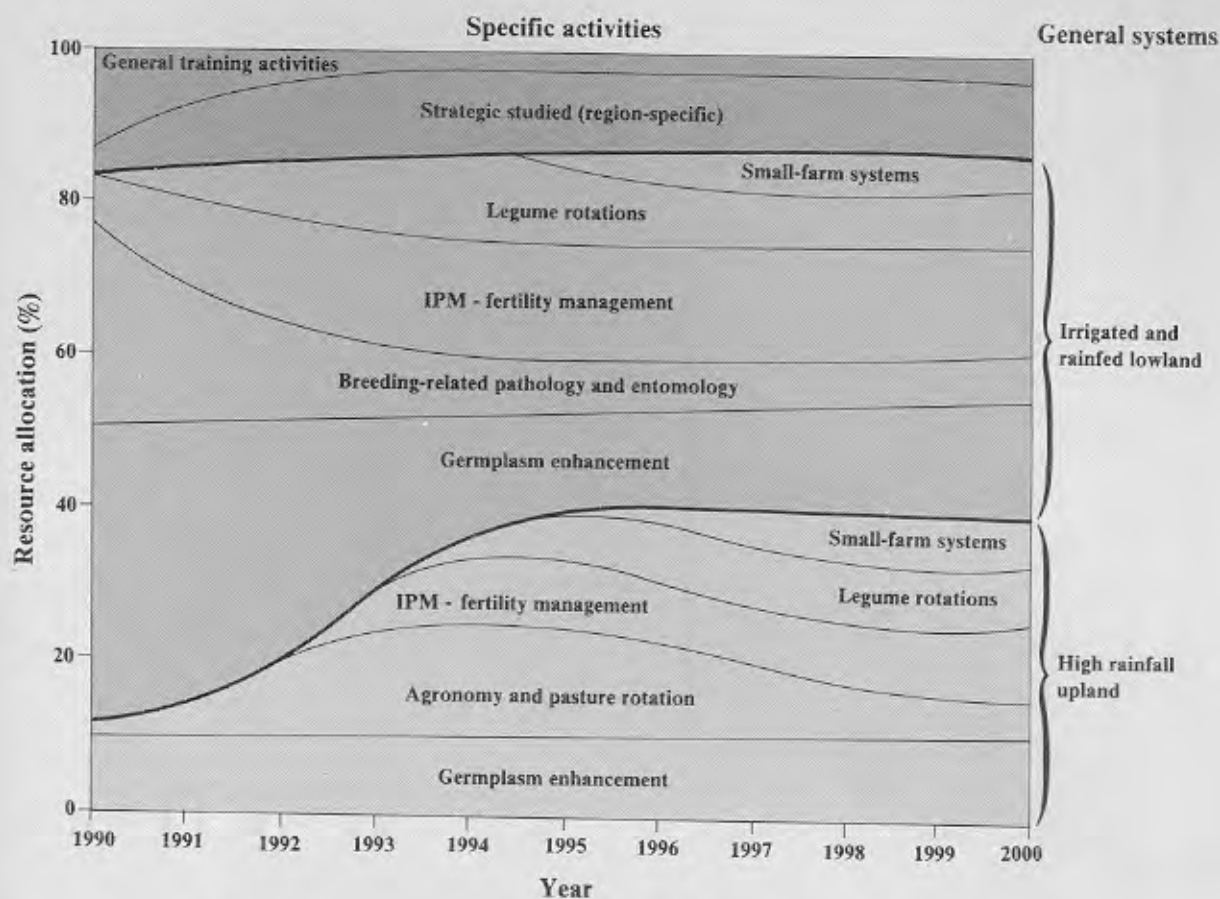


Figure 6. Projected Rice Program resource allocation for the 1990s.

- Present and potential rice-growing agroecological zones
- Germplasm
- Biotic and abiotic constraints
- Collaborating institutions

Figure 6 presents the Program's projected resource allocation for the 1990s.

Tropical Pastures Program

This Program's mandate is to develop legume-based pastures for the acid soils of the humid and subhumid lowland tropics. The Program devotes its efforts to the identification

of legume and grass germplasm adapted to these soils and climates and to grazing. It also has the major function of strengthening and supporting national programs in pasture research.

There is a clear need for the stable, more highly productive technology of legume-based pastures in order for production to keep pace with demand and in order to protect the fragile ecosystems of marginal areas to which cattle are increasingly pushed.

There are some major constraints to the Program's effort. There is a relatively poor knowledge of the mechanisms through which pastures adapt and recycle nutrients in acid,

infertile soils with high levels of aluminum saturation and low levels of plant nutrients. The socioeconomic framework of the extensive cattle industries, which operate at low levels of technical efficiency, is not conducive to the adoption of high-input technologies to increase productivity. Farmers' reluctance to use grass-legume associations in pastures, despite their proven technical effectiveness, is also hindered by the lack of roads and communications and the operational weakness of national research programs.

Significant accomplishments have been achieved. The Latin American savanna ecosystems and the existing cattle production

systems have been characterized and mapped, and methodologies for pastures development are at an advanced stage. Over 23,000 entries of grass and legume germplasm have been acquired, characterized and tested for adaptation. Many of these have been screened for adaptation to soil, climate, pests and diseases in four major screening centers and in regional trials in collaboration with NARDS in the International Tropical Pastures Evaluation Network (RIEPT). New cultivars have been released and are being adopted by farmers. Figure 7 shows the potential of the technology developed by the Program in acid-soil savannas.

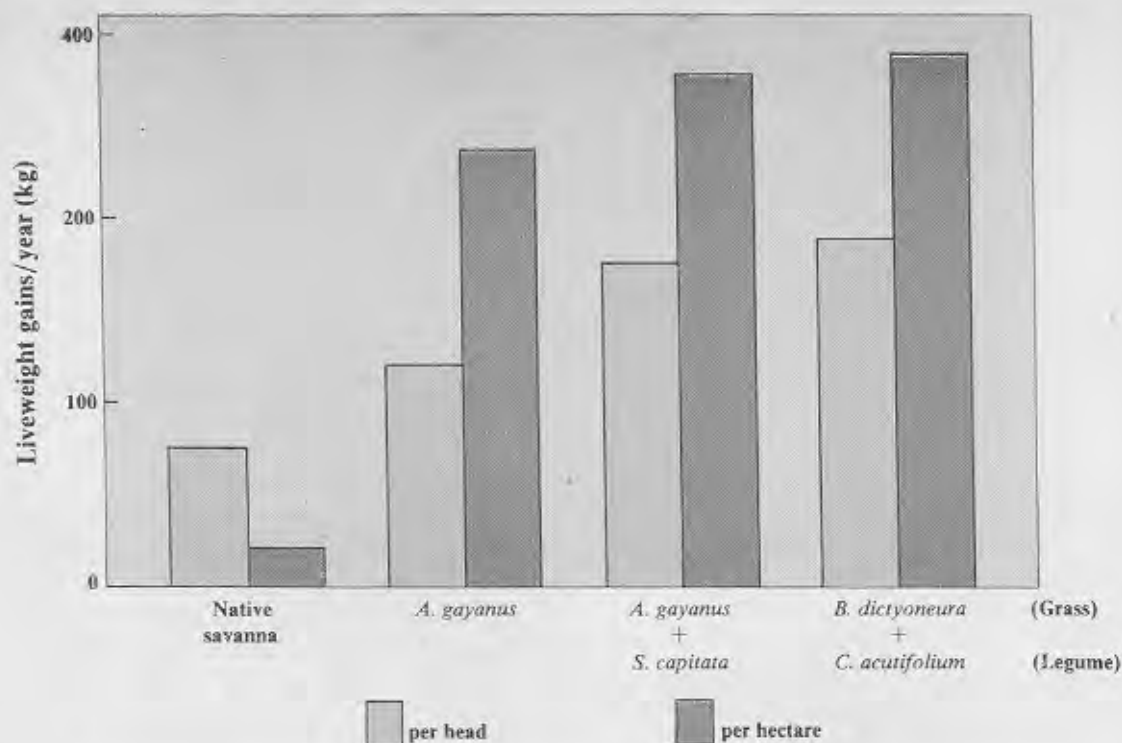


Figure 7. Potential productivity of improved pastures in the Latin American savannas. After more than five years on the poor acid soils of Carimagua, results have demonstrated the potential the new pasture technology developed by the Tropical Pastures Program has in improving animal performance and productivity. In contrast with the low productivity of the well-managed native savanna, the grass-legume mixtures have

more than doubled liveweight gains per animal and shown a tenfold increase in productivity per hectare. As Latin American cattle production is moving into areas of marginal acid soils, these results demonstrate the potential for great impact that the Program's key strategy, that is, new plants adapted to poor acid soils, can have in these areas.

The superior performance of cattle grazing legume-based pastures has been proven, as well as the technology developed to establish and manage these pastures. This technology has been demonstrated to cattle producers and offered to them for their use, but has not yet been implemented widely either on acid soils or on more fertile soils of the tropics.

Effective networks have been organized to enhance cooperation in pasture development. This has resulted in an increase in the past decade from 12 to 20 NARIs involved in collaborative activities; from 40 to 260 participating scientists; and from 40 to 180 field trials.

The challenges ahead are:

- Move, in cooperation with NARDS, the technically successful legume-based pasture technology from on-farm trial stage to commercial production stage in selected areas
- Show that, with properly managed and adapted cultivars, grazing systems can improve productivity of marginal lands while maintaining environmental quality
- Complement the evolving needs and increasing capabilities of the Latin American NARDS and, at the same time, expand activities in headquarters to more upstream research and initiate screening and evaluation in West Africa and Southeast Asia

Goal

To contribute to the overall economic growth and social welfare of both rural and urban populations in the tropics by increasing their access to beef and milk products through increases in the productivity of sustainable pasture-based production systems

Strategic objectives

1. **Document the soundness and commercial feasibility of using grass-legume pastures**

2. **Enhance the capacity of improved pastures in maintaining or recovering soil quality of pasture-based production systems on marginal lands**
3. **Develop sustainable pasture-based production systems on marginal lands**
4. **Strengthen national capabilities in the context of supply and demand for legume-based pasture technologies within the region**

Each strategic objective is subsequently discussed.

1. **Document the soundness and commercial feasibility of using grass-legume pastures**

Farmers traditionally plant only pure stands of grasses and are frequently unaware of legumes. The proposal to include almost unknown legume species is thus a radical departure from established practice. If this technology were adopted, the nitrogen-fixing and recycling capacity of pastures based on deep-rooted, well-adapted grasses and legumes could play an important role in enhancing sustainability in crop-pasture farming systems.

The challenge then is to focus on OFR and research and development linkages in collaboration with selected NARDS to prove this feasibility. This will be done in several microregions where new technology is available and of economic importance. The Program must also face the problem of seed supply, first, to allow research to go ahead and, second, to allow transfer of the technology, adoption and impact.

The strategies to be used are:

- Establish sharply focused research and development case studies in contrasting pasture-based farming systems
- Promote the development of public and private enterprise systems of seed supply, addressing constraints to the rapid and effective release of new cultivars

2. Enhance the capacity of improved pastures in maintaining or recovering soil quality of pasture-based production systems on marginal lands

Traditional pasture-based systems are not very sustainable, particularly those on acid soils, given the use of nonadapted germplasm, mismanagement, depletion of soil nutrient reserves and high levels of erosion. However, improved pastures based on adapted grasses and legumes that effectively fix nitrogen and recycle nutrients have the potential to contribute to sustainability. Well-adapted, well-managed pasture systems have low levels of soil nutrient extraction because most of the output is high quality energy and protein that is primarily made of freely available N, C, H and O and small amounts of K, P, Ca and Mg from the soil. Such pastures also maintain high density of cover and profuse and vigorous root systems, minimizing leaching and soil erosion and improving soil structure.

The basic strategy therefore is:

- Develop the techniques and methods to quantify nutrient cycling in grass-legume pastures under different soil and management conditions

This knowledge will enhance both CIAT's and NARDS' capacity to develop the agronomy for integrating pastures and crops, and/or trees into sustainable pasture-based farming systems.

3. Develop sustainable pasture-based production systems on marginal lands

In the savannas, integrating cropping at the time of pasture establishment would reduce pasture development costs, particularly for land preparation and fertilizers. Effective recycling within persistent grass-legume pastures will, in time, improve the soil for subsequent cropping cycles within sustainable crop-pasture farming systems.

In the disturbed lands of the rain forest, the major concerns are fragility and continued deforestation. The integration of pastures and

trees in silvopastoral production systems is an option for utilizing resources in an efficient and sustainable way. Integration of grazing animals with trees will reduce the cost of weeding and generate income in young plantations. Shade-tolerant grasses and legumes are also required for the establishment and maintenance of integrated tree-pasture systems. Other possible roles of trees need to be studied within the context of silvopastoral systems.

The challenge is to establish cooperative projects with crop and tree research teams such as those at CIAT (Rice and Cassava Programs), CIMMYT, IITA, the Nitrogen-Fixing Tree Association (NFTA) and ICRAF, to develop the knowledge of, and component technologies for, integrating crops and trees in the poor acid soils of these two areas.

The strategies to do this will therefore be:

- Selectively broaden the germplasm base of some grasses and herbaceous and woody legumes
 - Develop low-cost and low-risk technologies for the integration of pastures in relevant sustainable production systems
 - Understand the processes governing plant (pasture-crop-trees)/ animal/ management interfaces for effective nutrient cycling and sustainability
- ## **4. Strengthen national capabilities in the context of supply and demand for legume-based pasture technologies within the region**

A number of superior grasses and legumes are in the pipeline and being released commercially through the RIEPT network. The massive screening efforts of the 1980s are no longer needed and will be limited to specific needs. The RIEPT concept has been extremely successful in testing the recommended methodologies and research techniques and developing and defining them in manuals. The network needs to be strengthened to assist national partners make better use of

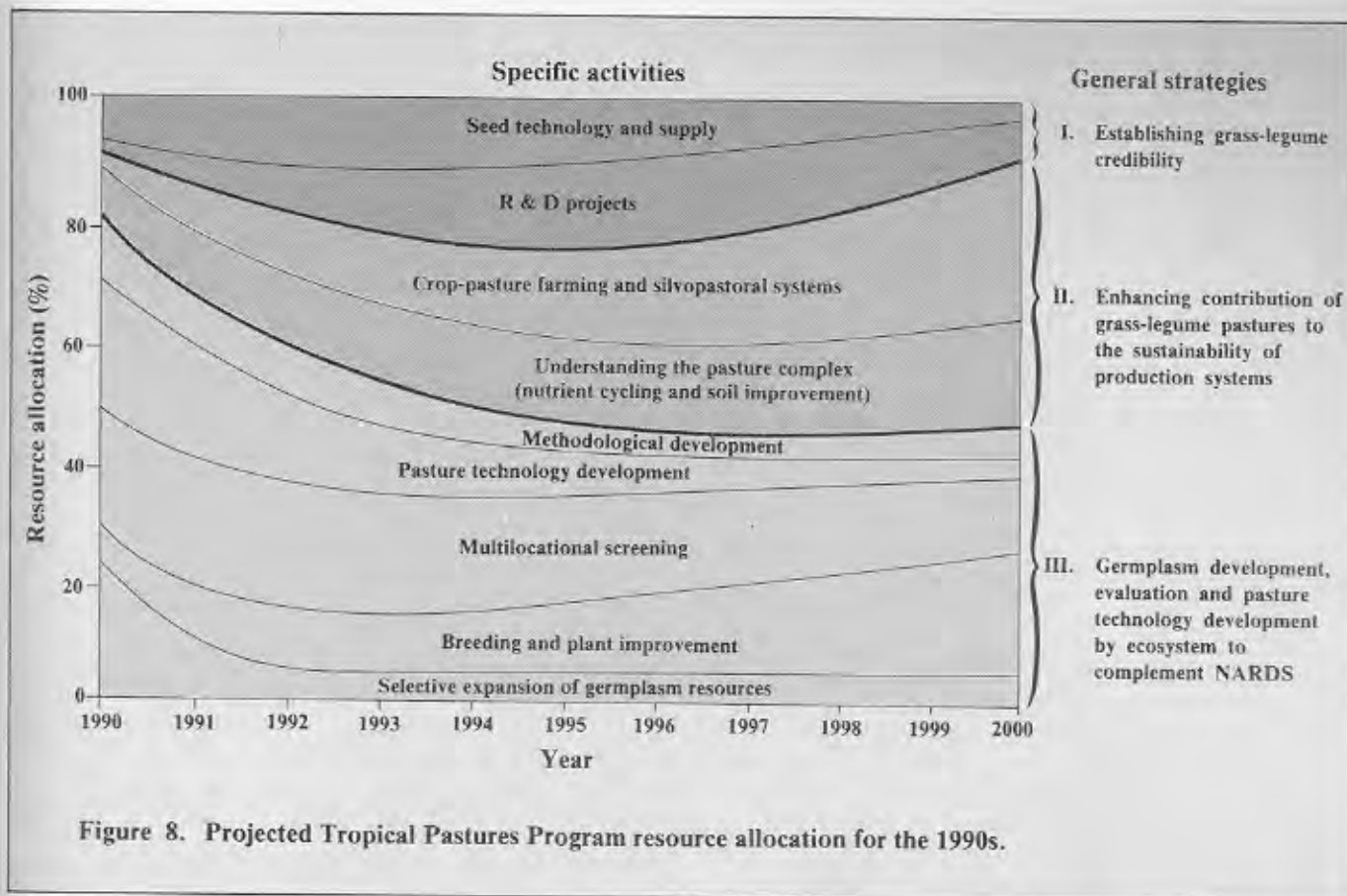


Figure 8. Projected Tropical Pastures Program resource allocation for the 1990s.

information, define research priorities, and avoid duplication. The challenge is to adjust to RIEPT's growth in diversity (NARDS instead of NARIs) by providing sound research and development approaches, methodologies and techniques for an effective linkage between research and development, as well as to upgrade the NARDS' technical leadership capacity on pasture research and development.

The following strategies will be adopted:

- Limit, together with tropical American networks, screening and/or evaluation activities in the region to sharply focused components of relevant systems; cooperate with ILCA/IEMVT and CSIRO to develop regional networks in West Africa and Southeast Asia, respectively
- Strengthen RIEPT networking by promoting cooperation among members in addressing regional problems

- Cooperate with RIEPT in developing a postgraduate training program to upgrade scientific and leadership capacity of member institutions

Figure 8 shows the projected relative allocation of resources to various activities contributing to the Program's general research strategies for the 1990s.

Research Support Units

The multidisciplinary nature of CIAT's commodity research is one of the Center's basic strengths. The creation of a series of support units has been a parallel feature of CIAT's evolution. These units provide a series of research- and service-oriented support activities to the commodity programs, both upstream and downstream. In more basic areas the Biotechnology (BRU), Virology (VRU) and Genetic Resources (GRU) units provide

backup and act as bridges for advanced research that has application to the commodity programs. More downstream, the Seed Unit provides an essential activity to ensure success of program research by enhancing the flow of technology through improved seed supply systems. Both the Agroecological Studies Unit (AESU) and the Data Services Unit (DSU) are involved in both upstream and downstream ends of the research continuum.

At the beginning of the research process, the GRU collects and evaluates germplasm and the AESU defines environments so priorities can be set. Further on in the research process, the GRU will characterize the germplasm, the BRU will develop biotechnological methods, and the VRU will solve virology-related problems. Toward the end of the research process, the AESU provides the information that allows programs to fit the technology to the environments, and the Seed Unit helps improve the seed supply systems for delivery to end users. The DSU supports all units and programs throughout the process.

The support units are characterized by four common features:

- Involvement in research and service activities as required by all CIAT commodity programs
- Research and service activities are specialized, requiring a degree of centralization of facilities and specialized equipment
- Many of the activities within each unit are of themselves interdisciplinary, requiring research specialization within the unit
- Support provided by the units is fully coordinated with commodity program requirements and does not constitute a free-standing or independent set of activities

Genetic Resources Unit

This Unit is concerned primarily with conservation of germplasm and associated

research. Conservation of germplasm in a centralized unit allows program scientists to get on with their research while having ready access to the germplasm. The Unit provides the essential building blocks for CIAT's move to more upstream research in the next decade. Constraints faced are the genetic erosion in centers of origin and the large numbers that have to be handled, particularly in the characterization stage.

Created in 1976, the Unit has assembled a large bean germplasm collection (about 42,000 accessions). This is expected to grow by 8000 by the year 2000. Primary characterization is in progress for the collection and a preliminary identification of gene pools has been carried out. Of the cassava collection (5000 clones), 90% has been placed in meristem culture, the field collection is complete, and primary characterization has been largely completed. A large collection of mainly undomesticated plants have been collected in the wild by the Tropical Pastures Program and its collaborators. Documentation and characterization is somewhat more difficult because of the nature of the materials. The challenges for all collections are to create a core set which is representative of the overall collection, and to evaluate and genetically characterize the materials.

Goal

To provide a means to conserve all critical germplasm resources in *Phaseolus*, *Manihot* and several genera of tropical pastures and to research these collections, thus ensuring fuller utilization in international and national programs

This goal encompasses both cultivated and wild relatives of domesticated species of beans and cassava and selected genera of pasture legumes and grasses. The collection at CIAT is freely available to bona fide researchers worldwide.

Strategic objectives

1. To collaborate with the International Board for Plant Genetic Resources (IBPGR) and national agencies in targeted collection missions

The collection activities have been largely completed. The remaining work to be done is in highly focused missions, in collaboration with national programs, to fill gaps and to ensure that "hot spots" are well covered.

2. To consolidate, evaluate, and characterize the collections for each commodity and to assemble core collections where warranted

The documentation of variability is a critical element in the work of the Unit because it ensures that the collections are more fully utilized.

3. To carry out collaborative research on the collections, in order to better understand the structure and variability, concentrating on those aspects of highest value for future research purposes

The research envisaged covers a wide field, in such areas as studies on the evolution and domestication of species, genetic structure of collections and seed physiology.

Biotechnology Research Unit

Created in 1985 as a bridge between advanced research done, mostly externally, and the commodity programs, the role of the Unit is to capture the benefits of advances in the new biology. Research in cellular and molecular biology add a new dimension to traditional research by providing powerful tools to aid plant breeding that result in significant payoffs in terms of technology development. The amount of advanced research on CIAT commodities, especially in *Manihot*, *Phaseolus* and tropical pasture species, in advanced institutions in developed and developing countries had been limited in

the past. Most research concentrates on the crops grown on large farms in developed countries, with the private sector making a significant contribution to the total effort.

More recently, advanced work on CIAT species has commenced in many laboratories, as well as at CIAT, and will continue in the 1990s. Tissue culture micropropagation and biochemical genetic fingerprinting have been developed for routine use in cassava, beans and tropical pasture germplasm; wide crossing and gene pool characterization by electrophoretic techniques are being carried out in common beans; anther culture is being used routinely in the rice program; and regeneration from protoplasts has been achieved in *Stylosanthes*. The major challenges ahead include the elucidation of biochemical and genetic factors involved in plant-pathogen and pest interactions in beans, cassava, rice and pasture species; the development of molecular markers and construction of genetic maps for important traits in beans and rice; and the development of genetic transformation and plant regeneration for the later application of genetic engineering, particularly in cassava and beans.

Goal

To increase the application of new methodologies derived from the new biology for greater efficiency in plant improvement and to develop means for increased utilization of a wider range of germplasm variability in the crops and pasture species in CIAT's mandate

Strategic objectives

1. Develop advanced research networks on beans and cassava and, later on, tropical pastures

The BRU will collaborate with CIAT programs in the identification of critical constraints in crop and pasture production and utilization which are not amenable to traditional research approaches.

Research strategies are then defined to resolve the constraints within the framework of multi-institutional advanced research networks. A network approach facilitates the establishment of research priorities and helps identify collaborators and funding for that research. The network links biotechnology research with agricultural objectives that can be translated into benefits for small farmers and poor consumers. The cassava advanced research network was established in 1988 and the one for *Phaseolus* will be established by the end of 1989. The BRU actively participates in and takes advantage of information and technologies supplied by the International Rice Biotechnology Network, sponsored by the Rockefeller Foundation.

2. Research at CIAT on biotic and abiotic resistance and tolerance mechanisms in priority areas of CIAT commodities

Understanding these processes will improve the efficiency of breeding and selection strategies by broadening access to the primary and secondary gene pools, and will overcome present limitations with respect to the speed and precision with which useful traits can be identified, selected and transferred.

3. Research on characterization of germplasm

It is critical to identify the genetic basis of important traits and the distribution of variation among genetic stocks. This work will be carried out in the context of the ongoing work of the Unit as well as in the advanced networks.

4. Technology transfer

Research in the BRU results in the development of practical techniques which are then transferred for routine use in CIAT programs and in NARIs. Through CIAT's Training and Communications Support Program, NARIs' personnel will be trained in biotechnology techniques, and information and

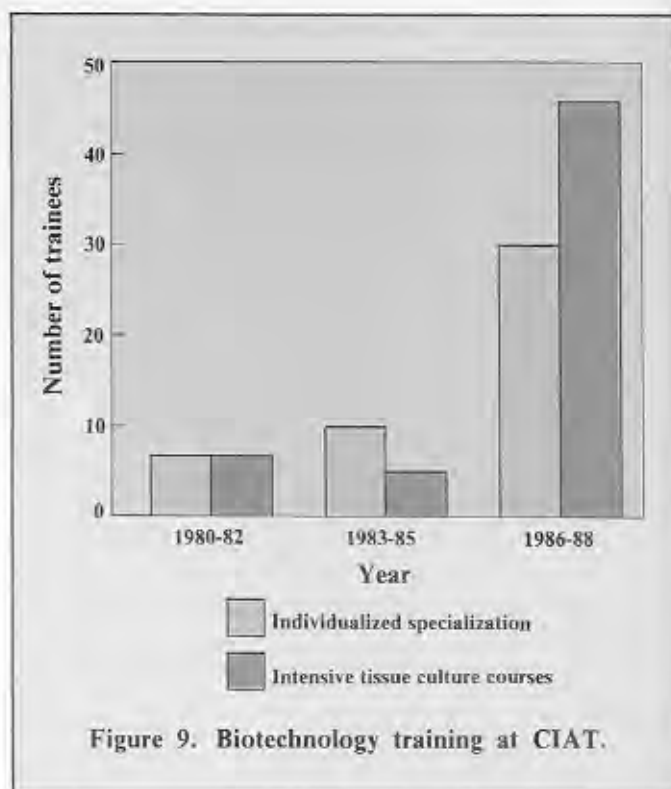


Figure 9. Biotechnology training at CIAT.

material exchange will facilitate the work of others. Figure 9 shows evidence that training in this area has already begun and is growing.

Virology Research Unit

This Unit was created in 1988 and was built on existing expertise in the Center. It provides a virology research service to all programs. Viruses and virus-like organisms constitute the one main phytosanitary constraint to international exchange and distribution of improved plant germplasm. Virological research on cassava and the tropical pastures species is very limited in other laboratories.

Excellent progress has been made on beans and cassava, while work is just beginning on the virus problems of pasture species. In beans, the sources of resistance have been identified for many virus diseases and methods of quarantine inspection have been identified. In cassava, effective means of cultural and phytosanitary control have been developed for some of the critical problems. Many other difficult problems remain to be resolved.

Goal

To develop, in collaboration with the commodity programs, appropriate virus disease control and phytosanitary procedures on the species in the CIAT mandate

Strategic objectives

1. Identify and characterize all virus and virus-like disease organisms that cause economic loss in CIAT commodities

This phase is often conducted in collaboration with other advanced laboratories.

2. Identify appropriate control procedures

The procedures involve breeding, cultural practices and phytosanitary procedures for effective quarantine.

3. Develop indexing and detection methodologies for routine quarantine purposes

The work done here specifically applies to the development of methods to identify the presence of virus organisms in CIAT germplasm.

4. Collaborate with commodity programs in applying the above knowledge to the virus problems of critical importance

The work done with the programs allows a transfer of the results of the Unit to effective use at CIAT and in NARIs.

Agroecological Studies Unit

This Unit has developed a land systems database for the tropical lowlands of South America with a thorough analysis of climate, landscape and soil factors. In addition to climate and soils, the agroecological database for CIAT's mandated crops includes data on cropping systems and mapping information. The climate database contains records from

16,200 meteorological stations throughout the tropics. Efforts are underway to digitize the diverse soil maps of Central America. Maps have been cataloged, using ISIS software. The potential of using Geographic Information Systems (GIS) is being explored.

Goal

To collect, catalog, and analyze biophysical and socioeconomic information to aid in both adaptation of mandated crops to different environments and understanding the way land is being used in selected ecosystems

Strategic objectives

1. Indication of homologue areas for the generation and transfer of new varieties and management practices
2. Examination of agricultural systems in detail at the ecosystem level

Seed Unit

The development of an effective national seed supply system has not kept pace with technology advances, except in the case of rice in some countries, thereby limiting the impact of those advances. This appears to be related more to the socioeconomic characteristics of the crop than to farm size. Small farmers play an important role in Latin America where, it is estimated, they contribute more than 50% of total food supply. For some basic staples such as beans, this increases to 90%. Both small-farmer productivity and income could improve if three key seed-related constraints were removed:

- Lag in adoption of new cultivars
- Low utilization rate of improved seed
- Seed availability

Goal

To complement the commodity programs by developing technologies and methodologies

that make improved seed available to farmers and ensure longer productive life of genetically improved varieties

Strategic objectives

1. Produce basic seed of promising lines and newly released varieties of CIAT commodity programs
2. Develop low-input technologies to overcome the most pressing problems related to field deterioration, drying, conditioning and storage
3. Design, test and promote institutional models appropriate for nonconventional seed production by small farmers
4. Train national partners on three essential components of seed supply systems: basic seed production; seed quality control; and seed production by small farmers.

Figure 10 shows that training is evolving from more generalized courses to individual specialization in those areas described in 4.

Data Services Unit

The DSU acts as a central group for support and advice to CIAT research programs and units on aspects of mathematical, statistical and computing techniques applied to agricultural research, focusing on biometry and data analysis and on database development. Such support has been particularly effective in the proper planning and execution of experiments, analysis of accumulated information, and the development of databases for each of the four commodities.

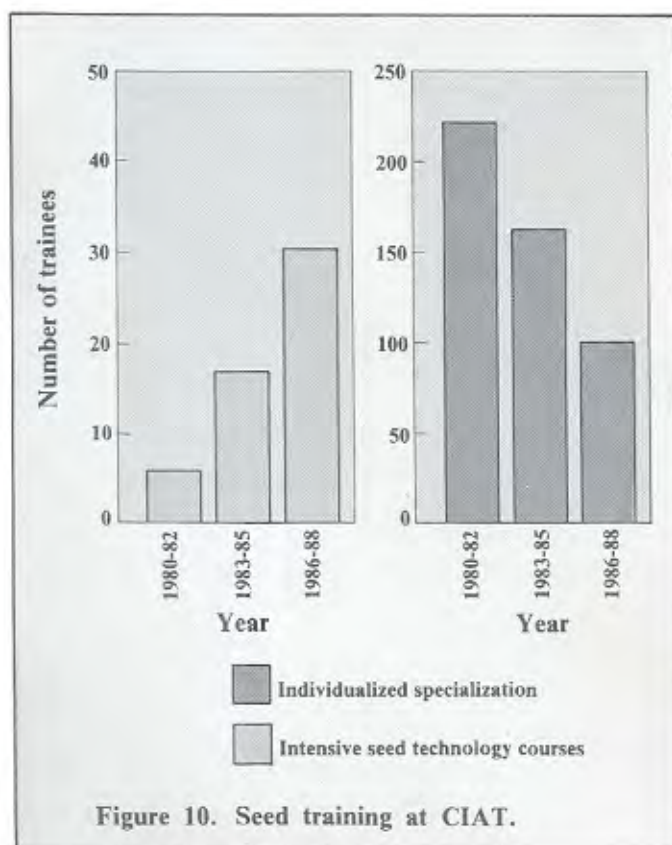
The challenge for CIAT in the coming decade is to integrate this and other sources of data into a dynamic management and scientific information system. This should be designed so that specific data are transformed into information for operational and control purposes, while serving planning purposes. By facilitating the conversion of data into information, and this into actions, such a system should reduce uncertainties in decision-making at the scientific and management levels.

Training and Communications Support Program

When CIAT developed its commodity teams, national research programs on these crops were mostly at an early stage of development or nonexistent. The Center, therefore, embarked on a major effort to enhance national research capacities through training.

Initially, a basic core of researchers was assembled by means of introductory commodity research and production courses. As progress was made, emphasis shifted toward individualized disciplinary specialization. At the same time, selection criteria moved from being based mainly on candidate qualifications to being the proactive choice of professionals aimed at developing and strengthening partner teams.

As the result of these efforts, a satisfactory capacity of human resources for adaptive



research is now in place in most relevant countries and, in some of the more advanced national systems, a capacity for applied research has also been developed. Important numbers of technology transfer professionals have also benefited from CIAT's training.

Figure 11 shows the number of professionals trained in the 1980s on commodity-specific topics both at CIAT and in participant countries.

Scientific and technical informational needs of CIAT's research programs and NARS are addressed by CIAT's library; specialized bibliographic information centers (SINFOCs); and the Center's own commodity newsletters, technical monographs, bulletins, proceedings,

reports and manuals. CIAT also informs the public about the Center's goals, strategies, activities and achievements through the *CIAT Annual Report*, the semiannual *CIAT International*, releases for mass media and articles for popular science publications.

Various challenges for the TCSP result from the Center's objectives of strengthening NARDS and helping articulate the international agriculture knowledge and technology system, as highlighted below:

- Working with NARDS in complementary activities that cover a wider spectrum of training needs, ranging from strategic research to technology transfer

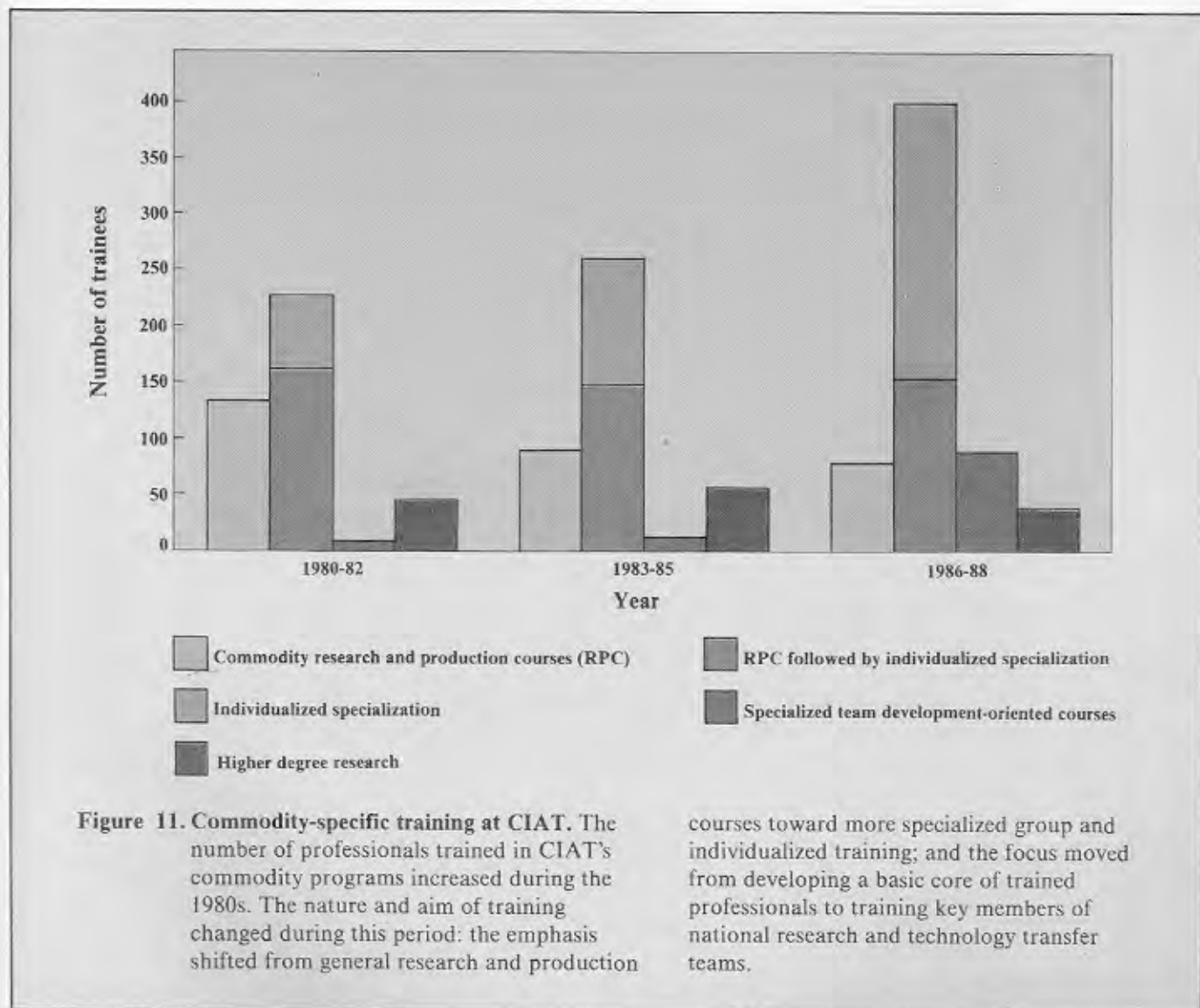


Figure 11. Commodity-specific training at CIAT. The number of professionals trained in CIAT's commodity programs increased during the 1980s. The nature and aim of training changed during this period: the emphasis shifted from general research and production

courses toward more specialized group and individualized training; and the focus moved from developing a basic core of trained professionals to training key members of national research and technology transfer teams.

- Strengthening communication channels with both our upstream and downstream partners, while stimulating greater horizontal communication among partners in increasingly complex national systems
- Drawing support for agricultural research by informing decision makers in national and international communities about agricultural research and its impact on sustainable socioeconomic development

Goal

To support CIAT's research and institution strengthening roles through the training of NARDS staff, provision of scientific and technical information, promotion of cooperation among NARDS and between them and CIAT, and by fostering a favorable policy environment for agricultural research through public information

Strategic objectives

1. **Maintain a country-level perspective and a Center-wide approach to CIAT's training and communication efforts aimed at NARDS enhancement; and to provide the educational, information and documentation, and communication expertise for joint efforts with the Center's research programs**
2. **Help national commodity research systems of large countries, and regional systems of smaller ones, reach the capability and capacity required to carry out their share of complementary activities concerning sustainable technology generation and transfer related to CIAT commodities**
3. **Organize research information and documentation systems, allowing partners to systematically receive the contents of CIAT's bibliographic databases, and to access the corresponding full documents**

4. **Broaden our publication scope to make available specialized materials to the whole spectrum of upstream to downstream audiences, including technology intermediaries**
5. **Organize events that bring together key actors from the various parts of the international knowledge and technology system, in order to enhance their cooperation, thus increasing the effectiveness of the technology generation and transfer related to CIAT's commodities**

The above objectives are subsequently discussed.

1. **Maintain a country-level perspective and a Center-wide approach to CIAT's training and communication efforts aimed at NARDS enhancement; and to provide the educational, information and documentation, and communication expertise for joint efforts with the Center's research programs**

The TCSP collaborates closely with the Center's research programs in the definition of commodity-specific training and publication strategies, and also provides subject-matter specialists for training and communication activities. The TCSP is responsible for maintaining a country-level perspective of, and a Center-wide approach to, NARDS-enhancing efforts by CIAT. This means, first, that it assesses the needs of the individual countries' technology generation and transfer systems as a whole (in relation to CIAT's commodities), vis-à-vis the more restricted needs and perceptions by individual institutions or commodity programs within the national systems. Second, the TCSP strives to ensure that CIAT's response to NARDS' needs are determined from a Center-wide standpoint, rather than from an exclusively commodity program point of view.

Strategies to be followed are:

- Monitor the goals, strategies, and operational capacities of NARDS in relation to CIAT's commodities in order to assess the human resource enhancement and information needs to be met by CIAT
- Maintain a balance between the specific interests of the Center's commodity programs and Center-wide interests in the use of resources allocated to the TCSP
- Use a multidisciplinary approach to institution strengthening, combining the subject-matter expertise of research program scientists with the educational, communications, and information skills available in the TCSP

2. Help national commodity research systems of large countries, and regional systems of smaller ones, reach the capability and capacity required to carry out their share of complementary activities concerning sustainable technology generation and transfer related to CIAT commodities

An increasing demand for CIAT training in applied and strategic research has emerged. This coexists, however, with the continuing demand for training in adaptive research on the part of weaker NARS, and also for the training of newly recruited scientists in the stronger ones, which can hardly be met by the NARS themselves because their training capacity is either weak or nonexistent.

To meet this projected demand, research training at CIAT's headquarters will become more specialized and advanced, giving greater emphasis to higher degree research training. Associated with this shift, NARDS will be encouraged to set up or strengthen national or regional training organizations, for which CIAT will train the corresponding trainers in commodity and OFR research, seed production and adult education methodologies.

Strategies to be followed aim at developing NARDS' capabilities for:

- Training on crop production in CIAT commodities at national levels
- Training for adaptive and OFR research at the national level for larger countries and on a regional basis for smaller ones
- Strategic research related to CIAT's commodities
- National or regional training capacity for OFR and seed technology

In summary, the principal changes in CIAT's training strategies for the nineties are to move research training to more specialized and advanced levels, and, at the same time, to train trainers for the NARDS' downstream training activities.

Major requisites for the new strategies are that NARDS set up their own training systems; regional integration for common research and training efforts, particularly among smaller countries, needs to be accepted; and international and national resources will have to be mobilized to fund the new activities.

3. Organize research information and documentation systems, allowing partners to systematically receive the contents of CIAT's bibliographic databases, and to access the corresponding full documents

For the collection of commodity-specific information CIAT has a comparative advantage. Delivery, on the other hand, is expected to improve as NARDS' services incorporate advanced information technology.

Initially, the contents of CIAT's bibliographic databases will be delivered systematically to the NARDS (on paper, microfiches or diskettes), followed by databases themselves being transferred to them. Eventually, it should become possible to

distribute whole information systems, that is, document collections and the databases to access them.

Strategies to be followed are:

- Coordinate the collection of research bibliography
 - Develop a regional network of IARC/NARDS' libraries and documentation centers to be inserted in the worldwide agriculture information/documentation network
- 4. Broaden our publication scope, to make available specialized materials to the whole spectrum of upstream to downstream audiences, including technology intermediaries**

CIAT's publications for the NARS will become more specialized according to discipline and to type of research (upstream-downstream), as the national research capacity in applied and strategic research increases.

The clientele will be expanded to include technology intermediaries. For them, the contents will cover such aspects as the diagnosis of production problems, production principles, new technologies and new production opportunities. Their general validity will be the guideline for these materials, as CIAT has no comparative advantage in dealing with location-specific topics.

For publications that enhance communications between CIAT and the NARDS and among NARDS, a more

participatory approach will be followed, to foster horizontal communication among NARDS as distinct from a CIAT-centered communication modality.

To keep CIAT's stakeholders and the public effectively informed on CIAT activities, an aggressive policy of accessing media in donor countries and in the countries served by CIAT will be implemented.

Strategies to be followed are:

- Maintain an effective supply of CIAT-generated information to the NARDS
 - Provide effective communication for networking and technical cooperation between CIAT and the NARDS, and among NARDS
 - Ensure that CIAT's stakeholders and the public are kept informed on the Center's endeavors and achievements
- 5. Organize events that bring together key actors from the various parts of the international knowledge and technology system, in order to enhance their cooperation, thus increasing the effectiveness of the technology generation and transfer related to CIAT's commodities**

The TCSP's support for conferences in the past concentrated on the logistics of gathering and assisting the participants. These services will now be expanded to include advice on the design of meetings and the methodological expertise for managing group interaction.

MANAGEMENT STRATEGIES

A strategic plan is useful only to the extent that it is effectively implemented. This chapter describes the leadership style and institutional policies that will be used to ensure the desired impact.

Managing the Internal Environment

CIAT leadership is responsible for maintaining a work environment that is conducive to creativity and innovation. To accomplish this we will continue to execute the necessary controls in a manner that leaves the staff relatively unencumbered by administrative and other tasks not directly related to their areas of endeavor. A nonhierarchical, open management system that emphasizes participatory, decentralized decision-making processes will be stressed.

Over the years an institutional culture called the "CIAT Spirit" has evolved. This sums up a combination of pride in the institution, the realization that the well-being of millions of people is at stake, the pursuit of excellence in all aspects of CIAT life, mutual respect and trust, and the collective desire to ensure success in CIAT's mission. To foster this spirit we have initiated a Center-wide culture management process. Through appropriate culture audits we are identifying the extent to which the institutional values described in this plan are, in fact, believed and acted upon in all components of the Center, and what policies and management practices reinforce or run counter to these values. This effort will continue and be strengthened in the coming decade, so that the positive elements of the CIAT culture will be nurtured and improved.

Managing the Process

The essence of CIAT's research management is program (as opposed to project) management. This means that once strategies are developed, appropriate mechanisms monitor and evaluate the activities of the programs and individual scientists to ensure that they contribute to achieving the stated objectives and priorities. The active involvement of the Program Committee of the Board, peer assessment through annual Center-wide and program level reviews, continuous monitoring and coaching by the program leaders, comments on reports and field visits by top management, and annual, individual staff evaluations are important elements in this process. Together they ensure the quality and relevance of each scientist's work and appraise the progress of the programs and the need for any mid-course corrections in priorities and methodologies. Individual and group performance planning will be further institutionalized in the coming decade to facilitate adherence to established goals and priorities within the framework of flexibility and creativity.

The model of multidisciplinary research teams organized around single commodities and supported by specialized research units and training and communications activities is effective and well proven. This model will be retained as the main feature of CIAT's organizational structure in the 1990s, continuing to eschew a matrix structure of programs and disciplines. The absence of formal disciplinary departments raises the question as to how scientists of individual disciplines can maintain adequate scientific excellence and depth when dispersed among different programs, and how expensive,

specialized equipment and facilities can be shared. These issues will become more intense as science becomes more specialized and the Center moves upstream. CIAT has successfully maintained disciplinary strength through encouragement of active participation in high quality, refereed journals and the informal association of disciplinary groups.

Intradisciplinary discourse and sharing of facilities are also facilitated by the policy of placing scientists of the same discipline from different programs in close physical proximity. These policies will be reinforced in the coming decade.

A related issue is how to manage highly specialized research and the concomitant support activities, especially in the interrelated areas of biotechnology, virology and genetic resources. Following the principle of multidisciplinary, commodity-based programs, the ideal is to have specialized, disciplinary scientists assigned full time to respective programs but working together and sharing facilities in specialized laboratories. The problem arises when resources are inadequate to allocate such scientists to each program in which the discipline is essential. Furthermore, these specialized research teams are often themselves multidisciplinary. Thus CIAT has taken the pragmatic approach of creating specialized research support units in these areas, each with their respective research agendas conceived to meet the highest priority research needs Center-wide. The CIAT management team will continue to coordinate the work of the specialized units with those of the programs and provide leadership in developing the expanding collaborative relationships with advanced research institutions. A review of the Center's organizational structure will be carried out in the near future to ensure its appropriateness.

Managing the Interfaces

CIAT cannot be an island; it can be productive and efficient through good internal management, but effective only through

external cooperation. Previous chapters have highlighted the importance of cooperation with NARDS partners, advanced research institutions, sister Centers, and international and regional institutions. The main interfaces for such cooperation is at the Program level; CIAT management will foster such cooperation through support of networking, conferences, workshops and personal contacts. Other interfaces are with host governments at headquarters and where staff are outposted. Through appropriate formal agreements and informal contacts these relationships will be cultivated on a continuing basis.

Managing the Funds

Supply

Execution of the Strategic Plan for the 1990s will require adequate funding. Although CIAT will make every effort to maximize self-generated income through sale of the products of its farms and careful cash management, the vast majority of its funds will have to come from contributions. CIAT will continue to rely heavily for these contributions on the donor members of the CGIAR. These governments and international development institutions are committed to the goals of the Center; such commitment must be maintained through effective communication to donors to keep them aware that their contributions are well managed and making a measurable impact on human welfare and economic development.

We intend to broaden the Center's funding base by encouraging contributions from those members of the CGIAR not currently donors to CIAT. Donor contact will continue to be one of the most important duties of management. We will also expand our efforts to add to these contributions by seeking nontraditional, non-CGIAR funding sources. We will seek to stimulate private sector funding whenever this can be done without compromising our priorities and values. We will also actively explore possibilities of adding financial resources through mechanisms such

as debt purchase and conversion and use of blocked currencies. If such efforts are successful we will study the desirability and mechanisms for the creation of an endowment to ensure greater financial stability.

Demand

We will ensure that spending is kept within the limits of total available resources by carefully restricting growth and by assiduous financial management.

The best measure of the size of our operations is the number of senior staff positions, since each of these represents a subprogram with long-term commitments to adequate staff and operational support. The Interim Plan approved by the CGIAR for the period ending in 1993 projected 105 senior staff positions. Significant growth beyond this approved level is not projected during the remainder of the decade. This severe restriction on future growth means that the various additions implied in this plan will have to be made by reallocation of resources within these limits. This will involve hard decisions, including the scaling down or phasing out of some current activities. CIAT is committed to the necessary discipline and rigor that staying near the approved level will demand. The only caveat placed on this commitment is that it may be necessary to increase the total establishment if the creation of a new natural resources program necessitates major resource additions.

Great attention will also be given to efficiency. CIAT is a trustee of funds from donors and these resources will be carefully managed with controls and cost-accounting mechanisms that ensure cost-effectiveness. We will actively seek out and firmly eliminate waste and misuse of resources. CIAT will continue to assign importance to having a lean, highly professional administration that operates on straightforward rules and regulations, a minimum of bureaucracy or officialdom, and open communication with all Center activities.

In times of severe financial stringency of probable long-term duration we will follow the principle of eliminating whole sections or subprograms rather than the simple but regressive practice of across-the-board budget cuts. When making necessary budget reductions we will pursue the goal of keeping staff costs below 65% of the total budget. Before reducing or eliminating a set of activities we will perform a careful analysis of the relative foregone benefits to CIAT's beneficiaries.

Managing the Facilities

We will not sanction the decapitalization of the Center. The excellent facilities at CIAT's disposal have been developed through generous contributions. We must not allow them to deteriorate. Even in times of severe financial stringency we will strive to budget adequate amounts for proper maintenance and equipment replacement. In line with the concept that research is of such import that mediocrity cannot be tolerated, CIAT will continue to insist on a clean, functional and well-kept environment. But good housekeeping must not be confused with luxury. The Center draws a clear line between what is needed to support a productive, neat context in which the work gets done, and ostentation. The former is essential to the success of the Center's work; the latter is unacceptable.

Managing Impact

CIAT leadership pledges itself to the achievement of the high goals and objectives described in this Plan. Through the various mechanisms and policies described above we expect to manage its successful execution. Success must be measured by real improvements in the lives of people we serve. New knowledge, scholarly publications, better methodologies, well-trained people and better institutional relationships are all important but they do not constitute the goal. Execution of this Plan must result in substantial and

sustainable production increases and improved personal income, thereby raising the standards of living of millions of people now in desperate need. To that end we dedicate this Plan, and

for that purpose we will ensure that each program has in place an adequate mechanism to monitor the adoption of our work and its social and environmental impact.

ACRONYMS

AESU	Agroecological Studies Unit (CIAT)	IBPGR	International Board for Plant Genetic Resources (Italy)
BRU	Biotechnology Research Unit (CIAT)	ICRAF	International Council for Research on Agroforestry (Kenya)
CGIAR	Consultative Group on International Agricultural Research (Washington, USA)	IEMVT	Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux (France)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)	IITA	International Institute of Tropical Agriculture (Nigeria)
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (Mexico)	ILCA	International Livestock Center for Africa (Ethiopia)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (France)	IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières (France)
COSCA	Cooperative Study of Cassava in Africa (CIAT and IITA)	IRRI	International Rice Research Institute (Philippines)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)	IRTP	International Rice Testing Program
DRI	Programa de Desarrollo Rural Integrado (Colombia)	ISIS	Integrated Set of Information Systems
DSU	Data Services Unit (CIAT)	NARDS	National agricultural research and development system
EEC	European Economic Community	NARI	National agricultural research institute
GIS	Geographic Information Systems	NARS	National agricultural research system
GRU	Genetic Resources Unit (CIAT)	NFTA	Nitrogen-Fixing Tree Association
IARC	International agricultural research center	OFR	On-farm research
		R & D	Research and development

RIEPT Red Internacional de Evaluación
de Pastos Tropicales
(International Tropical
Pastures Evaluation Network)

SINFOC Specialized Information Center
(CIAT)

TAC Technical Advisory Committee
(CGIAR)

TCSP Training and Communications
Support Program (CIAT)

VRU Virology Research Unit (CIAT)

WARDA West Africa Rice Development
Association (Côte d'Ivoire)