CIAT in the 1990s and Beyond:

A Strategic Plan

CIAT

Centro Internacional de Agricultura Tropical

The Centro Internacional de Agricultura Tropical (CIAT) is a development-oriented, agricultural research institution dedicated to the application of science towards lasting alleviation of hunger and poverty in developing countries.

CIAT is one of 13 international agricultural research centers under the auspices of the Consultative Group on International Agricultural Research (CGIAR).

The core budget of CIAT is financed by a number of donors. During 1991 these CIAT donors include the countries of Belgium, Canada, China, Finland, France, the Federal Republic of Germany, Italy, Japan, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States of America. Organizations that are CIAT donors in 1991 include the European Economic Community (EEC), the Ford Foundation, the Inter-American Development Bank (IDB), the International Bank for Reconstruction and Development (IBRD), the International Development Research Centre (IDRC), the Rockefeller Foundation, and the United Nations Development Programme (UNDP).

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CONTENTS

FOREWORD

We are pleased and proud to present this strategic plan for CIAT in the 1990s and beyond. It describes the new strategic directions that will guide a renewed center as it approaches the twenty-first 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 small number of 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 to national research and development systems, and decentralizing a growing share of its operations. During this period, it also expanded its activities in field beans to include Africa, and in cassava to include Asia. By the end of the decade, for all its programs, measurable impact was already seen in farmers' fields and in national production figures of many Latin American countries. In the 1990s, we expect that the large number of technologies near the end of the development process will have significant impact on the economy and agriculture of the Americas, Africa and Asia.

However, it has now become clear that CIAT's traditional commodity research is insufficient for achieving sustainable agricultural development. The 1990s will see the center moving assertively to combine commodity and resource management into an integrated systems approach in its efforts to increase food production and economic growth, without jeopardizing the natural resource base on which future progress depends. We also plan to accelerate further the incorporation of advanced science into our efforts, to share, where possible, international responsibilities with our national program partners, and develop collaborative approaches with a greatly expanded range of institutions.

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 who have given their valuable time to help us in the development and review of the various components of this plan. We single out especially those who spent long hours performing the analyses that helped determine our commodity and agroecosystem choices.

In the name of the entire CIAT community, we wish to express our profound gratitude and admiration to former Director General, Dr. John L. Nickel, who left CIAT in early 1990 after 15 years of outstanding leadership. With his clear and visionary thinking, he set in motion and guided the early stages of the process leading to the present strategic plan.

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 twenty-first century for those we serve. By working together in the urgent task of alleviating poverty and hunger and by moving toward more sustainable agricultural systems, we will achieve a more just, secure and prosperous future.

Signed,

For: Frederick Hutchinson
Chairman, Board of Trustees

Gustavo A. Nores
Director General

Cali, Colombia, April 1991

EXECUTIVE SUMMARY

This strategic plan results from an intensive, interactive process involving CIAT's Board of Trustees, internal task forces and many leaders of national programs. The planning process began with examination of CIAT's external and internal environments within a long-term perspective. Analyses were undertaken by various task forces of economic trends in Latin America and the Caribbean; trends of selected commodities; and of natural resource management for sustainable agriculture (see Supplement).

Guiding our planning process were the central targets we are aiming for, namely, growth, equity and enhancement of the resource base. In formulating our strategies, we took into consideration CIAT's cultural values, and present and future comparative advantages.

The analysis shows that change in CIAT's environment is rapid and continuous, such that CIAT must change radically to continue being relevant. Increasingly, traditional research paradigms based largely on productivity considerations must give way to new technology design conceptualizations. These conceptualizations must be sensitive to the complex biophysical interactions underlying cropping systems and to the socioeconomic, political and agroclimatic dimensions that determine land use patterns in given agroecosystems. Technology options must meet multiple performance criteria, ranging from microeconomic to ecological considerations. This requires a change from a supply-driven to a demand-driven systems approach.

Consequently, CIAT will integrate its current efforts on germplasm development with a major research effort on resource management.

Germplasm development research will focus on a set of commodities that are economically important, fit into the center's mission and allow CIAT to make a unique and important international contribution. The commodity portfolio will consist of beans, cassava, rice and tropical forages. Except for rice, for which CIAT assumes a regional responsibility for Latin America and the Caribbean, the center will exercise global responsibility for the commodities in its mandate. A secondary emphasis will be given to sorghum and soybeans, but limited to the development of these crops as components in cropping systems for the acid savannas of tropical America. Germplasm development efforts will increasingly focus on the more strategic end of research, emphasizing basic technology components that have the potential to constitute major advances in the development of productive and sustainable production systems. Germplasm development research will be closely interlinked with resource management research, meeting the latter's demand for essential commodity-specific technology inputs. Conversely, resource management research methodological tools and agroecosystems- related information will make it possible for germplasm development research to advance within an agroecosystems context.

Resource management research will focus on selected, important agroecosystems in tropical America with two aims: improving the management of resources available to agriculture, and helping relieve market and social pressures on the most fragile

environments. In this manner, the gains in output of food and other commodities will be compatible with long-term conservation of the resource base. This will involve research on critical resource management issues, and the design of land use options that optimize the social returns to agriculture under different trade-off scenarios between resource utilization and preservation.

Resource management research is a highly complex and wide-ranging endeavor that requires systematic cooperation among many institutions at national, regional and international levels. For the chosen agroecological zones, CIAT will provide an international focal point that will permit diverse institutional efforts to coalesce around the goal of improved management of agricultural resources. CIAT is fully prepared to assume the role of an ecoregional research center, enabling other institutions -- particularly other international centers and specialized agencies -- to make concerted contributions to the design of improved technology options. CIAT will provide a research platform, as well as the necessary physical and informational infrastructure, for these diverse institutional inputs.

To pursue its new mission of integrated germplasm development research and resource management research, CIAT will redeploy existing resources, and will need selected additional resources. An analysis of minimal resources needed for the planning period shows that the annual additional resources required will amount to about 10% above the level approved by the CGIAR for 1991.

Chapter 1

CIAT'S EXTERNAL ENVIRONMENT

A long-term view is necessary for assessing the payoff of long-term research. There are perils, however, in predicting the future in times of rapid technological and political change. Therefore, we have limited our analysis to the spheres of change that are of special importance to the center in developing its strategy for the 1990s and beyond. In particular, we have made an effort to anticipate major trends that will shape CIAT's environment during the first decade of the next century.

Economic trends in tropical America form the setting in which research topics must be selected and the results of research applied. The market and social pressures on the region's natural resource base have profound implications for the research agenda. The evolution of donor priorities, as influenced by national and regional development priorities, has a major influence on our strategies. Finally, the evolving trends in research methods and the capabilities of our partners determine the kinds of service that CIAT must offer.

Economic Trends

For many countries in Latin America and the Caribbean, the 1980s were a 'lost decade.' The region's debts took on unmanageable proportions, reaching US$415 billion by 1989. The capital inflow of the 1970s went into reverse, with more than US$30 billion a year leaving the region. Growth in exports declined as terms of trade deteriorated, and loose monetary policies led to rampant inflation. Economic growth came to a complete standstill, and in many countries the economy actually shrank. Agriculture weathered the critical years surprisingly well, maintaining a growth rate of 2.2% compared with 1.0% for industry. However, the increase in food production barely kept pace with the population growth rate.

By 1990, people were, on the average, about 10% poorer than in 1980. In 1986, poverty affected an estimated 37% of the region's population, 2% more than at the start of the decade. Having increased throughout the 1970s, per capita food consumption started to fall during the mid-1980s. In 1986, more than 55 million people in the region were malnourished or at serious nutritional risk. The crisis hit the urban poor especially hard. Realigned exchange rates led to declines in food imports and higher prices which decreased food security for the urban poor still further.

Most of the growth in agricultural production came from medium-sized farms. The conventional view of tropical American agriculture as highly polarized is gradually becoming out-of-date. A medium-sized commercially oriented sector has emerged, using modern inputs and specializing in a few products for the market. This sector may be expected to contribute substantially to development in the coming decades.

The small-farm sector fared less well, on the whole failing to participate in production

increases. Poor access to inputs and services meant that small-scale farmers had little incentive either to produce more or to invest in improving the land they cultivated. In their circumstances, resource endowment was critical to survival. In areas of medium to high potential, the sector proved remarkably resilient, with farmers generally able to ride out the crisis, particularly if they specialized in high-value cash crops for export. In more marginal areas, continuing impoverishment and, in some cases, utter destitution drove growing numbers of people off their land. Many migrated to cities; some went to forest areas; and others became landless rural laborers.

By the end of the decade, macroeconomic policies were modified in response to the crisis. Today, the economic environment of the region resembles free-market conditions more closely than ever before.

The general context of economic development in the Americas over the next 10 years will be one of increasing belief in market forces and in the private sector as the keys to growth. The need to reduce the role of the state in national economies has been generally accepted, and important policy changes have been implemented in many countries. Price and import controls are being gradually reduced; overvalued exchange rates, which particularly damage the agricultural sector, are being revised.

The new decade will be marked by a scarcity of resources for pursuing economic growth. Funds will be limited for solving equity problems. These will have to be addressed through growth-oriented strategies. Attitudes toward agriculture are changing. The sector now is widely regarded as an essential contributor to future growth, both through expanded exports that generate foreign exchange and through the value added by domestic linkage effects and expenditure multipliers, which are particularly high in the small- and medium-sized farm sectors. Countries will look for new export markets and will adhere more to the principle of comparative advantage. To develop these new markets, cost-reducing technologies that enhance comparative advantage will play a very important role.

Tropical America's land and labor endowment provides an excellent base on which to build strong comparative advantages, but they are not sufficient. Cost-reducing technologies are essential to expand domestic markets and remain competitive in international markets. Over the long term, agriculture has the potential to be the engine of growth. The time seems ripe to pursue strategies that speed up the transformation of subsistence farmers into small-scale entrepreneurs. A major challenge will be to organize and integrate these farmers into expanding markets, postharvest processing and other rural services. Research and its technology output are crucial for facilitating this process.

As economic recovery gathers pace, further pressures will be placed on tropical America's already threatened ecosystems. These pressures are of two kinds, market and social. Market pressures arise as private enterprise responds to domestic and export demand for raw materials and other commodities. Social pressures arise as the region's marginalized resource-poor farmers are forced either to mine the natural resource base in the areas they already farm or to migrate to bring new land into cultivation.

To sum up, the apparent current food surpluses of tropical America are largely a market rather than a social phenomenon. If the region's poor had more cash, they would spend a high proportion of it on food. Technology to reduce production costs and so lower the price of food is urgently needed to expand domestic markets and increase competitiveness in international markets. Even as it increases productivity, this technology must also help to preserve tropical America's fragile ecosystems. It must also make room for the resource-poor farmer to participate fully in the development process.

The Natural Resource Base

Powerful social and economic forces drive agricultural development in tropical America. The region as a whole has abundant land, with a rural population density of only 20 people/km^2, far lower than that of Asia (over 150 people/km^2). Yet, it also has rural areas of extreme overcrowding and poverty, where the natural resource base is already severely degraded. The results are land hunger, social conflict and a natural landscape that is undergoing rapid, sometimes catastrophic, change. Below we will analyze the situation in three distinct zones in tropical Latin America which, as shown in Section 4 of the Supplement, are highly important zones from a socioeconomic and agroecological point of view.

Frontier settlement in the forests. Tropical America is home to the world's largest remaining tropical forest, a resource under heavy and increasing pressure from the landless poor, as well as from commercial exploitation. Forest clearance and expansion of cultivated areas have been traditional sources of economic growth in the region. Although important increases in productivity have taken place during the 1980s, around 20% to 30% of agricultural production gains are still occurring as a result of expansion, mostly into areas of primary forest. These gains are highly ephemeral: cleared areas frequently turn to bush after a few years of cultivation followed by grazing.

Fragile forests are increasingly subject to exogenous and endogenous pressures. Settlement in those areas occurs as a result of both exogenous social and market pressures. Venture capital and surplus labor are attracted by the opportunities presented by cheap land that could rise rapidly in value, and, in the short term, income streams in from land use that mines the natural resource base. National policies in the region are frequently designed to stimulate rather than prevent frontier settlement. Direct clearance for ranching is an important cause of deforestation in both the Amazon and Central America. In Brazil, government policy has, until recently, provided tax shelters and other incentives to clear land for this purpose. Ranching represents a safe haven for capital in inflationary economies.

In the Amazon, ribbon development along roads typically follows an endogenous 'leapfrog' pattern. Unsustainable production systems drive slash-and-burn cultivators to clear new land; the degraded areas they leave behind are being taken over by larger scale ranchers. Degradation in other areas, notably the Andean hillsides and northeast Brazil, causes a steady influx of new settlers, accelerating the rate of slash-and-burn cultivation. In Central America, the remaining pockets and coastal strips of forest are

under similar threat from the densely populated uplands that flank them. Those lands that are cleared first in a given area tend to be those with a dry season. The wettest areas are in least demand because they are the most difficult to clear, burning being often impossible. The probability of abandonment after a few years of cultivation increases with humidity, because the more humid areas are prone to more rapid degradation after clearance. This means that, for the most part, deforestation is opening up increasingly marginal land for use, and that each successive wave of forest clearance is likely to culminate in the degradation of greater areas of land. Conversely, it means that the most vulnerable forest lands can still be protected if governments act to do so, and that, under current technological conditions, the protection of remaining forest areas does not entail sacrifices of large amounts of potentially arable land.

Rural poverty in the hillsides and seasonally dry lowlands. Many of the forest zone's immigrants are resource-poor farmers from the Andean hillsides, forced to abandon their holdings because of soil erosion, loss of soil fertility or lack of adequate water supply. Others have chosen to leave overcrowded, poverty-stricken areas in northeastern and coastal Brazil, constituting spontaneous colonizations in search of a better life.

The main forms of degradation in these areas include deforestation and the cultivation of steep or moderately sloping land, leading to increased runoff and erosion, and continuous cropping without inputs, leading to declining soil fertility and structure. Not only is the productive potential of these lands steadily reduced by these practices but there are also significant costs to water regimes downstream. The pressure on remaining areas of forest -- for firewood, building materials and additional arable land -- is considerable. Clearing these lands will increase erosion risks still further by bringing even steeper land into cultivation.

Land degradation in the hillsides and seasonally dry lowlands is poverty-driven. To ease the pressure on these lands and reduce migration to forest areas, comprehensive growth, land use and technology strategies that reduce social pressures and provide incentives and technologies for sustainable production are essential.

Opportunities for expansion in the savannas. A number of tropical American countries -- notably Brazil, Bolivia, Colombia and Venezuela -- possess large areas of currently underexploited acid-soil savannas. For these countries, developing these areas represents an attractive alternative to clearing more forest for commercial exploitation. However, in most savanna areas the right policy incentives and infrastructure, as well as the right technologies, have yet to be put in place.

Unlike the forest, savannas require little initial investment in land clearance, nor does their development incur the high environmental costs associated with the loss of forest. However, the acid, infertile soils of these lands -- just as susceptible to degradation if improperly used -- constitute a major barrier to development. Migrants to forest areas burn standing biomass not merely to clear land but also to fertilize it. To reach similar levels of fertility in savanna lands, they would have to invest heavily in

chemical fertilizers and soil amendments -- a cost that they are unable to bear.

The savannas offer some, yet limited, scope for relieving the social pressures causing land degradation in the hillsides and forests. Consisting largely of extensive plains with relatively poor soils, they are unlikely to absorb large amounts of surplus labor, being more suited to mechanization. However, they could relieve much of the market pressure on the forests, presenting considerable opportunities for ranching and medium-scale farming, which also would open up employment opportunities created through the agribusiness and service sectors supporting the production sector.

The expansion of agriculture in the savannas would lower the costs of staple commodities -- especially rice, beef and milk, maize, soybeans and other crops -- bringing significant benefits to poor urban consumers. In the longer term, lower prices would reduce the incentives to clear more forest areas, because the relative costs of production in these areas would become too high.

In savanna areas with good infrastructure, farming and ranching have recently become established. However, current management practices in these areas are already incurring deterioration of the resource base: the continuous cultivation of soybean is leading to soil compaction and erosion; the buildup of weeds and pests is provoking heavy use of toxic agrochemicals; and overgrazing, combined with the use of inferior plant species, is leading to the degradation of sown grass pastures. In addition, demand for building and fencing materials is threatening the remaining areas of gallery or Cerrado forest. Both here and in the vast underexploited savanna areas that remain, more sustainable production systems are needed.

The central issue in the savannas is whether their development can compete with that of forest areas. Policies and technologies must be developed to make savannas a more attractive area for investment, diverting pressures away from primary forests.

The International Agricultural Research Community

CIAT's future program of activities will reflect changes in the role of the international agricultural research system and the policies of the donors that support it.

Founded in the early 1970s, in response to the food crisis of the 1960s, the Consultative Group on International Agricultural Research (CGIAR), to which CIAT belongs, has evolved considerably and its objectives are currently being redefined. The evolution has seen an expansion of the criteria used for priority setting from food production to considerations of economic growth (including the potential of technical change to generate income and employment), and, recently, the long-term sustainability of agricultural production.

The initial objective of the group's earlier centers was to increase food self-sufficiency in developing countries. However, with the experience of the green revolution came the recognition that poverty is as important a cause of malnutrition as insufficient food availability. Increasing the supply of food is a necessary but not a sufficient condition for

the alleviation of hunger. Accordingly, the emphasis today is increasingly on food self-reliance rather than on food self-sufficiency, at both household and national levels. The inclusion of income generation as an explicit objective of the group has broadened the scope of its research, leading to increased emphasis on a wider range of crops and other commodities that meet cash needs rather than merely subsistence needs of small-scale producers. This trend is expected to continue through the 1990s, with the group expanding to cover aspects of forestry and fishery research in addition to agriculture.

Reflecting international concern, environmental issues have risen to the top of the agenda for international agricultural research in recent years. The CGIAR has defined effective management and conservation of natural resources for sustainable production as an explicit objective. The concept of sustainable development has become central to the work of the CGIAR. Less subject to political pressures to achieve short-term production gains than national research systems, the international research community is well placed to undertake research on sustainability issues, that is necessarily long-term and has a less easily appropriable payoff. To allow sustainability issues to be more fully addressed, the traditional commodity focus of the CGIAR's research is likely to be complemented in the future by a growing number of programs focusing on resource management research at the ecosystem level. The new emphasis on environmental concerns also implies increased research on land use options and related policy issues.

Possible alternatives for an evolution of the CGIAR system are being explored and discussed by the group. It has been suggested that two types of centers are necessary: one with a global germplasm focus and the other with an ecoregional resource management focus. While pressing for clear definitions of responsibilities across the CGIAR system, the Technical Advisory Committee (TAC) anticipates that there could be reasons for some centers to assume responsibilities for both global and ecoregional activities.

Within commodity research, the traditional role of the CGIAR centers has been to provide improved genetic materials and associated management techniques to national programs for further development. This too is changing. Stronger national programs will increasingly be in a position to share responsibilities for research along the entire continuum, encompassing basic, strategic and, in particular, applied and adaptive research. Such sharing of responsibilities will allow the centers to conduct more strategic research where their advantages as international research organizations can best be realized. The centers are ideally placed to collaborate with basic research laboratories around the globe to apply biotechnology to the agricultural problems of developing countries.

Stronger national programs will eventually allow the centers to relinquish a number of support activities which they perform at present. These include varietal development, the provision of production courses, assistance in problem identification and priority setting, involvement in technical

assistance projects and the ongoing coordination of networks. However, the rate at which the centers are able to devolve these and other responsibilities to national institutions will be highly variable, depending on the extent to which these institutions are able to secure adequate financial support from governments. The continuity of funding at present gives cause for concern in this respect.

The financial support environment. In real terms, financial resources from the traditional donors to the CGIAR system are not likely to increase in significant proportions. Many donors appear to be reaching their limits of assistance and despite the impressive results produced by the system there is evidence of a certain amount of donor fatigue after years of support. There is growing expectation from some donors (especially the development banks) for programs to be tied to their specific objectives for development assistance. This creates problems for an institution engaged in long-term research, where the priorities are generated in consultation with national and regional partners, and may not mesh with priorities developed in different contexts.

A strategic shift toward an integrated systems approach within ecoregional contexts, coupled with emphasis on strategic agricultural research, may have high cost implications. Likewise, a move to more resource management research, as will progressively become necessary, and the expansion of the system's scope to include forestry and fisheries involve increased costs. In a climate of flat or even decreased real funding from the existing donor base, this must lead to a thorough reappraisal of research priorities, as well as exploring possibilities to attract additional sources of funding.

Research and Institutional Trends

Trends in modern plant biology. In the 1980s, modern plant biology made great strides in a range of technologies applicable to plant improvement. Basic research in advanced institutions throughout the world is demonstrating the enormous range of possibilities which now exist for increasing the efficiency and scope of plant improvement research. The dynamism of these trends is illustrated by the fact that a definitive genetic transformation protocol was only available for rice in 1989 and for maize in 1990. Most of the other world crops will soon follow. At the same time, a wider range of institutions are utilizing various tissue culture methodologies, including anther culture, to increase the efficiency of plant breeding. The application of genetic marker systems in the tagging of particular genes or gene complexes responsible for critical traits is providing an important tool in plant breeding as a necessary adjunct to genetic transformation.

The foundation of this trend is basic research, best conducted by those who already have demonstrated comparative advantage. The international center system will provide important collaboration in this research effort in the sense that these centers are ideally placed as major players in the application of these plant improvement methodologies in developing countries. It is clear, however, that the centers will not need to develop institutional comparative advantages for basic research presently enjoyed by other advanced institutions.

The impact of advanced biology in plant improvement will be considerable. Indications are that there will be a revolution, particularly with respect to finding solutions to critical constraints which previously defied traditional methodologies. In addition, these new methodologies will allow institutions to increase their overall research efficiency and save time. The immediate role of biotechnology is in finding genetic solutions for environmental and biological constraints, allowing present yield potential to be more fully exploited. Biotechnology could also help increase the yield potential of the world's major food crops. The apparent physiological yield barriers demonstrated by those crops suggest that much more basic research will be required. The international center system can and should play an important role in facilitating these processes, leading to large social gains.

Legislation on intellectual property rights for biological materials will probably become a reality in many developing countries over the next decade. This will make a critical difference in the way in which the international centers will operate. A collaborative approach to biotechnology with advanced institutions and with national research institutions in developing countries will help to defuse the probable negative effects of property rights in terms of germplasm exchange and public/private research collaboration. The international centers' policy of free availability of germplasm will be an important factor within this context. The centers will need to develop in-house capacity to be able to work with those advanced institutions for the benefit of developing countries. Collaborative research can make this happen for the benefit of all.

A sustainable agricultural production system should mimic the key characteristics of natural ecosystems while, at the same time, maximizing the yields of one or more of its components. A key component of sustainable systems is the associated microflora in both aerial and edaphic environments. Beneficial associations, including those with mycorrhizal fungi, rhizobia, nonsymbiotic nitrogen fixers, growth-promoting rhizobacteria and a wide range of beneficial microorganisms in the aerial environment, have been shown to have positive effects upon productivity.

Recent research has shown the enormous benefits which could be derived from genetic transformation of beneficial microorganisms. As the world becomes increasingly concerned with sustainable production systems, research laboratories regard those microorganisms as a way of providing sustainable solutions.

Trend toward systems perspectives. As we move toward the twenty-first century, the world community has realized the urgency of finding lasting solutions to the widespread deterioration of the natural resource base for agricultural production, including the loss of genetic diversity, depletion of water resources, soil erosion, deforestation and environmental pollution. These solutions must also preserve the opportunities for achieving economic growth and, in developing countries, the production of food to meet the rapidly expanding demand. Research provides the scientific basis for improved understanding of the causes of

environmental degradation and options for policy and technology to contribute to sustainable resource management.

In this problem-solving environment, research on production must be closely related to the preservation of natural resources, and must be conducted in relation to prevailing agroecological and socioeconomic conditions. A land use systems approach is required for scientists to improve their understanding of the basic mechanisms determining the stability and productivity of particular ecosystems. This approach to natural resource management includes such components as agroecological characterization, analysis of land use patterns and options, understanding of soils, water and plant nutrition relations, crops and cropping systems alternatives and agricultural and forest policy alternatives. These components aim at creating the basis for sustainable development.

The systems perspective described here will be made possible by continuous advances in research approaches and methodologies, including systems modeling of crop growth in relation to soils, water and light, and by understanding the decision-making processes in small-farm agriculture. To complement this systems trend, improved understanding of gene-governed mechanisms as well as nutrient-cycling processes will be required for commodity research to undertake an integrated approach to solving sustainability problems.

Trend toward increased international cooperation. Agricultural production problems in the tropics tend to become international because of their interrelationships with issues that affect the developed world. Such issues as resource degradation, habitat destruction, the increase of carbon dioxide in the biosphere, ozone layer destruction, poverty and famine, to name a few, confront the developed world daily. It is now recognized that environmental research issues in the tropics are important for all countries, developing and developed alike. As a result, developed countries are taking greater interest in collaborating with international centers of expertise, and in developing linkages with national and regional organizations in the tropics. At the same time, agricultural researchers and their respective institutions around the world are seeking to reduce duplication of efforts and to relate their work to relevant research in other parts. In particular, resource management research requires cooperative efforts with more than just agricultural institutions because, in certain areas, the research methodology is still in a relatively early stage. This trend toward cooperation and complementary research is facilitated by revolutionary changes in information technology and associated modes of operation by which researchers define their priorities, engage in the research process and disseminate their findings.

Research is becoming more specialized as scientists seek to exploit developments in biotechnology, modeling, simulation techniques and data analysis and processing. This specialization is accompanied by significant increases in research costs in terms of highly specialized personnel, laboratories and equipment. This development gives rise to the need to constantly reassess economies of scale for the provision of infrastructures to serve given specializations. It is also an important

impetus for research organizations in developed and developing countries to organize their research efforts in a complementary fashion.

National research. CIAT's main research partners are the public-sector national agricultural research institutions. In the short term, their ability to collaborate with CIAT will be severely constrained by their funding limitations. Tropical America is somewhat better off in this respect than Africa, but probably worse off than Asia. Cutbacks in public spending in response to the debt crisis have hit public-sector research particularly hard.

In the longer term, the prospects are somewhat brighter. The number of trained professional staff in national institutions has risen substantially over the last decade. This 'human capital' provides a firm basis for collaboration once the current financial crisis is over. Latin America and the Caribbean are characterized by extreme variability in the size and strength of their national agricultural research systems. Larger countries, such as Brazil, Colombia and Mexico, tend to have stronger systems (although subject to drastic fluctuations in their budgets). Smaller countries, especially those of Central America and the Caribbean, tend to have less well developed systems in which the essential core for agricultural research is frequently lacking.

Two different trends in national institutional development may therefore be identified for the longer term. Larger, stronger systems will demand a more sophisticated range of services from CIAT. For germplasm development, these services will include gene mapping and transfer in order to complement current germplasm characterization and crossing methods. Smaller systems will increasingly focus on adapting technology developed elsewhere rather than on generating technology themselves. These countries will need to capitalize fully on the economies of scale made possible through regional projects and networks. Overall trends in the types of service likely to be required from CIAT by national systems during the 1990s are summarized in Box 1.

One outcome of the recent cutbacks in government spending on public-sector research is growing involvement of the private sector as a source of funding for commodity research. Such privately funded research ventures, carried out by public and private institutions, seem likely to become a permanent feature of future national research. However, they will be firmly oriented toward profitability. Other kinds of partnership will be required to cater to environmental concerns and to the needs of resource-poor farmers. Although plant breeding and input distribution are increasingly privatized, research on sustainability and equity issues will require more support from international centers, donor agencies and nongovernmental organizations. In addition, natural resources departments and institutions that had, until now, remained outside the national agricultural research system (sensu stricto) will increasingly be required to integrate with it. The major implication of this trend toward a greater number of institutional actors is that, in the future, CIAT will conduct its research with a broader range of partners than in the past.

Regional research. In contrast with national research, regional research is slowly but gradually building up. In an attempt to

Box 1. NARDS' Expectations of CIAT for the 1990s.*

The NARDS (national agricultural research and development systems) expect CIAT to increase its research efforts on:

Genetic resources characterization (including 'hi-tech' areas such as gene mapping) and documentation
New tools in breeding
Methodology development
Natural resource management
Integrated pest management components
Postharvest technology
Policy research and promotion;

and its institution-strengthening efforts in:

Varietal development
Training of trainers
Training methodology and materials development
Training in research management
Catalyzing regional cooperation.

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

Varietal development
On-farm research
Cultural practices;

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

Production training
In-country training.

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* Information obtained through consultation with the NARDS as part of the strategic planning exercise.

coordinate isolated research efforts, many countries are seeking cooperation at the regional level as a means of accessing external funding and achieving public-sector cost reductions through a more rational division of labor. This pooling of resources reflects Latin America's growing sense of regional identity.

In the agricultural sector, a number of new subregional, multicommodity network initiatives have been sponsored by the Inter-American Institute for Cooperation in Agriculture (IICA) and the Inter-American Development Bank (IDB). Regional networking may be expected to grow in strength as the trend toward regional integration gathers momentum.

Specialized institutions. In response to the increased privatization of plant breeding in developed countries, public-sector research is taking on a more strategic character and is looking for new roles. The currently limited interest of advanced research institutions in the food production problems of developing countries may therefore increase.

During the coming decades, a significant proportion of biotechnology research is likely to remain in the public sector. The private sector is investing heavily in the 'near market' applications of biotechnology, but public-sector research will still be needed to address long-term, basic research problems. Joint public-private research ventures are likely to increase.

Partly in response to public pressure, research to develop environmentally friendly agricultural technologies will gain ground in many public-sector research institutions in developed countries. The pollution caused by agrochemicals is already causing increasing concern in both the developed and developing countries. Biotechnology is seen as an important tool for addressing this and other resource conservation issues. Much of the research on such issues is long term and not profit oriented. It can therefore be expected to remain in the public sector. When research addresses issues, such as environmental pollution, that are of common concern to both developed and developing countries, the latter countries will have increasing opportunities to benefit from biotechnology and other advanced research techniques. However, as we have seen, national institutions in developing countries will be handicapped by funding and administrative constraints. In addition, lack of contact with their colleagues in advanced laboratories reduces the effectiveness of many scientists in developing countries to apply advanced techniques.

The international agricultural research centers will have an important role to play in overcoming these problems. Advanced research networks will increasingly be used to stimulate collaborative research, linking specialized laboratories with national and international institutions in developing countries.

Chapter 2

CIAT IN PERSPECTIVE

CIAT is in the midst of major changes in its external environment and must adjust its course to accommodate these changes. The preceding analysis of the external environment gives a clear indication of the degree of change that is currently occurring and will occur. In Latin America and the Caribbean, the comparative advantage of land and labor availability must be exploited. Land productivity has to be increased, however, and labor productivity must be enhanced if the region is to be competitive internationally and if the costs of staples are to be reduced locally. The move toward sustainability is not a fad; it is crucial to preserve the value of land assets for future generations, because future development potential depends on those assets. The trends emerging in the CGIAR and in the world of research point clearly to a new order in international agricultural research where centers can no longer be seen as the hubs around which all else revolves. Instead, they should be regarded as small but important components of the global system, closely interlinked, as cogs, with other components. In this chapter, we take a brief look at CIAT in the past, analyze its present strengths and weaknesses and conclude with a brief view of a future CIAT.

Where Have We Come From?

CIAT's original task was to develop technologies and production systems to exploit the potential of the humid lowland tropics of Latin America and the Caribbean through a farming systems approach that would suit fragile environments and small-scale farmers. By the mid-1970s, CIAT had begun to move toward a multidisciplinary commodity-based approach, with the initial programs researching rice, swine and beef, and later programs researching cassava and beans. By the late 1970s, CIAT's current set of four commodity programs had evolved. The commodities had been selected on the basis of their contribution to the diets and incomes of resource-poor farmers and consumers in tropical America. CIAT became a center with a dual nature, assuming global responsibilities for specific commodities and at the same time maintaining its original regional focus. The 1980s saw the consolidation and expansion of CIAT's program with a mandate to:

Generate and deliver, in collaboration with national and regional institutions, improved technology which will contribute to increased production, productivity and quality of specific food commodities in the tropics -- principally countries in Latin America and the Caribbean -- thereby enabling producers and consumers, especially those with limited resources, to increase their purchasing power and improve their nutrition.

This statement emphasized the food production (growth) and poverty alleviation (equity) objectives typical of an early 'green

revolution' center, omitting explicit reference to a resource preservation (sustainability) objective.

The strength of CIAT's commodity research and related activities over the last 15 years has led to many achievements. For all four commodities, the knowledge base has expanded tremendously, particularly with regard to the sources of resistance or tolerance to a wide range of biotic and abiotic stresses. In the case of rice, the rapid and dramatic gains achieved in output constitute an impressive response to the challenge of meeting regional growth and urban equity needs. With regard to beans, cassava and tropical pastures -- crops grown under less favorable conditions, and for which the knowledge base was narrower when CIAT began work -- the impact on output has been understandably slower to materialize; nevertheless, progress has been significant, with many exciting developments now emerging.

The important activity 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 the important cassava-producing countries of Latin America and Asia. Agroclimatic databases and other components of geographic information systems 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. Through training, networking and decentralization, CIAT has achieved an effective relationship with its national partners: many specialists have been able to apply their training to local problems, effective commodity-based networks have been established and the posting of CIAT staff on-site in regional programs has increased communication and collaboration.

CIAT has thus responded well to one of the tasks entrusted to it at foundation, namely, that of defining priorities among a set of relatively under-researched commodities and generating knowledge and technology to increase their productivity under low external-input conditions. In carrying out their mission, the commodity programs have given high priority to developing component technology that makes possible more sustainable production systems. In line with the center's low-input research philosophy, a sustainability perspective permeated all activities in the commodity programs, but limited attention was given to the task of designing integrated, sustainable production systems. Only recently has research progressed sufficiently so advances can be made to the full systems level where sustainability issues can more readily be addressed.

CIAT Today

CIAT is in a period of transition. To appraise its performance in the last two decades is to take considerable pride in its accomplishments; however, the analysis of trends in CIAT's external environment indicates that a more systems-oriented approach is needed to address sustainability issues adequately.

The existing CIAT research paradigm has been based on a supply-driven reductionist

approach, concentrating on developing products that would overcome the major production challenges posed by the environment. A new approach has to be followed if we want to promote sustainable systems. Technologies need to address factors that link a farm's ecological, economic and environmental performance. Agricultural production has to be approached not only from the point of view of how it is being affected by the environment but also from how it interacts with the environment. This implies a change from a supply-driven to a systems-derived approach. Clearly, CIAT does not have, at present, the organizational structure or trained staff to accommodate such a new approach. But it has the capacity to evolve and accommodate change, as has been seen over the two decades of its existence. CIAT's main strength undoubtedly lies in its four commodity programs, which have stable objectives and continuous funding, and were specifically designed to meet the needs of resource-poor farmers. CIAT's low-input approach to research has constituted one response to sustainability and rural equity considerations, that is, genetically induced resistance to major pests and diseases minimizes the need for agrochemicals, thus saving scarce foreign exchange and reducing pollution without sacrificing yields.

Networking, training and communication activities have been fundamental to CIAT's approach to commodity research, allowing a catalytic impact on the strength and productivity of national research teams.

Its location in a tropical country, the apolitical and international nature of its effort, the linkages with advanced research laboratories and strong relations with national research programs give CIAT broad credibility.

These strengths are tempered somewhat by a number of limitations. Funding ceilings have flattened and even lowered in real terms. Related to this is an increasing dependence on highly restricted funding. National program funding difficulties limit what CIAT can readily devolve. This creates ongoing expectations concerning delivery of products and services. Resources concentrated in few places limit CIAT's presence throughout the region, and a rather fixed organizational model limits the changes that can be accommodated, and the number of commodities that can be integrated at the systems level. Lastly, CIAT has a track record in solving problems along a commodity research approach. This approach, however, does not provide a strong framework on which to base a systems-oriented research paradigm, geared toward resource management research in important agroecological settings.

The CIAT Culture

The basic purpose of CIAT's existence has not changed since its creation. During two decades of work, a culture has evolved. This culture embodies basic values that translate into a set of guiding principles and form the philosophical foundation upon which this strategic plan was developed. CIAT is:

A development-oriented, agricultural research institution dedicated to contributing to the development of sustainable agricultural production as a means of bringing about lasting well-being of people in tropical developing countries.

Central to CIAT's values is the conviction that research is essential to provide a scientific basis for integrated and sustainable management of agricultural production. Perception of realities at all points on the agricultural continuum, from farmers to policy makers, allows rational management decisions that are consistent with the systems approach described earlier.

Another basis for CIAT's values is a concern for human dignity and welfare. Over 700 million people in developing countries have external symptoms of malnutrition, causing great reduction in human capacity, as well as significant welfare losses. The basic cause is poverty -- the lack of sufficient income to purchase food for an adequate diet. Other causes are inadequate food production or lack of resources to import food, and inadequate water, health and education services. Any solution to the world food problem, though dependent on sufficient quantities of staples, ultimately boils down to raising the income levels of the poorer segments of the population. 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.

Guiding Principles

In accordance with CIAT's culture, four interrelated principles are followed and will be reinforced by the center in its effort to maximize results. They are: relevance/goal orientation; systems perspective; multi-institutional approach; and comparative advantage.

Relevance/goal orientation. CIAT is an applied research institution, subjecting all its activities to the principle of relevance. It focuses on problem-solving, mission-oriented research, at whatever level of sophistication necessary to overcome major constraints. Through systematic planning, evaluation and monitoring, the center ensures that its programs concentrate on the most important rather than the merely interesting, and follow clearly defined priorities with a sense of urgency. Through its training program and interactions with collaborating institutions, CIAT encourages its partners to do the same.

Systems perspective. The center is highly conscious of the fact that agricultural production problems and opportunities cannot be resolved through unidimensional approaches that concentrate on given elements only. At the same time, we are aware of the pitfalls of a systems orientation per se that could easily result in endless systems analyses and location-specific research activities. Thus, we will seek to identify practical and relevant entry points into agricultural production systems. Work on these entry points will be undertaken with a clear perspective concerning the physical, biological, socioeconomic, policy and land use dimensions that may impinge on technology options. That is, throughout the process, a macro-agroecosystems perspective will be combined with a micro-production systems perspective.

Multi-institutional approach. A corollary to the principle of systems orientation is the

recognition that the task at hand is so large that no one institution can claim exclusive responsibility. Thus an integrated, multi-institutional approach is needed not only to pool resources and bring together different perspectives but to share a vision of the problems and challenges at hand, and to be able to arrive at joint research agendas and priorities.

Comparative advantage. Within a multi-institutional approach, it is essential that the activities of the various participants not only take place on the basis of partnership but also on the basis that the contributions of any one participant complement those of other participants so as to achieve synergy. The division of labor must be based on the principle of comparative advantage, each partner doing what it does best and at lower cost.

The chief performers in agricultural research and development are the national agricultural research institutions. Increasingly, their work is supported by a web of other institutions, be they in the public and private sectors at the national level, international or regional agricultural research institutions, or advanced research laboratories. The challenge is to identify and further develop the comparative advantage of all partners within the context in which they cooperate.

A View to the Future

Our analysis shows the changes needed for the future, the unquestionable, continued need for research to increase crop productivity and the growing concern about the widespread deterioration of the natural resource base for agricultural production. Thus, we conclude that in order to stay relevant to the needs of the region and to the evolving international agricultural research context, CIAT needs to shift gradually to integrated approaches centered around germplasm development and resource management.

Chapter 3

THE WAY AHEAD

The incorporation of concerns for the preservation and enhancement of the natural resource base, together with growth and equity, into the set of criteria to steer CIAT toward its goal has led us to restate our mission.

Mission

In partnership with other institutions, especially national agricultural research organizations, CIAT's mission is:

To contribute to the alleviation of hunger and poverty in tropical developing countries by applying science to the generation of technology that will lead to lasting increases in agricultural output while preserving the natural resource base.

The emphasis of this mission is on growth, equity and enhancement of the resource base.

Economic growth. The sine qua non of development is economic growth. Technology can contribute directly by increasing the productivity of resources used in agricultural production, mainly land and labor. But there is also a very important linkage, or secondary effect, in that increased supply will trigger demand for inputs. And as the income of producers and consumers increases, they will expand their consumption of other commodities. The resulting demand for goods and services allows other people to earn an income. The direct and indirect effects of technological change differ among agricultural commodities and types of technological changes. Therefore the determination of what technological change to work toward is an important consideration for CIAT.

Growth is not an end in itself, but because it raises incomes it is an important tool for meeting CIAT's mandate to improve human welfare.

Equity. Economic growth raises the incomes of the poor, but it often does so in absolute rather than relative terms, such that the poor benefit from development less than do other, more privileged groups. For this reason, the pursuit of growth must be tempered by equity considerations if the center's ultimate goal of alleviating hunger and poverty is to be met.

In Latin America, poverty has become more widespread in recent years. Although the share of poverty is still higher in rural areas, 57% of the 190 million poor are in urban areas, and about 55 million people are malnourished. Food availability for the poor needs to receive adequate emphasis in the future. Recent agricultural development has been characterized by a more intensive use of capital, with resulting low demand for agricultural labor and often labor displacement. Public policies, farm mechanization and input subsidies have benefited larger producers more than smaller ones. These developments have been the driving forces of urbanization, the increase in landless agricultural labor and in small-scale

farmers moving to less fertile or marginal lands. With CIAT's stated concern for equity, the center assigns basic importance to the development of technology options whose benefits go to the poor, be this increased purchasing power, increased employment opportunities and/or increased nutrition.

Resource base. Growth may also have adverse environmental consequences, undermining the quality of life through pollution and destruction of natural resources. The earth's natural resources are the 'capital' on which future growth depends. Sustainable growth means living off the interest from this capital, not off the capital itself, and, if possible, enhancing the quality and productivity of this resource base. Hence the preservation of natural resources must be used as a third criterion for assessing the potential impact of CIAT's research.

Equity and the preservation of the natural resource base are often complementary objectives. To survive, people with a marginal standard of living often have no option but to consume natural capital, mining the soils and vegetation on which their future livelihood -- and that of future generations -- depends. Increasing the incomes of the rural poor makes them better custodians of natural resources. Focusing research solely on conservation and excluding the interests of the poor would be socially divisive. The sustainable development goal implies an appropriate balance between exploitation and preservation of the natural resource base, with the poor enjoying access both to the resources that fuel growth and to the benefits that flow from it.

It is clear that CIAT must continue to give high priority to germplasm research leading to increased yields. A strong germplasm-development orientation is needed to accomplish the growth dimension of our mission. However, coming to terms with the preservation of the natural resource base will require a more integrated, systems-oriented approach to germplasm improvement.

It is equally clear, however, that the absence of a complementary effort in resource management research would prevent the reconceptualization of technology development in a systems-oriented perspective. There is an overriding need for agricultural research to put emphasis on understanding the underlying causes of resource degradation and on developing technology options within a land use perspective.

CIAT's work cannot be neatly packaged into separate commodity or ecoregional compartments. Neither would separate centers for commodities and ecoregional studies work in CIAT's environment. The two approaches are intimately interrelated and inseparable in CIAT's institutional setting and mandate.

Moving to a more systems-based sustainability perspective in germplasm improvement raises the complexity of the task at hand. Beyond a close integration within CIAT of germplasm development and resource management research, this task will require an increase in our associations with others who have different comparative advantages. It also calls for the devolution of many aspects of applied and adaptive

research to national partners. This will allow CIAT to exploit fully its own comparative advantage in strategic aspects of germplasm improvement. This comprises germplasm collection/characterization, basic manipulation of the genetic makeup, understanding of the mechanisms governing host-plant resistance and adaptation to soil stresses and other strategic research aimed at developing relevant technology options in important agricultural production systems.

To develop and exploit our comparative advantages in resource management research we must identify a number of high-priority and clearly defined agroecosystems. At this level of aggregation, it will be possible to develop an integrated approach to needs assessment, modeling, technology generation and mobilization of interinstitutional efforts around common goals.

Taking this approach is not without its concerns or challenges. The problem of continuity of funding is a major concern, because a dual approach will clearly require at least some additional resources. The management challenges will also be considerable. There is also the worry that national partners might not be able to accept a sufficient share of the germplasm improvement and training work to be devolved by the center. And last but not least there is the concern that national partners may be faced with resource limitations that deny them the opportunity of moving into resource management research as decisively as the situation may require.

Strategy Statement

During the 1990s, CIAT will pursue its mission through research on germplasm development and resource management.

Germplasm development research will be directed at characterizing and broadening the genetic base of selected commodities, and at understanding gene-governed mechanisms determining plant adaptation and productivity in major production areas, including the ecosystems of tropical America selected for intensive agroecological research. The aim is to develop the potential of germplasm resources for increasing output and efficiency of input use.

Resource management research will focus on important tropical American agroecosystems which are threatened by increasing land use intensity or natural resource degradation, as well as on those which may have the potential for relieving such pressure. The aim of research will be to understand the basic processes within the agroecosystems for the purpose of making agricultural production more sustainable.

This integrated approach will be pursued within a framework of interinstitutional cooperation aimed at enhancing complementarity and increasing cost-effectiveness of research at the national, regional and international levels.

The above statement highlights four strategic issues that CIAT will need to address in determining its new operational mandate. These are geographic orientation; commodity and ecosystem choices; integration; and interinstitutional relationships.

Geographic Orientation

CIAT's work focuses on the tropics and subtropics, the region where the largest food gaps exist and where increasing population pressure is leading to accelerated resource degradation.

For each commodity in CIAT's germplasm improvement research, the center assumes one of two types of mandate responsibilities: global or restricted.

A global mandate involves those commodities for which no other CGIAR centers have global responsibility, and for which CIAT is expected to provide strategic germplasm development research, which effectively addresses the production problems and potentials of the commodity on a global basis. Global mandate activities concentrate on germplasm collection, characterization, conservation and genetic enhancement.

A restricted mandate involves those commodities for which other international centers have assumed a global mandate, but which are of particular relevance to CIAT's agricultural development concerns in Latin America and the Caribbean. In this case, the research focus is on germplasm improvement that will enhance the contribution of the particular commodity within the context of important agricultural production systems in the region.

For its work on agroecosystems, CIAT shall exclusively concentrate on the Latin American and Caribbean region. It is in this region where CIAT has developed considerable agroecological knowledge and expertise, as well as a special relationship with national and regional research partners. Within the CGIAR system, CIAT is prepared to assume an ecoregional mandate for Latin America and the Caribbean, with particular emphasis on the agroecological zones identified as important and relevant in terms of international research.

Commodity and Ecosystem Choices

In selecting a portfolio of commodities and agroecozones on which to focus its future research, CIAT has sought maximum synergy among the three interrelated criteria for generating outputs that are implied in the mission statement -- growth, equity and preservation of the resource base. A fourth criterion, used as a screening mechanism, concerns the degree to which there is a perceived comparative advantage for CIAT to engage in research on a given commodity or zone in relation to other institutions.

Commodity choices. To determine appropriate commodity choices for CIAT, an intensive cross-commodity evaluation was carried out by CIAT economists. Details of this analysis appear in Section 2 of the Supplement.

Nineteen commodities were selected for an initial screening. Notwithstanding their importance, wheat, maize, potatoes and sweet potatoes were not included because they are within the mandate of the other international centers based in the region, that is, CIMMYT and CIP.

In phase one, the 19 commodities were screened according to the following criteria:

* Current value in Latin America and the Caribbean (as an indication of the significance of the commodity);

* Latin America's share in total developing-world production (as a means to assess the degree to which

CIAT research would contribute significantly to global development); and

* the case for international research on a given commodity (assessed by reviewing the strength of research by national programs, producer organizations or the private sector).

In phase two, the 11 commodities remaining after phase one were subjected to a multiple-criteria screening in relation to potential contribution to growth, equity and preservation of the resource base, including estimates of expected social benefits of research.

In this extensive analysis, CIAT's present commodity portfolio emerged as being very relevant. Sorghum and soybeans proved to be strong candidates for inclusion in the portfolio, especially for their potential in the acid-soil savannas of tropical America. The current four CIAT commodities (beans, cassava, forages and rice) were selected for primary focus; sorghum and soybeans for secondary emphasis.

Ecosystem choices. A thorough evaluation was undertaken to determine which ecosystems were most appropriate for CIAT's attention. The process and results of this evaluation are described in Section 4 of the Supplement. In addition to the criteria of growth, equity and resource preservation outlined above, those of feasibility and efficiency were added. Feasibility was assessed in terms of the potential of available and/or new technology, the ease of applying the technology and whether there is a role for an institution such as CIAT. Efficiency was assessed in terms of the coherence of the set with respect to common researchable issues, and the degree to which developments or trends in one zone would have repercussions in another zone within the set.

The evaluation had four main phases:

* Environmental descriptions of the continent;

* selection of likely candidates for environmental classes;

* characterization of land use within each class; and

* selection of agroecosystems as possible foci for research.

The results indicated where resource management research would fit best, given the various criteria and the most feasible areas for research.

Four agroecological clusters stood out:

* Forest margins;

* hillsides;

* savannas; and

* seasonally dry areas.

Of these, the first three stand out as a set having common environmental factors and presenting interrelated socioeconomic factors. They are linked by an underlying theme central to tropical American agriculture: the problems and opportunities of frontier development. Another common theme is the problems of acid, infertile soils. This is an area of research in which CIAT has acquired

special advantage by developing acid-tolerant pasture, rice and cassava cultivars. Each zone presents major opportunities to contribute to sustainable agricultural development.

Although constituting a significant agroecosystem, the seasonally dry areas will not yet be included in the center's overall resource management research. Nevertheless, CIAT will seek to contribute to the analysis of land use strategies and policies for this zone in relation to outmigration and crop production. The zone will also continue to receive direct attention from the cassava and bean programs.

A number of other agroecological zones in tropical America and the Caribbean experience significant resource degradation. These areas include highly productive lands and high-altitude hillsides. Neither will they be a subject of resource management research during the 1990s. However, as with the seasonally dry areas, these ecosystems will receive attention from the center with respect to analysis of land use strategies and policies, and from commodity research to the extent that the respective commodities are important in these zones.

Commodities within agroecosystems. In the process of selecting commodities and ecosystems, the extent to which the commodities are or could be grown in the agroecozones was an important consideration. In fact, the inclusion (with secondary emphasis) of sorghum and soybeans in the commodity portfolio was directly related to the potential of these crops in the savanna agroecosystem. It can be expected that the commodity and ecosystem selections will be revisited in the latter half of the 1990s. There will be a continued concern for the degree of coincidence between agroecological zones and the commodity mix in CIAT's operational mandate. In this context, however, we wish to point out that CIAT's integrated work of germplasm development and resource management research will provide for active participation from other research institutions that contribute germplasm and management components of their respective crops.

Choices in relation to the criteria of the plan. The commodity and ecosystem research choices respond to the set of criteria adopted for the plan, namely, equity, growth and enhancement of the resource base. Each criterion applies with more emphasis, in relative terms, to one or more choices, as follows: equity, to research on cassava, beans and hillsides; growth, to rice and savannas; resource enhancement, to forest margins and forages, the latter also contributing to the other two criteria.

Integration

Although significant change will take place in the way CIAT operates in the 1990s, this will, of necessity, be phased in gradually. Although CIAT has chosen two entry points (germplasm development and resource management) into the field of sustainable agricultural production systems, it is essential to view these two approaches not as separate thrusts but as interdependent and synergistic efforts, not only within CIAT but in other institutions.

The resource management thrust will need access to the expertise and commodity-based knowledge built up in CIAT over more than

20 years of research. In the course of conducting investigations on technological options in CIAT's targeted ecosystems, resource management researchers will need guidance on CIAT's germplasm stocks. They will also require access to the considerable commodity-focused agroecological research already done at CIAT in the areas of crop adaptation, production limiting factors, crop-soil and crop-crop interactions, pastures' role in nutrient cycling, the development of agroecosystem-specific ideotypes and other technological components, and analyses of commodities in the socioeconomic context. Similar inputs are expected from other international centers (e.g., CIMMYT's subprogram on maize acid-soil tolerance and CIP's Andean regional program, both hosted by CIAT; ICRAF in agroforestry, and the new CGIAR forestry initiative).

The germplasm development thrust will, in turn, require feedback on germplasm performance and needs, particularly in multispecies systems. Commodity programs will benefit from integrated knowledge of the production environment, exposure to a systems focus and associated research methodologies, understanding of mechanisms for agroecosystem-specific commodity development and prototype experience for use in other production environments.

We believe that this dynamic transfer of information can be done in an environment of separate yet cross-communicating organizational areas for germplasm development and resource management research, with support from institutional development and specialized research units.

Interinstitutional Relationships

In the previous CIAT research model, the emphasis was on building a center of excellence, with an orientation to technology development at the international level. National and other partners played a partially receptive role. With CIAT's new orientation toward systems-derived needs and research priorities, the emerging collaborative model is based more on decentralized execution, with greater emphasis on the integration of information and efficiency of communications.

The expansion of institutional interactions implies that solutions to problems will increasingly depend on the development of consortia and strategic alliances. Mutual benefit will be the output for each partner in return for specific expertise. CIAT's roles will center around its comparative advantages, that is, CIAT as:

* An international and apolitical organization;
* a research institution with well-defined strengths in research aspects, including hands-on experience of agroecological characterization;
* a research institution with a high degree of credibility in agricultural research and development, and experience in commodity research; and
* a research partner with stable and flexible funding, and excellent rapport with research organizations at the national, regional and international levels.

As CIAT moves into the future, it will find an environment in which increased sharing of research responsibilities, networking, information sharing and consolidation and large-scale interinstitutional efforts become routine. CIAT is in a unique position to assist in setting up appropriate frameworks for interinstitutional cooperation related to its mission. These cooperation mechanisms will provide an opportunity to involve research leaders and policy makers in setting regional research priorities. They will also serve as a means for attracting funds to cost-effective and accountable research projects. Lastly, strong interinstitutional programs will enable CIAT to relinquish some of its support activities and dedicate more resources to the research tasks for which it has comparative advantage.

As an international focal point on germplasm and resource management research, CIAT's knowledge base will be of considerable use to other participants in research, including the national research systems, specialized research institutions, development banks, nongovernmental organizations, international and regional organizations and government policy institutes.

CIAT's role in this new system will be primarily as a convener and catalyzer. Developing common research agendas can be seen as a natural avenue for which CIAT can take the lead. Similarly, CIAT's considerable expertise in managing workshops and conferences gives it a comparative advantage as a convener for discussions on major issues. The strong training and communications role built up over the years gives CIAT comparative advantage for institutional strengthening and for administering networks.

An opportunity exists for CIAT to provide a focal point for the development of an information support system. As research systems become more complex, the capture and dissemination of information become critical. What is implied here is not only the classical library or publishing approach to information handling but also the whole question of information resources management and their access in real time and in the form needed. Information-processing technology will evolve at an ever-increasing pace with associated cost reductions and simplification of operating procedures. The tendency toward partnerships and alliances gives CIAT a reason to develop an up-to-date capability in systems and services to provide for internal and interinstitutional information needs.

The foregoing discussion leads us to formulate the operational mandate presented in Box 2.

Box 2. Operational Mandate for the 1990s

CIAT will contribute to technology development that will lead to long-term improvement in productivity of agricultural resources; to the development of innovative, more cost-effective agricultural research approaches and methods; to the strengthening of agricultural research institutions in participating countries; and to the development of interinstitutional linkages. To that end, CIAT's activities center around the following three areas:

Germplasm development research

Beans: global responsibility for common beans, including a secondary emphasis on snap beans.

Cassava: global responsibility; in Africa, through and in coordination with IITA.

Rice: regional responsibility for Latin America and the Caribbean in coordination with IRRI.

Tropical forages: global responsibility in relation to acid, infertile soils found between sea level and 1800 m.a.s.l.; in Africa, through and in coordination with ILCA.

Furthermore, CIAT assumes a secondary responsibility for soybeans (in coordination with IITA) and sorghum (in coordination with ICRISAT), and is limited to the development of these crops as components in crop production systems for the acid, infertile soil environments, particularly in the savanna agroecosystem.

Resource management research in tropical America

Land use research, emphasizing land use strategies and policy alternatives.

Agroecosystems-oriented research in:

Cleared forest margins.

Hillsides with moderately acid, low-fertility soils, with particular emphasis on the mid-altitudes.

Savannas with acid soils.

Institutional development

Support activities at national and regional levels.

Chapter 4

PROGRAM STRATEGIES

CIAT's research strategies will pursue two complementary research directions: germplasm development and resource management. These will be supported by an institutional development support program and specialized research support units. This chapter outlines these programs' and units' operations and strategies in the next decade.

Germplasm Development

Commodities are the essence of agricultural production. They constitute the focal point for all economic activities in the agricultural sector. Commodity research is a basic entry point to this production complex.

Our analysis shows a continued need for international involvement in commodity research, particularly as it relates to germplasm collection, characterization, conservation and basic manipulation of the genetic makeup of commodities that have transnational and/or global utilization.

CIAT will give primary attention to four crops: beans, cassava, tropical forages and rice. For the first three, CIAT will assume a global mandate, and for rice, a regional mandate in Latin America and the Caribbean. Background information on the global and regional importance of these CIAT commodities is provided in Section 3 of the Supplement.

Germplasm development research at CIAT aims to increase the productivity and improve the quality of selected commodities by enhancing the exploration and utilization of germplasm resources for sustainable agriculture. CIAT has considerable expertise and experience in commodity research and expects to build future efforts on the strong base already available.

Beans

Goal. To increase food availability and incomes of the poor by improving bean productivity through developing sustainable technology in collaboration with national institutions.

Approach. Genetic improvement and cropping systems research can meet the needs of resource-poor farmers. Substantial improvement has already been made in pest and disease resistance -- the top research priority during the 1980s.

Strategic research will increase to meet the challenges of increasing yield potential and overcoming edaphic stresses, as well as to take advantage of opportunities for applying advances in biotechnology. Strategic research on global constraints will be conducted principally at headquarters to benefit both tropical America and sub-Saharan Africa, while regional problems will be addressed by outposted staff, mostly in Africa.

In tropical America, the Resource Management Research Division will assist in improving bean cropping systems, particularly in the hills. In other

agroecozones, e.g., highland Mexico and northeast Brazil, the Bean Program will work with national programs. Improvement of bean-based cropping systems will remain a major activity in Africa in the absence of an ecoregional center for eastern Africa.

To the degree that national program capacity continues to develop, CIAT will reduce its applied research and institutional strengthening. However, training in Africa will continue to receive significant attention.

Demand is growing rapidly for snap beans, an excellent income source for small-scale farmers. CIAT will expand its efforts to improve their tropical adaptation. Much of its strategic research on dry beans, especially on insect and disease resistance, is easily transferable to snap beans. Emphasis will be on work in tropical America but materials developed will also be useful in Asia and Africa.

The approximate allocation of this program's core resources between 1991 and 2001 appears in Figure 4.1. Although the overall effort will fall by more than one third, there will be a significant resource reallocation to strategic research. This is made possible by reducing applied research and institutional support resources from more than 60% to 20%.

Objectives. Five interrelated objectives will be pursued, as follows:

Objective 1. Exploit advanced biological methods to better utilize bean genetic resources.

Molecular biology offers substantial opportunities to efficiently identify and transfer useful genes, both within common beans and from related species. The world's largest collection of *Phaseolus* genetic resources gives CIAT special advantage in these methods, which are highly complementary to conventional breeding.

Genetic probes developed for use in national program breeding will be particularly useful for pyramiding genes for resistances to disease, pest and soil-related stresses. Gene pools will be characterized, and co-evolution between beans and pathogens, insects and rhizobia will be studied to prioritize further germplasm collection and aid field breeding.

Gene maps from basic research laboratories in developed countries will help CIAT isolate desired genes and adapt asexual transformation and regeneration methods for direct gene transfer. Interspecific introgression methods will allow access to desired traits in closely related species. The potential for improving rhizobia to increase biological nitrogen fixation efficiency will be assessed.

The success of increased strategic research depends on access to basic research results from laboratories in developed countries. An advanced bean research network will be a key to establish these linkages. Success will also depend on national program capacity to use the methods, components and parent materials developed by CIAT.

Objective 2. Reduce losses from pests and diseases.

Biotic losses remain a major constraint to bean productivity. Because these pressures are variable, a broad genetic base of resistance for sustainable control of pests and diseases is urgently needed. The program will concentrate its efforts on identifying new sources of resistance and developing integrated pest management techniques.

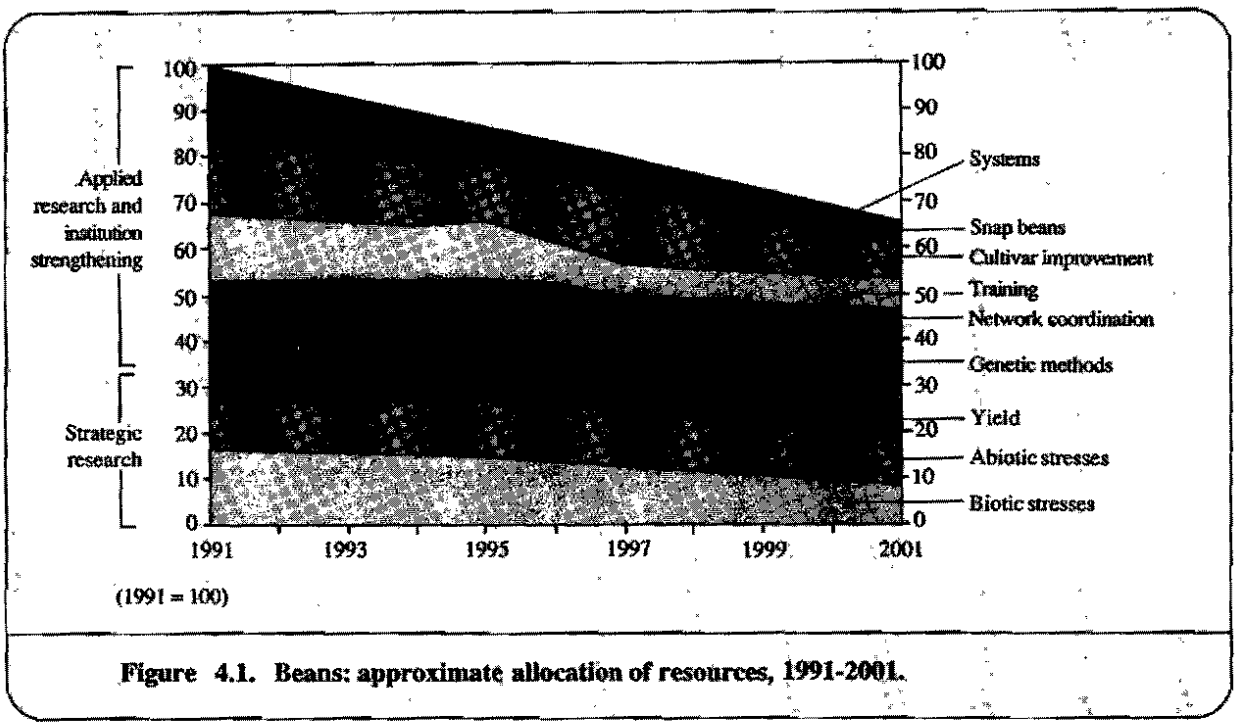

Figure 4.1. Beans: approximate allocation of resources, 1991-2001.

Sources of resistance to some major diseases and insects have not yet been identified in common beans. Thus, evaluating wild ancestors for resistance and utilizing genes known to be present in closely related species will be emphasized.

Molecular tools will be used increasingly to study pathogen and insect diversity. The existing limited biological knowledge of many major diseases and pests in Africa requires special attention.

The growing use of pesticides by small farmers is a serious environmental and economic problem in tropical America. CIAT will help national programs reduce pesticide applications through sustainable integrated control to complement genetic resistance.

Because of current and expected progress in national programs, resources allocated to disease and pest studies will decline.

Objective 3. Increase yield potential in beans.

The yield potential of beans under favorable conditions has not increased similarly to that of other more intensively researched crops. The program will further exploit variation across gene pools, thereby breaking undesirable genetic links. Physiological traits, such as photoperiod/temperature adaptation, canopy morphology and patterns of nitrogen uptake and partitioning, will be identified to maximize yields.

Delayed maturity and improved plant architecture will contribute to increased yield

potential. Yield will be improved for different plant types, maturity classes and grain colors. Overall yield improvement efforts should more than double.

Objective 4. Improve adaptation to edaphic constraints.

Soil fertility of bean-based systems is declining because of their expansion into marginal soils, short fallow periods, soil erosion and high costs and/or limited availability of fertilizers, especially in Africa. Biological nitrogen fixation contributes to sustainable production and can be improved. Bean adaptation mechanisms to low phosphorus or to acid soils have yet to be determined. Little is known about drought tolerance, even though water stress is the most important cause of unstable production.

To meet this objective, the program will focus first on identifying superior genetic adaptation to edaphic stresses; then, in collaboration with advanced research laboratories, on understanding adaptation mechanisms. Methods for germplasm enhancement will be developed and parental populations provided to national programs, together with support in fertility management in bean cropping systems. Overall efforts on abiotic constraints will initially increase and research.

Objective 5. Strengthen national capacity to improve bean productivity.

Many national programs have, with CIAT's assistance, trained a minimal cadre of bean researchers. Their participation in regional research networks has further increased their efficiency. The program has sparked the formation of networks in the Andean region, Central America, the African Great Lakes Region and eastern and southern Africa. As these networks become increasingly autonomous, CIAT will cease to be a coordinating hub.

Similarly, as national programs become increasingly autonomous in training extensionists, on-farm researchers and technicians, the program will focus on training mid-career bean scientists.

Seed systems remain weak. Input from CIAT's Institutional Development Support Program will ensure that the benefits of new varieties reach producers. Resources for training and network coordination will decline as national programs become increasingly self-sufficient.

Outputs and expected impact of the Bean Program are summarized in Table 4.1.

Table 4.1. Outputs and expected impact of the Bean Program.

Objective	Output	Expected Impact	Assumptions
1. Generate advanced methods for gene identification and transfer.	- Less expensive, faster genetic improvement; - access to genes in 'exotic' material.	- Lower research costs; - earlier adoption; - solution of previously intractable problems of BGMV, ascochyta, *Empoasca*.	- Continued progress in basic research at advanced laboratories; - continued public access to desirable genes; - effective national programs to utilize new genes as parental materials.
2. Increase yield potential.	- New, higher yielding ideotypes.	- Increased yields at farm level; - relief of pressure on fragile lands as beans move to higher productivity environments.	- Existence of useful genetic variability; - effective seed systems.
3. Improve microbial symbiosis.	- Better bean genotypes for nitrogen fixation; - improved strains for better symbiosis.	- Reduced production costs; - enriched soil biosphere; - more sustainable production.	- Effective inoculation/distribution systems.
4. Improve nutrient and water efficiency.	- Parental material adapted to edaphic systems and tolerant to abiotic stresses.	- Improved productivity under stress conditions.	- Effective seed systems; - genetic variability.
5. Achieve stable resistance to diseases and pests.	- Diverse parental materials with multiple resistances.	- Stabilized and improved productivity; - reduced pesticide use.	- Effective seed systems; - genetic variability.
6. Strengthen national programs.	- Trained national scientists.	- More effective adaptive and applied research, leading to higher on-farm productivity.	- Greater national commitment to agricultural research; - improved stability of scientists in national programs.
7. Form regional networks for horizontal technology transfer.	- More efficient resource utilization through specialization and coordination; - more rapid diffusion of new technology.	- Lower research costs; - broader, more rapid productivity increases.	- National willingness to exchange results.

Cassava

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

Approach. Cassava is an important rural and urban food in much of the developing world, being a major source of calories for 500 million people; in tropical Africa, it is the single most important source of calories. Cassava is also growing in importance as a carbohydrate source in food and feed industries. Demand studies have shown that cassava can compete in many markets. Through linking farmers to these markets, cassava contributes to the economic development of regions where the crop is an important commodity. Since cassava is grown mainly by small-scale farmers, investment in technology development can directly benefit the rural poor.

Over the last decade, CIAT's Cassava Program and its national partners adopted a demand-driven, integrated approach to cassava research and development. In this approach, the identification and characterization of market opportunities provide the basis on which appropriate production and processing technologies are designed and developed. These technologies are subsequently tested and adapted with farmer participation under market conditions, through research and development projects in representative production regions. Monitoring and evaluation help to fine-tune the technologies for subsequent diffusion over a wide area, and to provide feedback on new research needs. Thus, key areas are identified for research by CIAT and national programs.

The program's challenge in the 1990s is to promote the integration and consolidation of national cassava research and development systems in tropical America and Asia, and to facilitate linkages between these systems and institutes undertaking advanced research on cassava. The needs of African programs will be met through close collaboration with IITA. While maintaining a commodity system perspective, the program will emphasize germplasm resource development. Crop management, utilization and market research will concentrate on strategic issues of global importance. Applied research in these areas will gradually be devolved to national organizations, with horizontal cooperation being encouraged between countries at the regional level. The program will focus primarily on technology development for the subhumid, semiarid and subtropical ecosystems of the Americas and Asia, interacting closely with the Resource Management Research Division on hillside, savanna and forest margin ecosystems where an estimated 25%-30% of cassava is produced in tropical America.

The approximate allocation of Cassava Program resources from 1991 to 2001 appears in Figure 4.2. Overall core resources will decline slightly over the period in terms of actual staff positions, and significantly in terms of positions approved by TAC for 1989-1993.

Objectives. The program will pursue four objectives.

Objective 1. Genetically improve productivity and yield stability of cassava.

The growing ability of national programs in cassava breeding will generate a greater

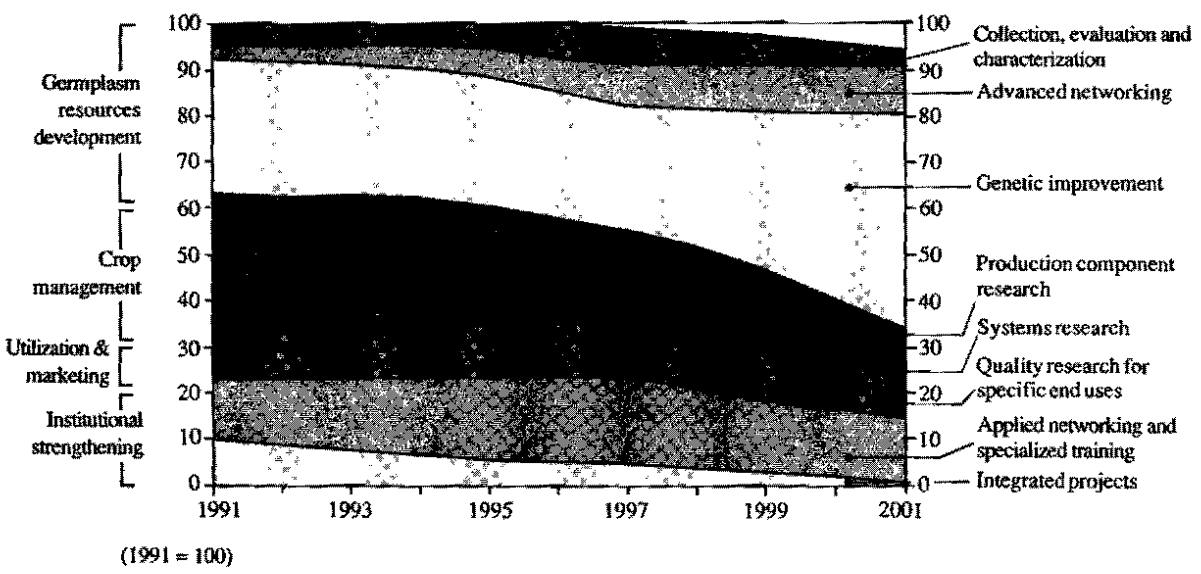

Figure 4.2. Cassava: approximate allocation of resources, 1991-2001.

demand for more precise germplasm characterization and a supply of genetic diversity in a range of forms.

More precise germplasm characterization will be achieved through molecular fingerprinting, gene mapping and more efficient screening for pest and disease resistance, drought tolerance, photosynthetic efficiency and quality factors. A wild *Manihot* collection will be established and characterized for potential contributions to cassava improvement. Well-characterized basic germplasm will be provided as a source of specific traits. Populations and elite clones will be targeted toward broadly defined ecosystems. Designing production systems based on true seed now appears technically feasible, and this will receive major effort during the decade.

Objective 2. Develop crop management practices for sustainable cassava production in selected agroecosystems.

The heterogeneity of conditions under which cassava is cultivated demands that improved crop management technology be developed for each major ecosystem. Low soil fertility and nutrient depletion, aggravated by erosion, and pests and diseases are major factors that lead to yield reduction in the harsh environments in which cassava is increasingly grown.

Comparative studies across ecosystems will elucidate principles determining crop productivity under stress conditions, and a greater understanding of the interactions between plant growth, the physical and biological environment and the

socioeconomic factors that determine management practices. This research will provide the basis for developing improved technology for testing by national programs. Emphasis will be given to cropping systems incorporating soil fertility improvement, erosion prevention and integrated pest and disease management. This work will be carried out in close cooperation with national programs and with the Resource Management Research Division.

A major challenge for the program, together with the Resource Management Research Division in its selected ecosystems, is to conserve and improve soil in less fertile environments where cassava is one of the few viable crops. Integrated pest and disease management research will continue to provide cost-effective alternatives for maintaining and improving yields. Supporting the International Institute of Tropical Agriculture (IITA) in its efforts to control the cassava green spider mite and mealybug in Africa will remain a high priority.

Objective 3. Improve the quality of cassava for diverse end uses.

Little work has been undertaken on the genetic, environmental and processing factors which affect the quality of cassava end products. Research is needed to ensure that new varieties are appropriate for their intended end uses and meet the requirements of farmers. The major quality factors of cassava roots and leaves, especially starch and cyanide contents, will be studied. This major new activity will result in better deployment of genetic resources and enhanced product quality through improved agronomic and processing practices. During the last decade, CIAT played a major role in developing postharvest conservation and processing technology for cassava, together with market and consumer research. In the 1990s, a major task will be to involve food science and technology institutions in this processing and product development work.

Objective 4. Strengthen the research and technology transfer capabilities of national research and development systems.

CIAT has contributed substantially to the development of national cassava research programs, especially in Latin America and Asia. However, several of these programs are underfinanced and understaffed to meet the increasing demand for improved cassava technology. Integrated research and development projects in specific cassava-growing regions have attracted research resources and are providing the focus needed for generating relevant technology.

The program will build on this positive experience, supporting national organizations through the selective training of national personnel, the definition of appropriate links between research and development institutions in developing and developed countries, the establishment of regional networks and in the design, planning and organization of integrated projects. Activities of a transitional nature will include enhancing institutional capacity to diagnose problems and opportunities, developing research methods and forming personnel with a view to devolving selected activities to national systems. Research networks in Asia will expand to encompass socioeconomic and postharvest issues. While continuing to support regional activities, the program will be seeking to make the networks autonomous by the end of the decade.

Outputs and impact of the Cassava Program are summarized in Table 4.2.

Table 4.2. Outputs and Impact of the Cassava Program.

Objective	Output	Impact	Assumptions
1. Genetically improve productivity and yield stability of cassava. 2. Develop crop management practices for sustainable cassava production in selected ecosystems. 3. Improve cassava quality for diverse end uses.	- High-yielding parental materials tolerant of biotic and abiotic stresses and with desirable quality characteristics for specific end uses; technology for the commercial production of cassava, using true seed; principles and technology components for the design of cassava-based cropping systems, emphasizing: . soil fertility maintenance . soil conservation . integrated pest and disease management; consumer-acceptable cassava-based products.	- Increased overall cassava production, stability and quality; economically and environmentally sustainable cassava production, especially under adverse edaphoclimatic conditions; increased incomes of the rural population in cassava-growing regions; increased market potential for cassava and cassava-based products; cheaper cassava for direct and indirect human consumption in urban areas.	- Continued and increasing interest in cassava research by advanced laboratories; adequate funding for cassava research at the international level; commitment of national governments to invest in the development of marginal areas where cassava is a principal crop; government policies that are not biased in favor of competing carbohydrate sources.
4. Strengthen national cassava research and development systems.	- Trained NARDS personnel; - regional cassava research and development networks; - integrated cassava production, processing and marketing projects.	- More effective and integrated national systems.	- Minimum investment in cassava research and development at the national level.

Rice

Goal. To improve the nutritional and economic well-being of rice growers and low-income consumers in Latin America and the Caribbean through sustainable increases in rice production and productivity.

Approach. The program generates and disseminates improved technology for increased and stable rice production in Latin America and the Caribbean. Having a regional mandate, it is the smallest of CIAT's commodity programs and is able to draw on the considerable research resources available from other centers, especially from the International Rice Research Institute (IRRI), which has a global mandate for rice and addresses global strategic research issues.

The emphasis has been on germplasm development for irrigated rice, and on incorporating resistance to prevalent blast races and pests into the high-yielding background developed in Asia. The program will now address a broader range of ecosystems and issues. Although research on irrigated rice will continue, increased attention will be given to tropical America's unique upland rice systems. Accounting for 40% of the region's rice production and 60% of the rice area, these systems allow considerable productivity increases.

For rice to keep pace with the expected annual population growth rate of 2%, substantial production increases must be realized. Because the region's economic difficulties will seriously limit expansion of the irrigated area, most increases in the irrigated rice supply will have to come through further yield increases. However, the region's vast savanna area generally supports only poor-quality native pastures. The high and generally reliable rainfall over much of this area offers the potential to markedly increase rice production through adapted, high-yielding, upland rice and rice-based systems.

For ecosystems, such as the acid-soil savannas where CIAT is focusing its efforts, germplasm and associated knowledge will be developed to meet the needs of specific production systems. This will require research on rice pests and germplasm adaptation to key environmental constraints. For ecosystems that are not a major focus for CIAT, such as the irrigated rice sector, we will continue to support national systems addressing growers' needs. Because diversification of cropping systems is a key to stabilizing yields and increasing productivity, the program will have to conduct some systems research for the irrigated sector. In many areas, beans use the residual soil moisture left after a rice crop. Collaboration with the Bean Program will explore ways of improving this system.

For both irrigated and upland systems, special attention will be directed toward integrated pest management (IPM), an area allowing major opportunities for reducing the current unacceptably high economic and environmental costs of rice production.

The program will continue to provide research training to national scientists and to ensure the flow of information at national, regional and international levels. A major challenge will be to adapt advances in the rapidly developing area of rice biotechnology to regional needs, and to ensure national access to new methods and products. Efforts will be made to build on existing regional networks and to address crop management issues, especially IPM, through such networks.

The program's breeding strategies will shift away from the development of fixed lines toward providing good parental material and breeding strategies for different target systems and areas. Many national programs will be encouraged to provide advanced materials for areas with similar requirements.

The approximate allocation of program resources between 1991 and 2001 appears in Figure 4.3. Although resources will be reduced over the decade by about 20%, there will be a significant increase in the absolute amount devoted to strategic research.

Objectives. During the planning period, the Rice Program will pursue the following objectives:

Objective 1. Broaden the available genetic resource base for irrigated rice to increase the stability of production.

The widespread diffusion of genetically related, modern, high-yielding varieties over most of tropical America's irrigated area means that breeding to increase genetic diversity must continue to be a high priority. Pest and disease resistance genes already incorporated into irrigated germplasm come from a limited number of sources, compromising the stability of resistance. Farmers tend to respond to instability by resorting to toxic agrochemicals for pest management. A further constraint to irrigated rice production is that modern germplasm usually requires plentiful and stable supplies of water for the full expression of its yield potential. Current trends in irrigation development suggest that water availability will continue to decline.

To meet this objective, the program will pursue two major initiatives: incorporation of diverse genetic sources of pest and disease resistance into breeding populations with improved genetic background; and transfer of upland rooting habits and other adaptive traits to high-yielding irrigated types. National partners will need relevant screening and evaluation methods to adequately exploit new resistance/tolerance genes and effectively use promising parental material.

Objective 2. Achieve and sustain a fuller expression of yield potential in irrigated systems while reducing the use of external inputs.

In many irrigated areas, the yield potential of modern varieties is not being realized because of pest pressure, inefficient use of inputs, suboptimal management practices and various socioeconomic factors. In Asia, increasingly sophisticated integrated pest and crop management practices are being developed from which tropical America stands to benefit. Similarly, the recent tremendous advances in rice biotechnology are making available new tools for managing pests and crops.

To meet this objective, the program will generate integrated crop management component technologies and seek improved understanding of plant biology and the factors governing component interactions. This will require addressing the importance, variability and interaction of key biotic and abiotic constraints in the region, including rice blast and 'hoja blanca' virus, together with *Sogatodes*, planthopper complex and red rice. An important aspect for technology relevance, design and adoption will be the implications of socioeconomic and long-term market environments for upland and irrigated rice production systems.

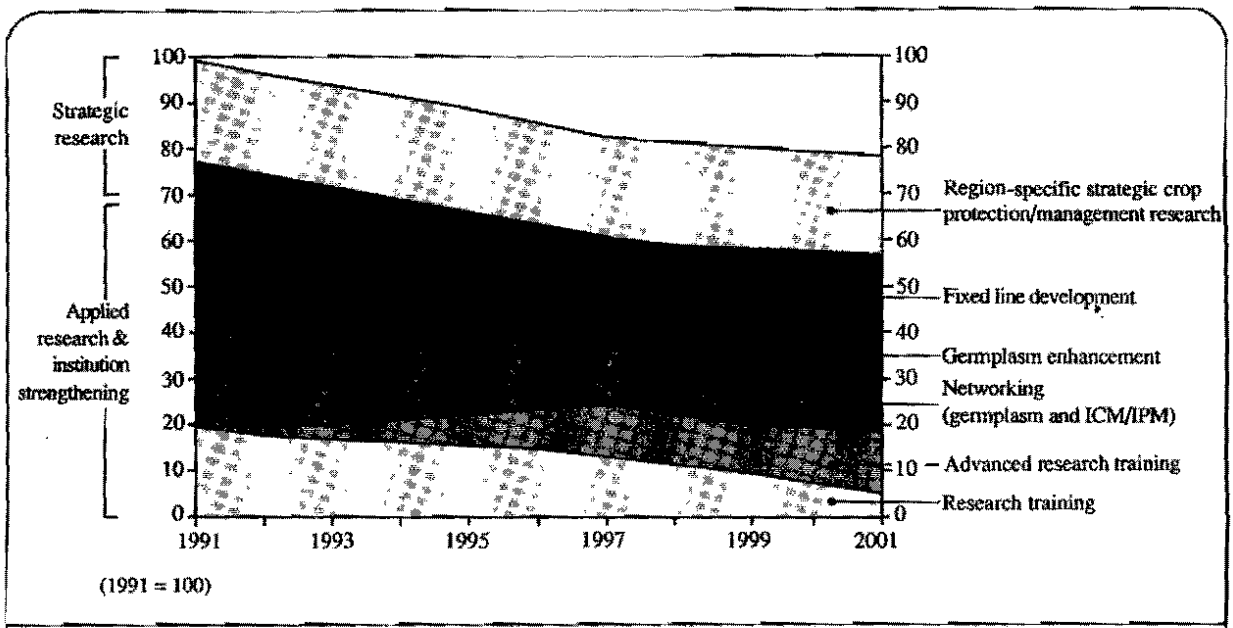

Figure 4.3. Rice: approximate allocation of resources, 1991-2001.

Objective 3. Develop high-yielding upland rice germplasm adapted to the savannas.

Over two million hectares of high-rainfall savanna upland rice have not benefited from high-yielding germplasm. Because populations being developed have produced lines with good yield potential that tolerate the harsh soils and biotic stresses of such areas, there is an opportunity for substantial production increases and area expansion. However, careful development of sustainable agronomic practices, rotations and associations will be needed for these fragile soils.

To meet this objective, the program will pursue three initiatives: develop breeding populations that incorporate sufficient variability to generate lines addressing production system requirements; explore and develop new plant characteristics that may open up new production alternatives; and understand the mechanisms of upland rice tolerance to acid soils. Close collaboration with CIAT's new Savanna Program will be essential.

Objective 4. Strengthen national capacity to conduct research to improve and stabilize rice production.

Stronger national rice research capacities are vital to the success of CIAT's Rice Program. As the program moves toward strategic research, it will be essential that its previous activities are adequately addressed by national programs.

To meet this objective, the program will pursue various training initiatives in collaboration with the Institutional Development Support Program, such as in-service training and short courses on specific

topics, taking full advantage of IRRI's training materials. CIAT will become a regional center for advanced training in rice research, hosting graduate students to conduct postgraduate projects in collaboration with Rice Program scientists. Postdoctoral fellowships will address specific issues of regional importance. The program will explore the possibility of strong national programs assuming some regional training. National capacity will be developed, allowing CIAT to relinquish responsibility for the general rice production training course, still a major training activity.

Objective 5. Promote effective information exchange.

Although germplasm exchange needs are met through the existing International Network for Genetic Enhancement of Rice (INGER), there is no structure to support information exchange and interactions among other national program scientists besides plant breeders.

To meet this objective, the program will work in close collaboration with the Institutional Development and Land Use Programs to address the need for increased communication. A network of rice agronomists will be established, emphasizing IPM; a Latin American rice research newsletter will be launched; and databases will be developed on present and potential rice-growing agroecological zones, germplasm development and biotic and abiotic constraints.

Outputs and expected impact of the Rice Program are summarized in Table 4.3.

Table 4.3. Outputs and expected impact of the Rice Program.

Objective	Output	Expected Impact	Assumptions
1. Broaden the available genetic resource base.	- Populations with disease resistance background; - parental material for crossing programs at national level; - irrigated lines with upland root systems; - evaluation methodologies for NARDS.	- Stabilized high productivity levels; expanded area based on rice lines with higher efficiency of water use.	- Continued support for national rice improvement programs; - continued INGER/IRRI support for germplasm exchange.
2. Achieve and sustain a fuller expression of yield potential.	- IPM/ICM component technologies; - understanding of component interaction; - understanding of biotic/abiotic constraints and germplasm interaction; - ICM network.	- Reduced pesticide use; - reduced production costs; - reduced price for consumers in the rural sector.	- Effective extension systems; - high price/cost transmission through the system; - national programs with ICM perspective.
3. Develop high-yielding rice germplasm adapted to the savannas.	- High-yielding adapted upland germplasm.	- Additional 5 million tons of rice/year by year 2000.	- Variety release and adoption by 1993/1994.
4. Strengthen national rice research capacity.	- Trained NARDS scientists; in-country training of researchers by NARDS staff.	- Realization of goals 1 and 2.	- National commitment to rice research; - adequate support from CIAT resources.
5. Promote effective information exchange among and within NARDS.	- Information in usable form; - books, pamphlets, newsletters; - compact read only disks (including germplasm databases).	- Availability of knowledge to enable broad implementation of goals 1-4 at all NARDS.	- CIAT support for information exchange mechanisms, and capability to develop them.

Tropical Forages

Goal. To increase the supply of ruminant meat and milk through improved nutrition while enhancing the natural resource base for sustainable agriculture.

Approach. Undernutrition was identified in the late 1970s and early 1980s as the key constraint to increased ruminant productivity throughout tropical America. Given that 90% of the cattle population is raised on grazed pastures and native grasslands, and that it is being progressively displaced to the poorer soils of the region, the Tropical Pastures Program was created to develop species adapted to the region.

The program has made solid progress in the past 12 years in the collection and screening of grass and legume germplasm and its deployment in pastures. A number of key species have been selected for adaptation to very acid, infertile soils in the American tropical lowlands. Such species can contribute to both increasing feed availability and improving soil fertility in crop-livestock systems.

Besides further improving the key species already identified, and developing new ones as needed, the program will extend germplasm selection to tropical Asia and Africa, thus taking global responsibility for forage development in the acid soils of the tropics. It will also broaden its germplasm base to include woody tree and shrub species of forage value for selected agroecosystems, where species adapted to acid soils can again play the double role of supplying forage while improving soil quality. For the mid-altitude hillsides, the program will expand germplasm development to higher elevations (to about 1800 m.a.s.l.).

Deployment of these genetic resources in sustainable production systems will be gradually transferred to CIAT's ecosystems programs, as these become operational.

The approximate allocation of resources within the program between 1991 and 2001 appears in Figure 4.4. Overall resources will be about 40% below those of the existing Tropical Pastures Program.

Objectives. The Tropical Forages Program will organize its resource deployment around the following objectives:

Objective 1. Develop productive herbaceous and woody forage germplasm for acid soils.

Productive forage germplasm adapted to acid soils and resistant to biotic and abiotic constraints is needed to increase milk and meat production in existing agropastoral systems, as well as functioning as a major sustainability component across CIAT's three priority ecosystems.

To meet this objective, the program will continue to screen pasture species for the lowlands, improve the most promising forage species already selected, develop germplasm for higher elevations and select further pasture and multipurpose tree species. Pasture improvement will focus on genetic manipulation to solve major limitations.

Development of forage germplasm for higher elevations (800-1800 m at the equator) in target ecosystems will include definition of plant ideotypes, expansion of existing collections, targeted collection missions and

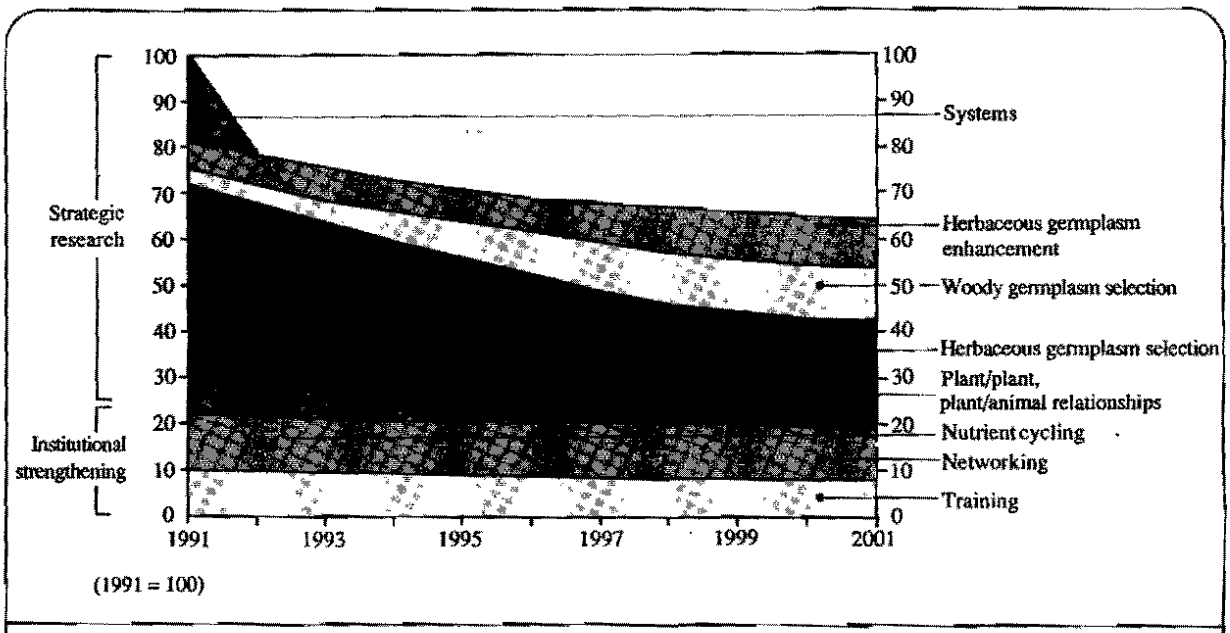

Figure 4.4. Tropical forages: approximate allocation of resources, 1991-2001.

determination of quality and antiquality factors in new acquisitions.

Selection of forage and multipurpose forage trees and shrubs (MPFTS) will be multilocational in collaboration with national agricultural research systems. Major screening sites will be established in each priority ecosystem. Multilocational testing of preselected materials will be done through existing networks, including the Red Internacional de Evaluación de Pastos Tropicales (RIEPT), the West and Central African Forages Project within ILCA's Pan-African Livestock Feed Resources Network (AFRNET), and the Southeast Asian Forages Research and Development Network (SEAFRAD). Seed supplies will be developed for multilocational testing, and the existing *Rhizobium* collection will be maintained.

Because the Forages Program will deal mostly with undomesticated species, it will seek to understand the biological mechanisms of flowering and seed setting of key species to support efficient seed multiplication by CIAT's Seed Unit and national partners.

Objective 2. Understand the ecological compatibility mechanisms of pasture components.

For efficient pasture germplasm development, an understanding is needed of how pasture components interact in response to different biotic and abiotic stresses and management regimes.

To meet this objective, the program will explore three major areas: plant-soil interactions, particularly mechanisms for adaptation to acid soils and for soil enhancement; plant biotic constraints and interactions, including the mechanisms underlying resistance; and plant-animal interactions.

Studies to understand plant-soil interactions include anatomical, physiological and

biochemical analyses of root systems and patterns, nutrient uptake, contribution of roots and litter to organic matter, root and shoot relationships and identification of genes responsible for various adaptive mechanisms. This type of research will contribute to the understanding and manipulation of the improvement of soils under pastures and, as such, forms a natural link with the agroecosystems programs.

Studies will be carried out to understand plant biotic constraints and interactions, emphasizing key pests and diseases and including the anatomy and biochemistry of spittlebug (in *Brachiaria* spp.), anthracnose (in *Stylosanthes* spp.) and rhizoctonia (in *Centrosema* spp.). Studies aimed at characterizing the genetic variability of diseases and pests and at identifying genes responsible for plant resistance will also be carried out.

To understand the plant-animal interactions in mixed species systems, the program will study quality and antiquality factors for ruminant production, and the physiological, biological and biochemical factors affecting fiber digestion.

Objective 3. Strengthen national and regional capabilities to develop forage germplasm.

Stronger national and regional capabilities are essential for successful forage germplasm development in tropical acid soils.

To meet this objective, CIAT will build on existing and new research networks in tropical America (RIEPT), Asia (SEAFRAD) and Africa (through AFRNET/ILCA), while developing new collaborative mechanisms in strategic research.

In tropical America, CIAT will concentrate on advanced training for national scientists, seeking to increase the share of national institution responsibilities. Jointly with CIAT's Seed Unit, the program will promote experimental and basic seed supply development. Further network development and improved screening methods will be major priorities for Asia and Africa.

Outputs and expected impact of the Tropical Forages Program are summarized in Table 4.4.

Table 4.4. Outputs and expected impact of the Tropical Forages Program.

Objective	Output	Expected Impact	Assumptions
1. Generate herbaceous and woody species adapted to acid soils.	- Improved grasses and legumes for poor acid-soil lands, from 0 to 1800 m.a.s.l.	- Improved ruminant production and fertility in low-fertility acid soil lands.	- Resources for continued acquisition of germplasm and support by GRU; - effective feedback from agroecosystems programs.
2. Improve efficiency of germplasm development through the understanding of ecological compatibility mechanisms.	- Knowledge of acid-soil adaptation mechanisms; - knowledge of mechanisms of plant resistance to pests and diseases; - quality and antiquality factors affecting ruminant nutrition; - identification of genes.	- New pastures and MPFTS components that are efficient in contributing to animal production and to soil enhancement.	- Effective links with advanced institutions, and support by BRU and VRU.
3. Strengthen national and regional capabilities.	- NARDS and networks (RIEPT, AFRNET and SEAFRAD) capable of developing germplasm and pastures and deploying multipurpose forage trees and shrubs (MPFTS).	- Broad adoption of new adapted pastures and MPFTS to low-fertility acid soils.	- National commitment to forage research; - adequate support by CIAT's IDS program, especially in seed supply systems.

Resource Management

In the agricultural sector, commodities are the focal point of socioeconomic activities, whereas management of the resource base constitutes a fundamental component of the medium- to long-term sustainability of the sector. Resource management also affects the transfer of resources from generation to generation. The goal of resource management research is therefore to improve the management of resources available for agriculture in tropical America, such that gains in food outputs and other commodities are compatible with long-term preservation of the resource base.

This goal will be pursued through the design of land use options aimed at optimizing the social returns to agriculture under different trade-off scenarios between production and conservation. The central strategy is to integrate land use and farming systems options that help relieve market and social pressures on the most fragile environments. Such a strategy will be the result of activities carried out at two levels of aggregation. At the sectorial level, emphasis will be on developing alternative land use strategies and understanding the relationship between those strategies and policy instruments. At the production level, emphasis will be on generating management technologies and integrating them into agroecologically sound, input-use-efficient and economically viable production systems.

With regard to input use, research will seek to maximize germplasm adaptation and/or tolerance to reduce the need for agrochemical inputs. It will also seek to optimize input-use efficiency through effective nutrient cycling and economic use of external inputs.

Research at the production level will focus on three major agroecosystems: the forest margins, the hillsides and the savannas of tropical America, each with its inter-disciplinary research team. Concurrent activities in all three agroecosystems will contribute to a regional approach to sustainability. This will be achieved through a balance in emphasis on economic growth in the savannas with equity concerns in the hillsides and resource conservation concerns in forest margins. Research at the sectorial level will be carried out across agroecosystems in tropical America and will be undertaken by a multidisciplinary land use program. All four teams are expected to build up a common base of information and methodology, and develop sustainable systems in close association with CIAT's germplasm development programs and national, regional and international partners.

The four programs will pay particular attention to understanding immigration patterns, and will undertake a dynamic farming systems approach from a user perspective, including household decision making, labor use by gender and age group, income generation and food availability.

The approximate allocation of resources to the Land Use and Agroecosystems Programs in the period 1991 to 2001 is shown in Figure 4.5. Figure 4.6 shows the same resource allocation by fields of specialization.

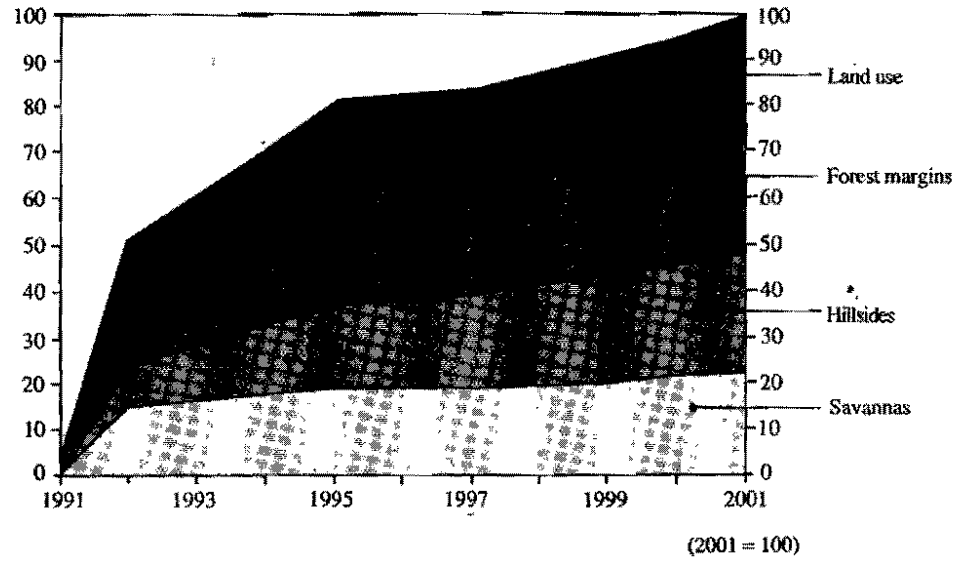

Figure 4.5. Resource management: approximate allocation of resources by programs, 1991-2001.

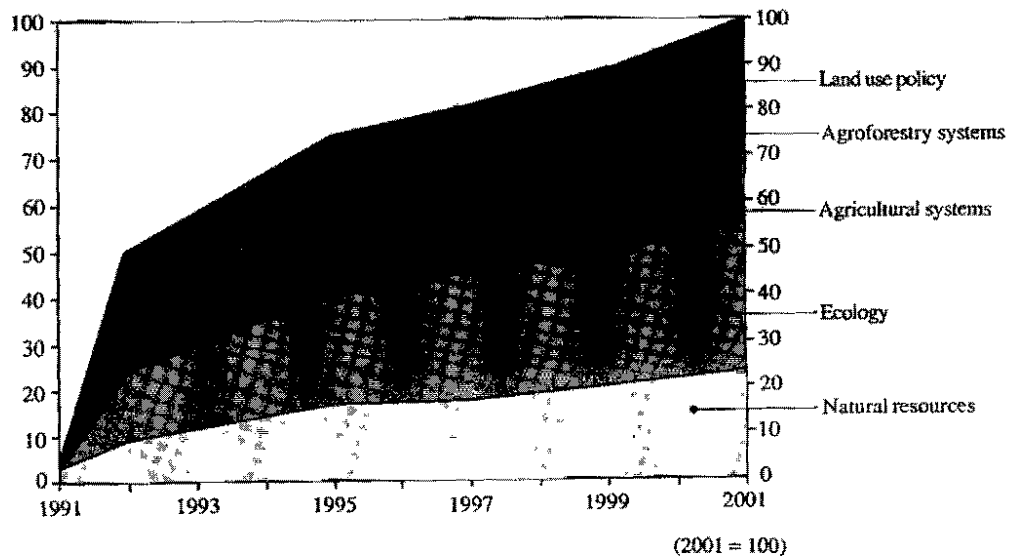

Figure 4.6. Resource management: approximate allocation of resources by areas of expertise, 1991-2001.

Land Use Research

Goal. Land use research at CIAT aims to improve the management of land resources in tropical America. In pursuing this goal, the Land Use Program will work in partnership with the agroecosystems research and commodity research programs, and with IFPRI and the new CGIAR forestry initiative.

Approach. This program will seek to integrate the development of production components and systems with appropriate land use strategies and policies. This will require detailed studies of production systems within land use patterns, and broader comparative studies of land use patterns within different environments and under different policy scenarios. To do this, CIAT will use its existing database on climates, soils, vegetation and socioeconomic factors, augmented with data from other sources where necessary. In collaboration with other CIAT research programs, the Land Use Program will design and conduct rural surveys as a basis for generating technology and assessing its impact.

Objectives. The Land Use Program will organize its activities around the following objectives:

Objective 1. Understand the dynamics of land use.

The dynamics of existing and alternative land uses must be understood before improved technologies, land use strategies and policies can be designed.

To meet this objective, the program will identify trends in land use patterns, analyze causal relations between socioeconomic and policy factors and land use, measure the social costs of different land use practices and characterize and monitor the land resource base. Particular attention will be paid to the possible impact of new technologies and policies on human migration patterns.

Objective 2. Appraise policy alternatives for improved land use.

A policy environment conducive to the adoption of resource-conserving technology is crucial. Such adoption and that of many production-oriented technologies are rare at present. The reasons range from unreliable input supplies, through unavailability of credit and price incentives, to insecure land tenure. In tropical America, human migration patterns and investment at the frontier are strongly affected by infrastructure and taxation policies.

To meet this objective, the program will conduct cross-country studies on impact of policy on land use and technology adoption, and support national and regional entities in their design of alternative policies. CIAT will not define policies, but will work with national policy analysts to present policy makers with a range of options and assessment of their probable impact. Different policy implications for technology design and dissemination will be assessed, paying special attention to comparative advantage and the need to avoid the negative external effects of agriculture.

Objective 3. Assess the impact on land use of new technologies and policies.

Once technologies and policies have been introduced, their social, economic and environmental impact must be locally and

regionally assessed. Many agricultural activities have high social costs that affect other locations outside the farm.

To meet this objective, the program will study how technologies and policies affect land use dynamics, particularly human migration patterns, and monitor the effects of new technologies on the resource base. Field studies and models will be used to assess local impact, and to extrapolate the assessments to the ecosystem. The program will exchange data and information with other research institutions, especially those monitoring and predicting regional and global climatic changes.

Objective 4. Strengthen national capacity to improve land resource management.

Stronger national research and training capacities are a prerequisite to improved land management. National research and policy-making bodies need stronger mutual links, as well as increased capacity, to conduct surveys, access regional information, analyze critical policy issues and design resource-conserving technology.

To meet this objective, CIAT will engage in collaborative research and training; host meetings of agricultural research and resource management institutions and policy-making bodies; and distribute information through databases, library services and publications.

The expected outputs and impact of the Land Use Program are specified in Table 4.5.

Table 4.5. Outputs and expected impact of the Land Use Program.

Objective	Output	Expected Impact	Assumptions
1. Understand land use dynamics.	- Understanding trends in land use; - estimates of trade-offs in alternative land use patterns; - improved data resources.	- A more relevant research agenda; - better informed decision-making process for policy makers.	- Effective links with policy, environmental and land use institutes (e.g., IFPRI); - access to detailed GIS, surveys, secondary data.
2. Appraise policy alternatives.	- Understanding policies on land use; - alternative policy scenarios.	- Adoption of policies conducive to sustainable agriculture.	- National institutions that influence land use patterns; - links with policy makers.
3. Study impact of policy and technology on land use.	- Recommendations for technology design; - estimates of environmental impact.	- More sustainable technologies; - improved conservation of resource base.	- Effective links with national agricultural research systems.
4. Improve links between policy makers and agricultural research and resource management institutions.	- Policy seminars; - interinstitutional research; - documentation.	- Improved policy for land use; - improved design of technology; - increased interinstitutional cooperation.	- Willingness of national institutes to cooperate with each other; - political support by public sector.

Forest Margins

Goal. To reduce the pressure on tropical forests by developing ecologically and economically sound production systems for already cleared land.

Approach. To reduce deforestation in tropical America, two types of action are needed. First is a change in macroeconomic policies to discourage large-scale entrepreneurial deforestation for plantations and ranches. Research on this issue will be the Land Use Program's responsibility. Second, technologies are needed to intensify and stabilize agriculture, reducing the amount of land needed for acceptable living and allowing small- to medium-sized shifting cultivators to settle. This issue will be the responsibility of this program.

A major concern will be to ensure that improved technology for use in forest areas does not encourage further deforestation. Although it is imperative that degraded areas be regenerated, there is a risk that more sustainable and profitable production systems might attract still more landless people and commercial farmers and ranchers to the frontier. For these reasons, technology development for cleared areas must be accompanied by microeconomic and policy studies that lead to improved land use strategies for remaining uncleared areas. The program will target its research on the shifting cultivator. By focusing on the generation of soil-enhancing technologies for use on small- to medium-sized farms in deforested areas, rather than on large-sized farms, we will avoid the risk of attracting venture capital to forest development. At the same time, jointly with the Land Use Program, this program will gauge the potential impact of technologies, and assist in the development of national land use strategies.

Initially, the program will emphasize production systems research only in those countries lacking extensive savanna areas and hence having limitations on alternative development paths (e.g., Central America). Land use and policy studies will comprise a wider range of countries, including those with savannas. Once it becomes clear that improved forest technology can be developed without pulling investment away from the savannas, CIAT will turn its attention to other countries, using a network approach for technology testing and information exchange.

Natural forest often contains indigenous cultivation systems. These may offer valuable lessons in how to sustain agriculture in forests without substantially reducing biodiversity. For this reason, resource management research will carefully study such systems on the still-forested side of the margins, in combination with improved technologies for the cleared area.

The use of forest for nonagricultural purposes is an important policy alternative to land clearance for agriculture. CIAT has no special advantage in this area, but will liaise closely with the new CGIAR forestry initiative and forestry research institutions to ensure that this alternative is being adequately explored. In some degraded areas, reforestation is the most promising land use option. Again, CIAT has no expertise in this area, but will seek inputs from appropriate forestry research institutions.

To address the agroforestry and forestry aspects of resource management research more fully, CIAT may seek to host a

regional initiative of the International Council for Research in Agroforestry (ICRAF), and the new CGIAR forestry initiative.

Objectives. The Forest Margins Program will pursue the following objectives:

Objective 1. Assess the possible social and environmental impact of technological innovation on shifting cultivation.

To meet this objective, the program will conduct socioeconomic studies of existing production systems, including traditional systems of cultivation. The studies will comprise current migration patterns within the zone, the origins of settlers, their socioeconomic circumstances before and after migration and the potential influence of improved technology. The aim will be to gauge the impact of improved technology on the demand for land from within the ecozone.

Objective 2. Reduce the destructive effects of shifting cultivation.

To reduce the demand for land in forest areas, it is necessary to prevent degradation by intensifying and stabilizing shifting cultivation systems on already cleared land.

To meet this objective, the program will develop agroforestry/ley-farming systems in small- to medium-sized colonization areas. The degree of intensification will vary from area to area, according to the resource base and input availability. The general aim will be to increase considerably per capita income, using an area a fraction of the current farm size. Improved pastures, browsing species and trees will be used to enhance the sustainability of the system and will be rotated with improved food crop components. Provided there is appropriate forestry research and policy backing, other tree species adapted to acid soils will be introduced. The desirable characteristics of improved systems will be defined in more detail with collaborating institutions and farmers. Pathways to achieve the transition from unsustainable to sustainable systems will be identified, together with intermediate targets to measure progress. Once improved technology has been designed, its economic, social and environmental impact will be carefully monitored.

Objective 3. Assist in the development of improved land use strategies in humid forest areas.

Better land use planning for forest areas as a whole will be needed to ensure that new technology has an impact on deforestation rates. Improved agricultural systems cannot be considered in isolation from the surrounding forest areas.

To meet this objective, the program, jointly with the Land Use Program, will provide a forum for national policy bodies and forestry research institutions (including the new CGIAR forestry initiative) to help formulate regional land use strategies. Besides improved agricultural systems, reforestation will be considered as an option for severely degraded areas. For uncleared forest areas, policy options include protection and sustainable use for nonagricultural purposes. Special attention will be paid to infrastructure and policy-related issues.

Objective 4. Strengthen national capabilities for improving forest-margin production systems.

Stronger national capabilities are essential for development of sustainable agriculture in cleared forest areas.

To meet this objective, the program will identify the principles and methods to generate and implement improved technologies. CIAT will train regional and national researchers in production systems research. Regional and international collaborative mechanisms for technology development and information exchange will be developed, which will eventually contribute to technology diffusion.

Hillsides

Goal. To improve the welfare of the hillside farming community by developing sustainable, commercially viable agricultural production systems.

Approach. Income-generating activities that permit capital accumulation and agricultural intensification, while conserving soil and water resources, are the key to resolving the hillsides' environmental problems.

Hillside areas are highly heterogeneous in terms of their resource base and production systems. Access to markets is also highly variable. In areas with good market access, equity problems are least severe. In contrast, the worst equity problems occur in the most severely degraded areas, allowing little opportunity for the success of agricultural technology. Acid soils, a common denominator in many hillside areas and other ecosystems, will be the major focus of the program, particularly on well-watered acid-soil areas with moderate potential and reasonable access to markets.

Given the complexity of the socioeconomic, technical and environmental problems of the hillsides, initiatives to improve their natural resource management must be part of the overall regional development plans which consider agricultural and nonagricultural activities. This will require strong interinstitutional and intersectorial cooperation to permit accurate identification of the problems and deployment of adequate staff and other resources for their solution.

Many other organizations -- especially nongovernmental ones -- already have activities in the hillsides. The program will begin by selecting representative sites for research and identifying partner organizations to set a common research agenda. In view of the hillsides' heterogeneity, careful thought will be given to the appropriate interinstitutional collaboration model for maximum impact.

As in the forest areas, there is a danger that improved technology will attract immigration from more degraded areas. Again, CIAT will conduct socioeconomic studies to determine their potential impact before designing improved production systems. Links will be established with relevant forestry research institutions.

Numerous technologies to conserve soil and water exist, but farmers seldom adopt them without policy inducements. Studies to identify potential instruments for policy adoption will be a necessary adjunct to technology development in the field.

Objectives. The Hillsides Program will center its activities around the following objectives:

Objective 1. Characterize the mechanisms leading to resource degradation and assess technological options.

Before intervening with new technology, it is necessary to understand and characterize the mechanisms leading to resource degradation in hillside areas.

To meet this objective, the program will conduct diagnostic research on resource management problems in selected, contrasting areas. Farmers' decisions on natural resource management will be analyzed and modeled in each type of area. The energy flow (including nutrient balance) in degraded and nondegraded systems will be studied. The program will then construct and/or adapt models to analyze alternative technological interventions in terms of their sustainability impact on soil structure and stability, accumulation of organic matter, water runoff and soil erosion. Lastly, biological and socioeconomic models will be combined to predict the income and environmental effects of different interventions.

Objective 2. Generate agroecologically and economically viable components, acceptable to farmers, for soil and water conservation and management practices.

To prevent further hillside degradation, resource-conserving technology is vital for providing farmers with short-term income. Trade-offs between income generation and resource conservation will be location-specific, but CIAT can assist with strategic research to understand the underlying mechanisms.

To meet this objective, the program will collect information on and evaluate a broad spectrum of component technologies. Management of data on component technology is the key to providing information to interested parties on components likely to succeed under specific conditions. Most adaptive research, that is, testing technologies in the field, will be conducted by CIAT's national research partners. Participatory research methods will be used to involve farmers in the design, testing and evaluation of prototype technologies. Strategic research will include monitoring and evaluation of nutrient balances, energy flows, household decision making, labor use by gender and age, income generation and food availability, and methods for monitoring and evaluating activities. Special attention will be paid to integrated pest management, the overuse of pesticides being a growing problem in hillside areas. In conjunction with the Land Use Program, potential policy instruments to promote adoption will be studied with national research groups.

Objective 3. Strengthen the capacity of national systems to generate and transfer resource-enhancing technology.

Stronger national capacity is vital for finding appropriate site-specific solutions for hillside farmers' problems. Strong links will be needed between agricultural, forestry and policy-making bodies, as well as between governmental and nongovernmental organizations.

To meet this objective, the program will play a role in the interaction of the various organizations working on natural resource preservation in the hillsides, as well as in the joint planning of research, study tours, seminars, training courses and other activities. The program will seek to establish an information exchange network of groups conducting location-specific resource management research and development. It will also formulate projects to extend results over wider areas, and train national staff in relevant areas of expertise.

Savannas

Goal. To develop sustainable and productive agricultural systems for the acid-soil savannas.

Approach. The challenge in the savannas is threefold: first, understanding the social, economic and policy factors that limit or foster agricultural development at present; research on this issue will be the responsibility of the Land Use Program; second, developing technologies that enrich the soils, allowing them to support productive mixed-farming systems; third, encouraging the formulation of policies and the development of technologies to protect the zone's remaining forests as cropping expands.

Over the last 15 years, CIAT has acquired a great deal of knowledge on land use patterns and predominant cropping and grazing production systems and their constraints in the savannas. At the same time, improved varieties and management practices for important crops, such as cassava, pastures and rice, have been jointly developed with national programs. CIAT also hosts CIMMYT's acid-tolerant maize subprogram. Adaptation of soybeans and sorghum to acid soils will be undertaken in cooperation with IITA, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Sorghum and Millet Program (INTSORMIL) and national programs. Therefore, the center will be well placed to proceed rapidly with technology generation and testing for this ecosystem.

Technological interventions are needed for the varying resource endowments of different savanna areas. The improved grass pastures already developed are applicable across large areas with more extensive systems. Where intensification is appropriate, a rice-based ley-farming system appears suitable in subhumid areas, but other components are needed to replace rice in drier areas.

In the 10 million or so hectares of savanna lands so far developed for agriculture and ranching, a number of sustainability issues have already arisen. Our major task will be to design more sustainable systems, ensuring that such problems do not recur as savanna development proceeds. Savanna farmers in Brazil and Colombia have expressed keen interest in profitable crop and pasture rotations and associations. Such systems may be seen as mechanisms for maintaining and improving land productivity, and for recuperating degraded systems. However, more research on their impact and a policy environment conducive to their adoption are needed.

Objectives. The Savanna Program will pursue the following objectives:

Objective 1. Identify key agricultural sustainability problems and development opportunities in the acid-soil savannas.

As a basis for the further intensification of production in the savannas, more information is needed on the sustainability issues arising in areas already developed, and on the opportunities in currently underexploited areas.

To meet this objective, the Savanna Program will collaborate with the Land Use Program, national institutions and farmers to characterize existing production systems, identify and prioritize the main sustainability problems and place these in a policy environment context. These studies will compare production systems in which problems are occurring with those which appear to be more stable. Of particular concern are physical and chemical characteristics of soils, pest management,

biodiversity of the savannas, farmers' decision-making processes, seasonality of employment, market access and the dynamics of land tenure.

Objective 2. Design technological interventions tailored to savanna environments to increase productivity, while preventing or reversing resource degradation.

To meet this objective, testing will be performed on improved grasses, legume-based pastures and rice-based ley-farming systems that are already developed; on improved varieties of soybean and sorghum to replace rice in drier areas; and on multipurpose tree species adapted to acid soils. Other components will be considered where appropriate. Long-term research on soil-plant relations under different cropping and grazing schemes will be required to develop methods for monitoring and predicting the sustainability of alternative systems. This research will also relate different production systems to market access, labor availability, management requirements and other socioeconomic parameters.

Objective 3. Understand the biophysical aspects of savanna production systems and their management for sustainable production.

Designing technological interventions requires an understanding of the basic processes that contribute to long-term system productivity or degeneration.

To meet this objective, the program will study biotic and abiotic factors at the systems level with special attention to plant-soil-microbe relationships and pest-plant interactions. Inputs in these and other areas will be obtained from the commodity programs and other research institutions. Nutrient-cycling models will be constructed by using data from the pilot systems and parallel controlled studies. From these models will emerge methods for designing intensive, sustainable systems, for predicting the decline of a production system or recommending early intervention before decline occurs. It is recognized that the biophysical components are only a part of a sustainable system; thus, studies will also address the management skills required for these systems, and their socioeconomic implications.

Objective 4. Strengthen national capacities for designing and monitoring savanna production systems.

Stronger national capacities are essential for the correct diagnosis of problems and opportunities in the savannas, the design of improved systems and their dissemination. Countries with savanna environments have recently displayed increased interest in their development, such that CIAT could play a catalytic role in integrating inputs from national and regional institutions.

To meet this objective, the program will seek appropriate partners for interinstitutional collaboration. It will also offer formal and informal training, and develop and disseminate relevant information. In collaboration with the Land Use Program, the Savanna Program will seek stronger links with policy-making bodies with a view to improving the policy environment for savanna development, especially the provision of infrastructure and services.

The expected outputs and impact of the agroecosystems research programs are specified in Table 4.6.

Table 4.6. Outputs and expected impact of the Agroecosystems Programs.

Objective	Output	Expected Impact	Assumptions
1. Characterize farm types and their influence on the use of resources.	- Understanding of farmer decision-making processes; - agroecosystem-specific models of farm land uses; - research priorities.	- Relevant common research agenda for national/regional institutions and CIAT; - more appropriate design of sustainable agricultural research.	- Ability of interested research and development institutions to follow a dynamic farming systems approach.
2. Do strategic research.	- Mechanistic models of nutrient cycling, water use and vegetation dynamics.	- Systematic body of knowledge on causal relationships.	- Continued progress in soil/plant/animal research; - effective links with advanced institutions.
3. Develop and test technology.	- Technological components; - sustainable systems; - estimates of spillover effects; - estimates of required management skills.	- Wider and faster adoption of sustainable technologies and farming systems; - improved conservation of resource base; - increased food production.	- Access to relevant component technology and germplasm; - effective seed production systems; - commitment from national programs to participate in collaborative activities.
4. Enhance national research systems.	- Trained scientists; - joint pilot projects; - networks; - documentation.	- More effective national research systems; - efficient research and extension work on sustainable agriculture.	- Improved stability of scientists in national programs.

Interinstitutional Cooperation

Underlying this strategic plan are two interrelated basic shifts in CIAT's approach to technology development. First is increased emphasis on the context, or system, in which agricultural development occurs. In the case of commodity research, this focuses on germplasm development and component technologies for specific agroecological production environments. In the case of resource management research, the systems perspective focuses on selected, important agroecosystems within which resource management problems can be coherently approached by considering the entire range of biophysical, socioeconomic and land use factors in those agroecosystems. The second shift in approach is the realization that integrated solution models require the participation of many actors; this implies that technology generation is a highly participatory endeavor in which interinstitutional coordination and mutual support are as important as the research activities themselves.

As already outlined, CIAT is in a unique position as an international research organization to assume strong leadership, not only in high-priority research but also in providing an international focal point to its own research. By contributing appropriate platforms, CIAT can make it possible for international centers and national and regional programs to contribute their energies and expertise in a collaborative fashion to well-defined research agendas.

Accordingly, CIAT plans to engage in the following roles:

* As an advocate of the need for research and development work in the problems in which it has chosen to be active. In this role, CIAT will attempt to focus attention on the commodity and agroecosystem domains.

* As a contributor to interinstitutional cooperative work by:

  ** Making an inventory of individuals, institutions and organizations that may potentially contribute to the overall efforts. This inventory includes the assessment of actual and latent interest, resources, strengths, weaknesses and potential.

  ** Hosting and integrating programs of other international centers that contribute to farming systems development in the selected agroecologies.

  ** Coordinating common research plans and priorities, and assigning responsibilities.

  ** Assisting in the identification of funding sources and their channeling to cooperative research and development.

* As a developer of international information support mechanisms on which to build cooperative efforts (databases, information systems, regional networks, formal and informal communication channels).

* As a trainer in areas of CIAT's research, identifying at the same time training needs and opportunities within interinstitutional research settings.

Although these roles are assumed by the respective research programs and the center

as a whole, a well-defined support program will assist the center and the programs to exercise these roles effectively.

Institutional Development Support

Goal. To assist CIAT's research programs in strengthening the capacity and increasing the efficiency of national and regional research systems to contribute to sustainable agriculture.

Approach. During the 1980s, CIAT helped strengthen national commodity programs through training, training materials and technical publications, bibliographic information and the organization of conferences. These services need to be extended to resource management research and expanded to reach a wider clientele.

Joint projects to carry out this mission will be of three kinds: research projects; special projects linking research with pre-development activities to validate new technologies; and projects to strengthen specific national research and training activities, especially commodity production and adaptive research. These projects are a means of devolving applied and training activities to national programs.

CIAT's germplasm and resource management programs will be assisted with the design of appropriate institutional mechanisms and output-oriented special projects.

Objectives. The Institutional Development Support Program will pursue the following objectives:

Objective 1. Strengthen the capacity of public and private research institutions at the national level.

Staff in research institutions need up-to-date information, training in new research methods and opportunities to exchange experiences.

To meet this objective, the program will cooperate with CIAT's research programs to supply specialized library information services, organize conferences and other meetings and publish for specific audiences. The program will also assist in specialized training to strengthen national research teams rather than meet individual training needs.

Objective 2. Increase the efficiency of national research systems and strengthen their links with development.

The efficiency of national research and development systems depends on appropriate interinstitutional research models, on strong organizational links within the systems and on ensuring that all technology generation and transfer tasks are present in the system.

To meet this objective, the program will assist CIAT's programs in the design of collaborative research and pre-development activities (networks, consortia and projects). It will support these activities with expertise in interinstitutional cooperation, with training in project management (using actual projects as training ground) and with other support services as mentioned under Objective 1.

Objective 3. Develop seed supply systems suitable to small farms' circumstances.

Past seed-related efforts by CIAT have significantly strengthened existing seed supply systems. However, these systems face considerable barriers in servicing the small-farm sector and its specific needs. Large private enterprises are not attracted by

what often represents small and atomized markets. Large public enterprises face major financial and organizational difficulties to serve the small-farm sector. New seed supply systems are needed. These should be based on small seed enterprises closely integrated with the local research systems and the farming community they serve. Thus, the aim of CIAT's future seed-related efforts will be to extend the benefits of seed-embodied technologies to resource-poor farmers. This is particularly important in the case of crops not attended by existing seed systems.

In close collaboration with CIAT's research programs and those of other international, regional and national programs, the Institutional Development Support Program will assist in the development of small seed enterprises integrated in local seed supply systems. Activities will focus on organizational aspects; on the integration of the small enterprises with research and rural development programs; and on developing pre- and postharvest technologies appropriate to such new organizational arrangements.

Objective 4. Enhance national and regional training in commodity production and adaptive research.

This is a transitional objective to enable CIAT to relinquish some of its current training activities.

To meet this objective, the program will cooperate with CIAT's research programs to train trainers at national or regional levels. Subject areas will include research and production methods for CIAT's commodities, course organization and adult education techniques. CIAT will seek to ensure institutionalization of this type of training at national or regional levels.

Outputs and expected impact of the Institutional Development Support Program are specified in Table 4.7.

Table 4.7. Outputs and expected impact of the Institutional Development Support Program.

Objective	Output	Expected Impact	Assumptions
1. Strengthen the capacity of national research institutions.	- Human resources and teams with appropriate knowledge, skills and information for applied and strategic research.	- Increased generation of relevant technology by NARS; - increased efficiency of research through national programs/CIAT complementarity.	- Continuity of alumni in mother institutions and in their field of specialization, and availability of resources.
2. Increase the efficiency of national research systems and facilitate their interfacing with agricultural development.	- Mechanisms for interinstitutional complementary research; - tightly designed projects;	- Increased efficiency of research through interinstitutional collaboration.	- Political support and institutional willingness to cooperate and fulfill commitments.
3. Develop seed supply systems suitable for small farms' circumstances.	- New organizational mechanisms and enterprises for seed supply; - new seed production and processing technologies for small seed enterprises.	- Adoption of improved crop varieties and of pastures and MPFTS for resource conservation.	- Support from national research and development programs, and donor financial support to initiate pilot projects.
4. Enhance national/regional training in commodity production and adaptive research.	- Institutionalized national and regional training programs for commodity production and adaptive research.	- Increased effectiveness of CIAT/regional/national research and technology transfer systems; therefore, more efficient technology generation and adoption.	- Political decision to institutionalize training at national/subregional levels, and ongoing political and financial support.

Research Support

Genetic Resources

The Genetic Resources Unit is concerned primarily with the acquisition, conservation and distribution of germplasm of CIAT's mandate commodities and related species, and with associated research on the collections of *Manihot, Phaseolus* and tropical forages. The unit will continue to provide these essential building blocks for CIAT's and other institutions' commodity research, and especially for their move into strategic germplasm improvement over the next decade.

The expanded needs of the Tropical Forages Program for multipurpose tree and shrub species for priority ecosystems will require acquisition of their germplasm. The unit will continue providing disease-free germplasm to bona fide research institutions around the world and will safeguard and duplicate all of CIAT's base collections.

The need to widen the genetic base for crop improvement and the recent development of methods for more efficient use of wild germplasm imply major expansion of CIAT's collections. This is particularly true for beans and cassava, for which the unit will seek to establish comprehensive wild collections.

Research will comprise taxonomy, reproductive biology, evolution and genetic diversity; and the establishment of a core collection and germplasm conservation methodologies. In almost all instances, this work will be done in collaborative projects with other programs or institutions, including those in advanced research networks.

Biotechnology

The main aims of the Biotechnology Research Unit are to develop and apply advanced techniques to increase research efficiency and improve technologies. The unit monitors and adapts methods developed through basic research in areas such as cell biology, biochemistry, genetics and molecular biology, so that these can be integrated into CIAT's commodity research. The unit is also active in information exchange and training, assisting in the development of an indigenous capacity to conduct biotechnology research in national programs. A third important function is to contribute to the maintenance of high biosafety standards in CIAT's use of recombinant DNA technology and in the future release of transgenic organisms into the environment. Priorities are set in collaboration with CIAT's research programs.

During the 1990s, the unit will be increasingly involved in the application of molecular genetic markers for plant and microbial characterization and for developing molecular linkages with important traits. Tissue culture will be used to facilitate gene introgression from wild to cultivated germplasm of CIAT's crops. Genetic transformation techniques will be developed and eventually used to achieve gene transfer from more distant gene pools and other alien sources. Research will be conducted to identify the factors involved in selected plant-biotic and abiotic stress interactions. Such identification would help develop more efficient techniques for understanding a plant's mechanisms of adapting to stress and also for screening resistances and tolerances.

Characterization of root-microbial associations by means of molecular fingerprinting techniques will allow a better understanding of microorganism population dynamics, especially in the rhizosphere. This information, in turn, can be useful for managing pest and pathogen biocontrol practices and for increasing the efficiency of the plant's nutrient use.

The unit will continue to collaborate with CIAT's commodity programs to identify critical production constraints for research in advanced research laboratories in developed and developing countries. A training course is planned to further strengthen national capacities and foster permanent links between developing and developed country laboratories participating in advanced networks.

Virology

The Virology Research Unit was created to characterize and find means to control the viruses that limit the safety of germplasm exchange and productivity of the plant species under research by CIAT's commodity programs. To meet these objectives, the unit cooperates with CIAT's other research support units, particularly with the Biotechnology Research and Genetic Resources Units, to take full advantage of the advanced molecular biology techniques now available and to ensure high quarantine standards in the introduction and production of germplasm.

During the 1990s, the unit will continue to fulfill those functions, paying increased attention to the application of advanced techniques to priority problems identified by CIAT's commodity programs.

Information Systems

The Information Systems Unit will steer and coordinate the development of an integrated information base at CIAT. This information base will be designed to increasingly serve the needs of not only the center but also the international research partnerships in which CIAT participates.

This unit will take full advantage of the evolving technologies in information storage, processing and distribution. Its approach will be based on the concept that each work domain (e.g., agroecology/geography; commodity improvement; soil-plant relations; socioeconomics; institutional development; and finance and administration) develops and maintains data structures and bases that are uniquely suited to its needs. These diverse databases, however, will be brought together by underlying standards that will allow ready interconnection. Any given user of the information system -- whether inside or outside the center -- will have available all the information collected and analyzed by the different domains. Such access will be obtained in a query-type environment that will permit the user to make decisions on the basis of relevant data available.

The role of information systems will be to exercise central leadership for the development of such an information system. Its responsibilities will include:

* development of center-wide standards that will help decentralize databases;

* guidance and support for different research fields in developing their databases;

* development of integrated management information systems based on the databases of the various domains and designed to meet the information needs of researchers, other decision makers and other users, both inside and outside CIAT; and

* development and administration of local-area networks and wide-area networks that will interconnect CIAT with its research partners internationally.

Chapter 5

IMPLEMENTATION

The previous pages outline the main shifts in CIAT's approach to its mission as we look toward the year 2000 and beyond. They show that the context in which CIAT seeks to make a major contribution is very large and complex, and success in that context requires the participation of many institutions. They also show that CIAT -- as an international, apolitical research organization -- is in a unique position to make a substantial research contribution. Equally, CIAT is in a position to enlist the participation of many institutions and policy-making bodies on the issues that the center is focusing on as a result of a dispassionate analysis of future needs and opportunities.

Two important challenges are: to determine the modes of operation that will permit the center to engage successfully in the complementary roles of a research organization and a catalyst of interinstitutional cooperation; and to identify the minimum resources needed. These subjects are dealt with in this chapter.

Resource Requirements

Throughout the planning process, global estimates of resource availability were kept in mind. After identifying the portfolio of commodities and agroecological zones that CIAT should work with, the planning process concentrated on identifying the minimal efforts and resources required to deliver specific outputs. In the course of this analysis, it was realized that the financial and personnel requirements implied by assuming international responsibility for soybeans and sorghum would be beyond realistic resource expectations. This led to limiting the proposed work on these two crops to exploratory research on their adaptation to acid soils, aimed at developing them as component crops in production systems for the savanna ecology, where the expected payoffs from their production are very high. They are included in this plan as complementary activities. Core resources for all other program areas identified as highest priority for CIAT were defined as the minimum required for achieving the stated objectives. Core resources below that minimum would seriously impair the ability to carry out the center's mission.

The minimal resources required for each program area are summarized in Table 5.1 and expressed in senior staff person-years. Shown are the actual and CGIAR-approved positions for 1991, and the proposed allocation of positions in 1996 and 2001.

Table 5.1 shows that, toward the end of the planning period, CIAT proposes to allocate 47 senior staff to germplasm development research (including positions in research support), and 34 senior staff to resource management research. Considerable reductions are proposed in bean and pasture/forages research, and modest reductions in cassava and rice research (in the case of cassava, the reductions are considerable, compared with the CGIAR-approved positions for that program). It is intended that the germplasm development programs (except for rice) will fully exercise

Table 5.1. Proposed core resource allocation (in senior staff positions) for 1991 (CGIAR-approved and actual), 1996 and 2001.

Program or area	Senior staff positions			
	1991		1996	2001
	CGIAR-approved	Actual		
Germplasm Development	69	65	51	47
Beans	24.5	24.4	18	16
Cassava	15.5	12.3	12	11.5
Rice	9	9	8	7.5
Tropical forages	20	19.3	13	12
Resource Management	2	1	30	34
Land use	2	1	7	9
Forest margins	-	-	8	9
Hillsides	-	-	6	9
Savannas	-	-	9	7
Instit. Development	7	6	8	8
Mgt./Admin./Cent.Serv.	10	10	9	9
Total	88	82	98	98

their global responsibilities. By 1996, CIAT expects to have all its programs in resource management research operational and fully consolidated by the year 2001.

CIAT is planning to complement its core programs with highly selective activities in specific areas that require sustained commitment in the medium term, but not necessarily in the longer term. Table 5.2 shows the required staffing for core and complementary activities, broken down by geographic regions.

In tropical America, complementary positions are projected in the four commodity programs to support commodity research networks in Central America and the Caribbean. Two complementary positions are projected for carrying out germplasm development research on sorghum and soybeans for acid soils in the Savanna Program. Work on these crops will be coordinated with ICRISAT and IITA, respectively, preferably through joint projects, and in a networking mode, with INTSORMIL, EMBRAPA, ICA and other institutions. Two and three positions, respectively, are contemplated for the Hillsides and Forest Margins Programs to work within pilot projects at selected sites. A further complementary position is projected for the Institutional Development Support Program to assist CIAT and its partners in project design. This function is considered essential for the development of

Table 5.2. Proposed core and projected complementary senior staff positions in 1996.

Program or area	America		Africa		Asia		Total	
	Core	Comp.	Core	Comp.	Core	Comp.	Core	Comp.
Germplasm Development	42	4	6	8	3	1	51	13
Beans	14	1	4	7	-	-	18	8
Cassava	9	1	1	1	2	1	12	3
Tropical forages	11	1	1	-	1	-	13	1
Rice	8	1	-	-	-	-	8	1
Resource Management	30	7	-	-	-	-	30	7
Land use	7	-	-	-	-	-	7	-
Forest margins	8	3	-	-	-	-	8	3
Hillsides	6	2	-	-	-	-	6	2
Savannas	9	2	-	-	-	-	9	2
Instit. Development	8	1	-	-	-	-	8	1
Mgt./Admin./Cent.Serv.	9	-	-	-	-	-	9	-
Total	89	12	6	8	3	1	98	21

interinstitutional and pilot projects related to the mandate of the center.

Given the critical importance of beans in eastern, central and southern Africa, CIAT proposes to continue its current research and cooperation through a blend of core-funded germplasm development activities (4 senior staff positions) and complementary research and training activities (7 positions). One cassava germplasm specialist is, at present, based at IITA in West Africa; CIAT envisages the need for a complementary staff position to cooperate with IITA in East Africa to facilitate the transfer of germplasm to the cassava agroecologies of that part of Africa. One core-funded forage germplasm specialist is projected for cooperation with ILCA in germplasm introduction and screening.

In Asia, CIAT proposes to complete its cassava research team with an economist/utilization specialist. This position is to carry out complementary work that enables germplasm development to focus on quality characteristics required in the expanding cassava markets in the region. A new, core-funded position will help introduce and screen forage germplasm and support forage research networking in the region.

In summary, by 1996 CIAT expects to be fully exercising its global germplasm development responsibilities through long-term core programs, and to complement these with extra-core resources allocated to high-priority activities of shorter duration. Complementary activities are expected to represent less than 20% of the center's total financial resources.

Although it is difficult to project activities over the long term, Table 5.3 outlines CIAT's best estimate of complementary staff requirements for the year 2001, broken down by geographic areas. The number of bean research positions in Africa will depend on advances achieved toward the end of the planning period, and on institutional developments in eastern and southern Africa. The numbers shown (4 senior staff for complementary activities) are based on the assumption that the institutional setting remains essentially as it was in the early 1990s, and that CIAT will continue to be expected to assume responsibilities for complementary research and research-related activities in the region. The reduction envisaged between 1996 and 2001 (from 7 to 4 senior staff positions) is based on anticipated progress in research and increased strength of national programs.

Management of Resources and Processes

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

CIAT is strongly guided by the concept of comparative advantage. Wherever there is an opportunity to hand over to a collaborating institution the responsibility for a given set of activities, CIAT will do so. In fact, the center will actively help develop the capacity of collaborating national and/or regional institutions to assume increased responsibilities for tasks at present carried out by CIAT. This process will liberate resources which the center can redeploy in accordance with the objectives and priorities outlined in this strategic plan.

The work plan implied by the strategic plan is obviously ambitious. It can only be carried out successfully to the extent that the collaboration of institutions at national, regional and international levels can be enlisted. This will require a high degree of coordination of activities, which can often be best accomplished through project-based joint activities. To this end, CIAT will further develop its capacity to conceptualize and develop research and/or pilot projects, and to execute research and/or development projects that involve relevant national and regional institutions. To the extent possible, these projects will be executed by the respective partners.

Organizationally, CIAT envisages that the research endeavors proposed in this strategic plan will be carried out within two closely collaborating divisions, one devoted to germplasm development research and the other to resource management research. Broad outlines of the organization charts are shown in Figures 5.1, 5.2 and 5.3.

During the initial five years of the plan, that is, until 1996, it is anticipated that the Tropical Forages Program will form part of the Resource Management Division. This will equip this division with the considerable expertise and experience of the program in resource management research. It will also enable the program to conclude the research agenda it had already embarked on, which clearly falls within resource management research. By the end of 1996, it is anticipated that the Tropical Forages Program will join the Germplasm Development Research Division.

Managing the internal environment. CIAT's leadership is responsible for maintaining a work environment conducive to creativity and innovation. To accomplish this, an open management system that

Table 5.3. Proposed deployment of core and projected complementary senior staff positions in 2001.

Program or area	America		Africa		Asia		Total	
	Core	Comp.	Core	Comp.	Core	Comp.	Core	Comp.
Germplasm Development	38	2	6	5	3	1	47	8
Beans	12	-	4	4	-	-	16	4
Cassava	8.5	1	1	1	2	1	11.5	2
Tropical forages	10	0	1	-	1	-	12	1
Rice	7.5	1	-	-	-	-	7.5	1
Resource Management	34	10	-	-	-	-	34	10
Land use	9	-	-	-	-	-	9	-
Forest margins	9	4	-	-	-	-	9	4
Hillsides	9	3	-	-	-	-	9	3
Savannas	7	3	-	-	-	-	7	3
Instit. Development	8	1	-	-	-	-	8	1
Mgt./Admin./Cent.Serv.	9	-	-	-	-	-	9	-
Total	89	13	6	5	3	1	98	19

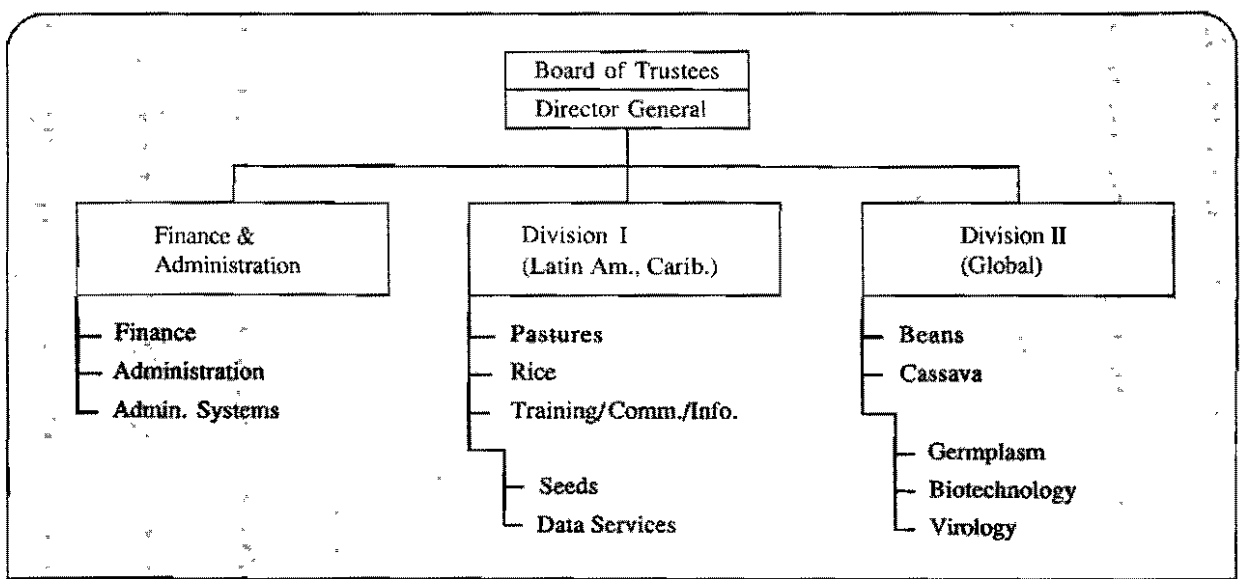

Figure 5.1. Organization chart (1991).

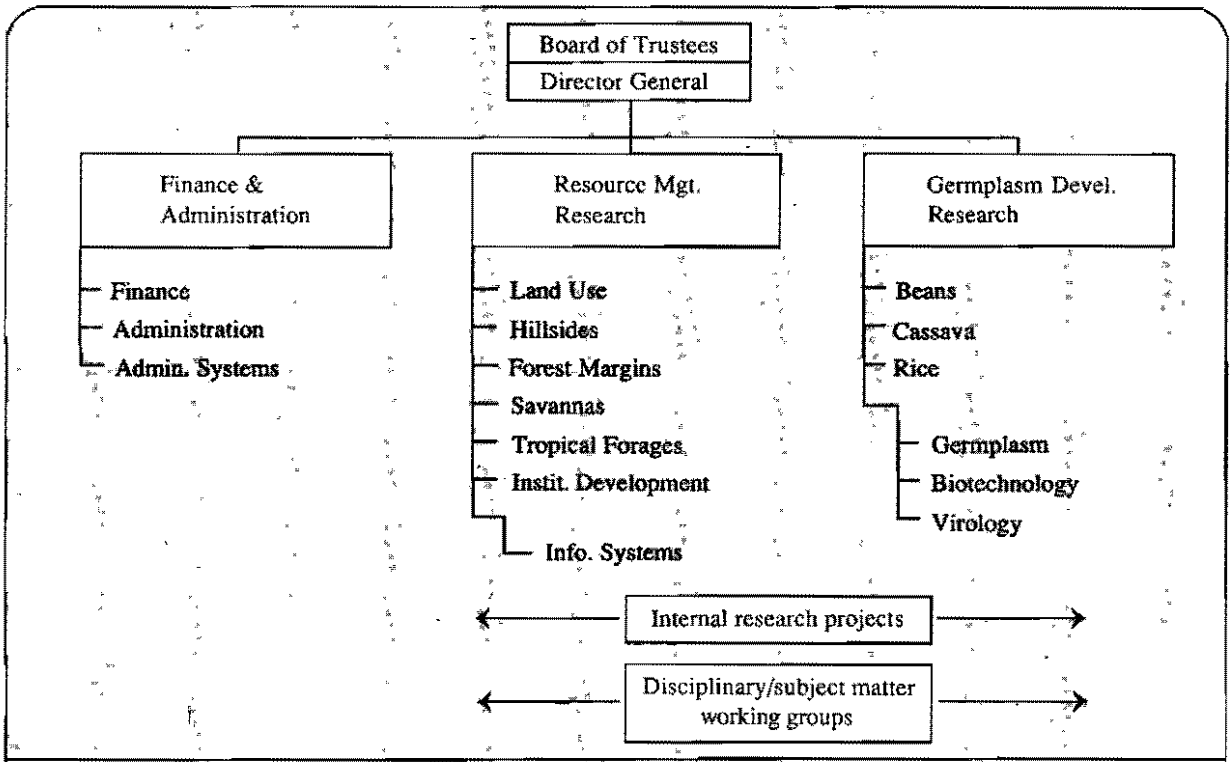

Figure 5.2. Organization chart (1992-1996).

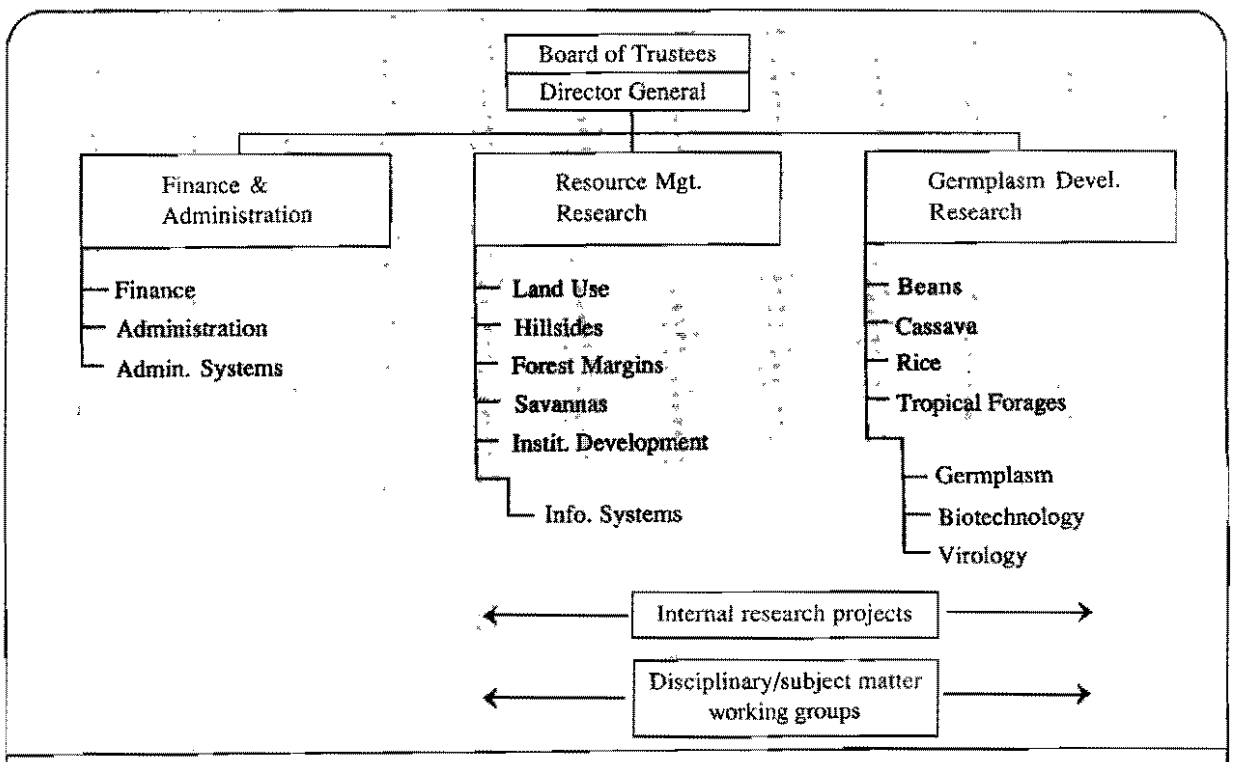

Figure 5.3. Organization chart (2001).

emphasizes participatory, decentralized decision-making processes will be used.

Over the years, a strong institutional culture has emerged, as explained in Chapter 2. Underlying features of this culture are 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's endeavors and the collective desire to ensure the success of CIAT's mission. Through appropriate culture audits we are identifying the extent to which the institutional values are, in fact, believed and acted upon throughout 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 CIAT's culture will be nurtured and improved.

Managing the process. The essence of CIAT's research administration 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 by 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 mid-course corrections in priorities and methodologies.

The model of multidisciplinary research teams organized around single commodities or agroecologies and supported by specialized research units and institutional development activities is effective and well proven. This model will be retained as the main feature of CIAT's organizational structure in the 1990s; it will be complemented by increased use of ad hoc work teams for specific research problems that must be addressed outside the organizational program structure (Figures 5.2 and 5.3). These ad hoc teams will be composed of staff members from various programs and units, as appropriate, and will be supported with flexible budgets. The organization can be described as following a partial, flexible matrix approach, with programs being the pivotal axle of the organization and selected projects cutting across programs.

For reasons of cost-effectiveness and practicability, most support services will continue being centralized, service-oriented support programs or units. Increasingly, CIAT will rely on allocating only limited, basic funding to support units, with part of the operational resources channeled through the principal programs so to ensure that the work of the support activities is in tune with the priorities and requirements of the research programs. Disciplinary strength will be fostered through active participation in high-quality, refereed journals, informal association of disciplinary groups and project-oriented research groups. Intradisciplinary discourse and sharing of facilities are helped by placing scientists of the same discipline from different programs in physical proximity.

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 national program partners, advanced research institutions, related centers and international and regional institutions. The main interfaces for such cooperation are at the program level. CIAT management will foster such cooperation through monitoring, evaluation and 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. A very particular challenge is awaiting CIAT: that of establishing solid interfaces with institutions engaged in resource management research. As is evident from the description of this research effort, the development of appropriate interinstitutional links is fundamental for CIAT research programs, assisted by the Institutional Development Support Program. CIAT's management will devote special attention to guide and support these efforts.

Managing the funds. *Supply.* Execution of the strategic plan for the 1990s will require adequate funding. CIAT will continue to rely principally on the CGIAR donor members for its core program. These governments, international development organizations and foundations are committed to the goals of the center; such commitment must be maintained through effective communication 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 funds from non-CGIAR funding sources. We will seek private sector funding whenever this can be done without compromising our priorities and values. We will also explore possibilities of adding financial resources through mechanisms such as debt purchase and conversion and use of blocked currencies. We will also study the desirability of, 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. 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 and accountability. CIAT will continue 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 financial stringency of probable long 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 contribution 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 and thoughtful management. We must not allow them to deteriorate. Even in times of severe financial restrictions 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 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 necessary and important outputs, but they do not constitute the ultimate goal. Execution of this plan must result in substantial and sustainable production increases and improved standards of living for millions of people now in acute need. It must also result in progress toward the understanding of the socioeconomic and biological processes determining sustainable growth in given agroecosystems. Additionally, it must result in substantial progress toward sound exploitation of the agroecological zones in which CIAT intends to work. To that end, we dedicate this strategic plan.

ACRONYMS

Acronym	Institution	Country
AFRNET	Pan-African Livestock Feed Resources Network	Ethiopia
CGIAR	Consultative Group on International Agricultural Research	USA
CIAT	Centro Internacional de Agricultura Tropical	Colombia
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo	Mexico
CIP	Centro Internacional de la Papa	Peru
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária	Brazil
ICA	Instituto Colombiano Agropecuario	Colombia
ICRAF	International Council for Research in Agroforestry	Kenya
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics	India
IDB	Inter-American Development Bank	USA
IFPRI	International Food Policy Research Institute	USA

IICA	Inter-American Institute for Cooperation in Agriculture	Costa Rica
IITA	International Institute of Tropical Agriculture	Nigeria
ILCA	International Livestock Center for Africa	Ethiopia
INGER	International Network for Genetic Enhancement of Rice	Philippines
INTSORMIL	International Sorghum and Millet Program	USA
IRRI	International Rice Research Institute	Philippines
RIEPT	Red Internacional de Evaluación de Pastos Tropicales	Colombia
SEAFRAD	Southeast Asian Forages Research and Development Network	Philippines