PROGRAM PLANS AND RESOURCE REQUIREMENTS 1992 - 1996

FUNDING REQUEST FOR 1992

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CIAT Centro Internacional de Agricultura Tropical

CONTENTS

Part I

PROGRAM PLANS AND RESOURCE REQUIREMENTS 1992-1996

OVERVIEW

This operational plan is a companion document to CIAT's strategic plan, *CIAT in the 1990s and Beyond: A Strategic Plan*. It presents, in operational terms, the program plans and funding requirements for the first five years of the strategic plan, that is, from 1992 to 1996.

The strategic plan for the 1990s, which was developed over a two-year period, involved an interactive process that included significant input from national program partners. The planning exercise was based on comprehensive assessments of trends in CIAT's environment, particularly those in the agricultural economics context in which the center operates; the agricultural research scene at national and regional levels; the international agricultural research and development community; and agricultural research per se. This analysis revealed that fundamental changes are taking place, to which CIAT must adapt if it is to continue providing science-based solutions to agricultural development problems.

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." This mission is pursued through two mutually interrelated approaches to the Center's research work in the years ahead: germplasm development and resource management.

As a germplasm development center, CIAT will continue assuming global responsibilities for cassava, field beans, and tropical forage species in acid soils; and regional responsibility for rice in Latin America and the Caribbean. In this area, CIAT will increasingly emphasize strategic research, while at the same time assisting national and regional research partners to assume major responsibilities for applied and adaptive research.

As an ecoregional center, CIAT will assume responsibility for selected, important agroecosystems in Latin America. In close collaboration with other international, regional, and national institutions, CIAT proposes to develop integrated technology options for these agroecosystems from two different perspectives: (1) a macroscopic perspective that takes into consideration socioeconomic data, alternative land use patterns, and policy considerations; and (2) a microscopic perspective, focusing on soil/plant, plant/plant, and plant/animal interrelationships, and on how farmers manage these relationships. In its role as an ecoregional center, CIAT will seek to provide an international platform for participating institutions to develop a common research agenda in which the various participants can contribute according to their particular comparative advantages.

The above strategies are more fully defined in the strategic plan for the 1990s from a long-term perspective. The strategic plan also presents the objectives, outputs, expected impact, and assumptions for each program. More specific short-term objectives and outputs are described for each program in the respective chapters of this report.

Chapter 1, which follows, summarizes the center's strategies, its operational mandate, and the relative allocation of resources.

Chapter 1

CENTERWIDE STRATEGIES AND OPERATIONAL MANDATE

Germplasm development research aims at (1) characterizing and broadening the genetic base of selected commodities and (2) understanding the gene-governed mechanisms that determine plant adaptation and productivity in major production areas, including the tropical American ecosystems that were selected for intensive agroecological research. The goal is to develop the potential of germplasm resources for increasing their output and efficiency for using inputs. The germplasm development thrust will require feedback on germplasm performance and needs, particularly in multispecies systems. Germplasm development programs will benefit from integrated knowledge of the production environment, a systems focus, and prototype experience for use in other production environments.

Resource management research focuses on (1) important tropical American agroecosystems that are threatened by increasingly intensive land use or natural resource degradation and (2) those that may have potential for relieving such pressures. The aim is to understand the basic processes operating within agroecosystems in order to make agricultural production more sustainable. In its strategic plan, CIAT indicated the need to access expertise and commodity-focused agroecological knowledge built up at CIAT over the last twenty years. In the course of investigating technological options in the targeted ecosystems, resource management researchers will require guidance on CIAT's germplasm stocks, as well as those developed by CIAT's sister centers.

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

Box 1 shows the operational mandate that will govern CIAT's activities in the 1990s.

Box 1. 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.

Germplasm Development and Resource Management: An Integrated Approach

The pursuit of sustainable agricultural development, combining lasting increases in agricultural output with environmental preservation, requires reconciling the crucial trade-off between agricultural production and conservation of the natural resource base. In order to accomplish its mission, CIAT focuses on generating adoptable land use management practices that address trade-offs in a dual approach: germplasm development and resource management.

These two spheres of activity complement each other by independently and jointly contributing to three interrelated efforts. These efforts are being pursued in the development of CIAT's technological contribution to sustainable agriculture. They are (a) focusing on socioeconomic incentives, (b) efficiently using external inputs, and (c) developing environmental management techniques.

(a) The *socioeconomic incentives* approach deals with agriculture-related policies, land use strategies, and sectoral development plans affecting land use patterns across the landscape, as well as influencing farmers' decision making on choice of crops, resource allocation, and management techniques.

(b) The *efficient use of external inputs* in the production process seeks maximum efficiency in the utilization of available resources. Innovations will be based on understanding both gene-governed plant responses to external variables (abiotic/biotic) and ecological processes linking biotic and abiotic system components.

(c) The *environmental management* approach will focus on the effects of crop/soil and crop/crop interactions on soil structure/erosion and their effect on soil stability and hydrology. Integrated crop and pest management will be important complementary strategies.

This dynamic interaction between the two spheres of activity will be reflected in organizational areas that are linked not only by the exchange of materials and information but also by joint research activities. The essential flows are as follows:

* The Land Use Program provides agroecological and socioeconomic information that is relevant for the commodities.

* The Agroecosystems Programs provide a systems perspective and a systems understanding that allow the Germplasm Development Programs to focus their technology efforts.

* The Germplasm Development Programs provide the Land Use Program with commodity-specific information that allows for the development of alternative land use scenarios and analysis of the effect of policy changes.

* The Germplasm Development Programs provide the Agroecosystems Programs with information on feasibility of technical change for specific commodities in the relevant ecosystems, and tested components.

Box 2 further specifies the nature and types of linkages that will join the two principal spheres of activity.

Box 2. Linkages between Germplasm Development Programs (GDP) and Resource Management Research Programs (RMRP).

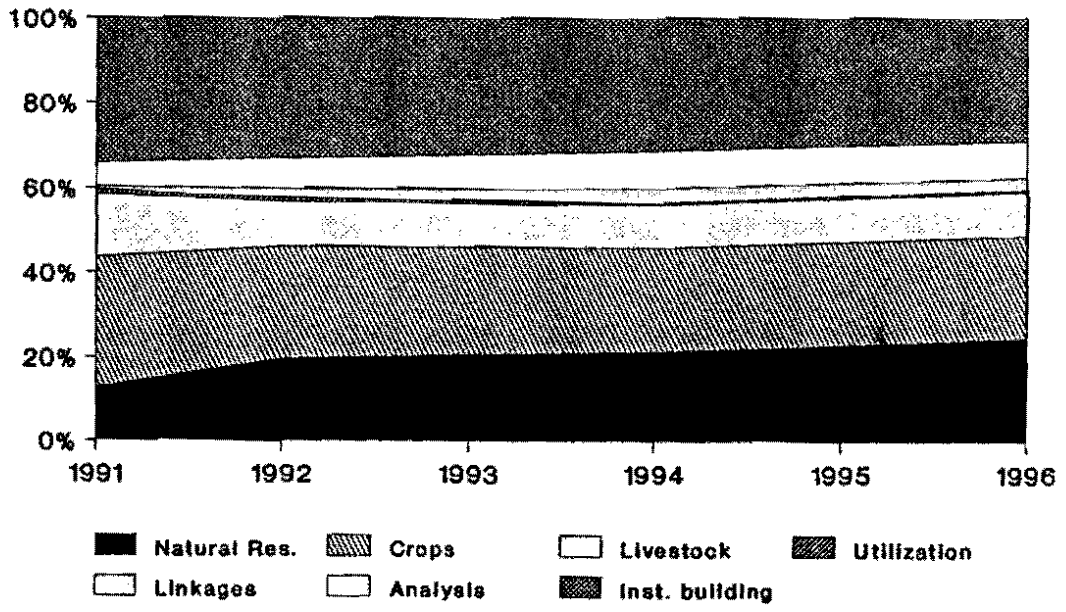
	Inputs provided by RMRP to GDP	Joint activities between GDP & RMRP	Inputs from GDP to RMRP	Inter-program monitoring & evaluation
Land Use Program	-Identification & description of principal crop ecosystems. -Data for assessing alternate strategies favoring different growing areas. -Agroecological data that will permit extrapolation of research results. -Determination of demand in different markets. -Characterization & quantification of physical, social, & economic indicators.	-Identification & prioritization of biophysical & macroeconomic constraints. -Identification of representative screening sites. -Genotype x environment interaction in relation to ecosystem analysis. -Analysis of commodity policy implications & requirements, e.g., for IPM in rice. -Assessment of implications of new plant types for land use patterns.	-Biophysical & socioeconomic parameters for defining major growing regions of crops, as well as their major comparative regional advantages. -Tolerance ranges of cultivars. -Crop-based farming systems information.	-Information on evolution of areas sown to given crop, productivity in selected areas, & market supply/demand. -Information to assess relevance of sets of characteristics needed in alternative & potential production areas & systems.
Agroecosystems Programs: * Hillsides * Forest Margins * Savannas	-Identification of crop- & ecosystem- specific constraints & desirable traits. -Participatory research techniques at the micro-socioeconomic level to identify farmer profiles, production practices & systems, & suitable technology options. -Socioeconomic analyses of specific crops. -Environmental limits of principal production areas, as well as potential input limitations. -Specific indicators of component competition & nutrient cycling. -Needs & opportunities for germplasm development & profile of needed cultivars.	-Design of plant ideotypes. -Development of crop/soil simulation models -Design, development, & validation of prototype production systems including specific crop under consideration & crop-specific technology components. -Assessment of role of given crop in critical nutrient cycling & sustainability facets. -Design of on-farm evaluation activities.	-Adapted germplasm & associated management technologies. -Information on potential of crop-specific technologies. -Physiological parameters indicating flexible points for management. -Test sites. -Test institutional & individual collaborators.	-Evaluation of results. -Evaluation of impact of technical change within commodity on rest of system. -Technical, social, & economic information for the design of better technology components.

Resource Requirements, Allocations, and Program Plans

Detailed information on the proposed allocation of resources is provided in Chapter 8, Summary and Analysis of Resource Requirements. Figure 1 compares the proposed resource allocations for the 1992-1996 period with the resource allocation patterns in 1991.

It can be seen that the trends confirm those outlined in CIAT's strategic plan in the 1990s. Noticeable is a considerable shift of resource allocation to resource conservation and management, reflecting the fact that a large portion of this new research effort is directly related to the activities subsumed under this category. The largest shift will take place in 1992 when CIAT proposes to launch the Resource Management Research Program. By 1996 this activity will claim 25% of the resources. Crop productivity research will diminish in relative terms as CIAT emphasizes strategic research in germplasm development. Research on human linkages (e.g., analysis of nutrition, sociocultural organization, understanding the gender issues) will increase slightly over time, as will socioeconomic and policy research in the area of resource management. The relative decrease in institution building and networking is largely due to a qualitative change in the relationship envisaged between national programs and CIAT. Now that significant corps of trained specialists are available in national programs, training in production and production-related subjects can be carried out at the country level. Traditional institution-building activities will give way to interinstitutional research endeavors based on individual comparative advantages.

Figure 1. Allocation of resources: 1991 (actual), 1992-1996 (proposed).



The presentation of program plans and associated resource requirements follows the organizational pattern that CIAT proposes to implement during the planning period. The two research thrusts--germplasm development and resource management--are presented first. Although the Tropical Forages Program (formerly the Tropical Pastures Program) appears with the other commodity programs in the Germplasm Development Division, organizationally it will be assigned to the Resource Management Research Division. Once the Tropical Forages Program has finished a series of medium-term research undertakings integral to the new Resource Management Research Division, the Program will organizationally join the other commodity programs in the Germplasm Development Division, probably at the end of the planning period, i.e., 1996.

Following the presentation of the two research divisions, the plans and resource requirements of research support and administration are discussed. This is followed by a separate section on capital requirements.

All resource requirements are stated in terms of core and complementary resources. Core resources are defined as those that are considered to constitute the minimal resources necessary to achieve the stated objectives. Complementary resources are those considered directly and highly relevant to the core effort, i.e., resources that will significantly accelerate progress toward achieving the objectives and/or permit the center to cover aspects of problem setting that are relevant but not sufficiently covered by core resources.

Chapter 2

GERMPLASM DEVELOPMENT DIVISION

Strategic research on the commodities in CIAT's mandate will focus on plant improvement over the next decade. Research during the 1970s and 1980s, conducted in collaboration with national programs, mostly at the applied level, has been effective in developing an excellent base from which to direct CIAT's germplasm improvement activities toward strategic research for the 1990s. CIAT's move into strategic germplasm research has been facilitated by the evolution in national programs over the last twenty years. The programs have strengthened their ability to conduct research directly related to their national needs. Regional research cooperation on the commodities has also been established, providing opportunities for horizontal collaboration in Asia and Latin America; and in Africa, with the International Institute of Tropical Agriculture (IITA), for cassava.

The commodity programs' mode of operation in the Germplasm Development Division is similar for all the programs, allowing for some economies of scale, particularly with respect to research support from the Germplasm Resources Unit (GRU), the Virology Research Unit (VRU), and the Biotechnology Research Unit (BRU). Centralized support facilitates the commodity programs' strategic research, particularly when exploiting modern biotechnology during the next decade.

The bases for each commodity program are the germplasm resources maintained by the GRU (except for rice, the collection of which is maintained at the International Rice Research Institute [IRRI]). Program research aims at genetic solutions for biotic and abiotic constraints, thereby increasing productivity. Yield potential will also be investigated. In all such research, modern biotechnology and plant physiology will play an important role.

The Germplasm Development Division will maintain very close research linkages with resource management research at CIAT, particularly through technology components that will provide the driving force for work in selected ecosystems. The research conducted by the commodity programs will have direct relevance to the resource management programs in that the technology developed by the former influences the ecological balance between the crop and its environment, thereby ensuring sustainable production in the longer term.

The philosophy of the commodity programs remains centered on the development of germplasm-based technology that is input-use efficient and adapted to less fertile conditions in tropical and subtropical developing countries. In general, CIAT's commodities are not widely grown on highly fertile soils, except for irrigated rice; but even there, input-use efficiency is becoming a critical issue in terms of sustainable production systems. The central theme of input-use efficiency within the context of less favorable production environments continues to be emphasized by CIAT. This particular philosophy is critical with respect to the complementarity of resource management and commodity research.

This operational plan describes CIAT's work. As a center that follows the ecoregional concept, CIAT has also hosted regional programs from other centers in the Consultative Group on International Agricultural Research (CGIAR) and similar organizations. These hosted programs, while having a more general mandate in accord with their own institutional strategies, contribute to CIAT's work through technologies focused on areas where this center has particular interest. The Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), along with its regional Andean program, has major responsibility for developing maize for acid soils. The International Sorghum and Millet Program (INTSORMIL), another hosted program, has had a successful record of sorghum research for acid soils. CIAT also hosts regional coordination activities of the International Board for Plant Genetic Resources (IBPGR) for South America and activities of the International Fertilizer Development Center (IFDC). In this way, these centers and others can contribute to the objectives of an ecoregional approach as embodied in CIAT's strategic plan.

The following operational plans describe the research activities to be conducted by the four commodity programs over a period of five years, beginning in 1992. Each program describes its strategies and objectives, reflecting CIAT's strategic plan for the 1990s. This is followed by a synthesis of activities to be conducted in response to the basic strategies and objectives. The linkages to be established between the Germplasm Development and Resource Management Research Divisions are clarified. In addition, linkages to advanced research institutions in developed and developing countries are discussed, particularly complementary activities in soybean and sorghum research for the acid-soil savanna ecosystems in tropical and subtropical Latin America.

Bean Program

Goal

To make a lasting increase in food availability and incomes of the poor by improving bean productivity through technology developed in collaboration with national institutions.

Strategies

Strategic research will increase as national programs' capacity for adaptive research grows. The focus will be on genetic improvement and crop management research to meet the needs of resource-poor farmers. Advances in molecular biology will be exploited to solve practical problems of genetic improvement. Germplasm enhancement will be emphasized to achieve major strategic breakthroughs and to provide parental materials for national program breeding. In the interim, CIAT's breeding of advanced lines will be phased out. Greater attention will also be given to raising yield potential and overcoming edaphic stresses.

The new CIAT Hillsides Program will assume prime responsibility for crop management research in bean-based systems in the Andean and Central Andean regions. Finally, as national capacity develops, CIAT will gradually reduce its training and institutional development activities, although Africa will continue to receive priority attention.

Objectives and Activities

The program has five broad objectives, each of which is discussed with its corresponding activities and expected outcomes.

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

Rapid advances in molecular biology offer substantial opportunities for applying novel methods for the more efficient identification and transfer of useful genes, both within common beans and from related species. Advanced laboratories, mostly in industrialized countries, are primarily engaged in basic research that constitutes the foundation of these new methods.

CIAT will interact with these laboratories through the formation of a network of advanced research on beans. The network will direct researchers to utilize beans as a model system and devote attention to priority bean problems.

CIAT's Biotechnology Research Unit (BRU) will play a key role in bringing advances in basic science to CIAT, and at the same time conduct strategic research to develop new methods. The Bean Program will apply these methods to solve priority problems that limit bean productivity and will assist in their adaptation for bean improvement.

The application of molecular techniques is intimately linked to a strong commitment to field breeding. Classical breeding is essential not only for identifying desired characters and understanding their genetic control but also for the agronomic evaluation of new variability. Thus field activities for germplasm enhancement will focus more on character improvement and much less on cultivar improvement, which will increasingly become a responsibility of the national programs.

Activity 1. Characterize patterns of genetic variability in beans through the use of molecular markers, field evaluations, and inheritance studies

Emphasis will be placed on, first, primary gene pools of cultivated *Phaseolus vulgaris*; second, wild ancestors of *P. vulgaris*; and third, cultivated relatives (*P. acutifolium, P. coccineus, P. lunatus*, and *P. polyanthus*).

The Bean Program will be primarily responsible for germplasm evaluation; the BRU, for methods development; and the GRU, for acquisition of germplasm and its conservation, including the development of improved conservation methods. This ongoing activity will continue at a high level until the mid-1990s, when it will be scaled down.

Activity 2. Develop a saturated bean genome map in collaboration with advanced research laboratories and the BRU

The program will focus on the use of probes to tag genes associated with desired traits. This will assist in pyramiding multiple characters. Probes will be developed both for use by national program breeders and for internal applications. This activity will increase during the early 1990s.

Activity 3. Adapt regeneration and transformation systems to solve priority bean problems

By the mid-1990s, protocols developed in advanced laboratories and by the BRU should be ready for application by the program. Priorities include refining and applying

regeneration and transformation systems; isolating and transferring desired genes not easily introgressed through classical techniques; and achieving stable gene expression in the progeny of transgenic plants. Known traits that are candidates for transfer include resistance or tolerance of Ascochyta (from *P. polyanthus*); drought (*P. acutifolius*); leafhopper (*P. lunatus*); and bean fly (*P. coccineus*).

Objective 2. Reduce losses to diseases and pests

Improved genetic resistance to major diseases and pests is key to an integrated approach to sustainable management of diseases and pests of economic importance. Both molecular biology tools and conventional field work will be used to identify, understand, and exploit desirable disease and pest resistance mechanisms, as well as to understand pathogen and pest diversity as it interacts with host resistance in beans. The VRU will continue to provide needed support on viral pathogens.

Activity 1. Broaden the genetic base of resistance

Because many biotic stresses are highly variable and resistance to some diseases and pests is not available, the identification of new and additional resistance sources and their transfer to useful backgrounds are urgently needed.

Activity 2. Improve understanding of pathogenic and pest variability, including its coevolution with beans

Such an understanding will permit more effective deployment of resistance genes to improve sustainability. Increased knowledge of the biology of major diseases and pests in Africa is a high priority.

Activity 3. Contribute to the development of integrated control strategies

The growing abuse of pesticides by small farmers throughout tropical America and even in some cases in Africa is becoming an ever more serious economic and environmental problem. The program will develop, together with national programs, sustainable integrated management strategies that complement genetic resistance and reduce pesticide use.

Objective 3. Increase yield potential

Increased bean yield potential in the absence of stress is essential to maintain competitiveness in Brazil and Mexico, which together account for over one-third of the world's bean consumption. The yield potential for beans has not yet increased as much as for other more intensively researched crops.

Activity 1. Identify yield-maximizing optima for physiological traits, including nitrogen partitioning, canopy morphology, and photoperiod and temperature adaptation

Activity 2. Exploit genetic variation across gene pools while breaking undesirable linkages. By 1995, molecular biology techniques may be utilized

Activity 3. Extend maturity of bush beans to increase biomass, and then improve harvest index and plant architecture

Activity 4. Modify growth habits of preferred large-seeded grain types, and at the

same time extend the range of adaptation of climbing beans

Objective 4. Improve adaptation to edaphic stresses

Soil fertility is declining in a high proportion of bean-based crop systems because of the crop's expansion onto marginal lands, shortened fallow periods, soil erosion, and, especially in Africa, high costs or limited availability of inorganic and organic fertilizers. Improved biological nitrogen fixation (BNF)--the top priority--can make an important contribution to more sustainable agricultural systems.

The program's strategy focuses on increasing the efficiency of nutrient and water utilization by the bean plant, taking into account the fact that many farmers will find it economically advantageous to amend their soils.

Efforts in abiotic research will be increased over this period. The synergistic interaction between the program's expertise in plant nutrition and BNF and that of CIAT's Resource Management Division in soils and nutrient cycling will be critical to the program's success.

Activity 1. Improve BNF in beans

Traits in bean genotypes associated with improved BNF will be identified and combined in suitable backgrounds. Inheritance studies will be conducted to choose efficient breeding methods, and screening methods will be developed.

Rhizobium phaseoli germplasm will be collected and characterized. Broadly adapted, competitive, and effective *R. phaseoli* strains will be selected. As *R. phaseoli* traits that contribute to competitiveness and effectiveness are identified, they may be combined in a program of genetic improvement.

Activity 2. Improve adaptation to water stress, phosphorus deficiency, and aluminum toxicity

Genetic variation for these characters will be evaluated and the physiological traits involved will be studied. Screening methods and optimal breeding strategies will be developed. Desired traits will be combined in useful backgrounds and made available to national breeding programs. The effect of vesicular-arbuscular mycorrhizae (VAM) on phosphorus nutrition will be assessed.

Objective 5. Strengthen national capacity to improve bean productivity

National research and extension institutions are the key actors in improving bean productivity. Progress in this respect depends principally on national efforts.

Many national programs have trained a minimal cadre of bean researchers with CIAT's assistance. Moreover, their efficiency has increased through their participation in regional networks established by CIAT in the Andean region, Central America, eastern and southern Africa, and the African Great Lakes Region.

The strategy for the 1990s must build on progress already achieved by the national programs and regional networks. As these institutions strengthen, the nature of CIAT's input will change, and its overall efforts will decrease.

Activity 1. Facilitate stronger links among national research institutions, extension

agencies, universities, nongovernmental organizations, and the seed sector

Improved productivity at the farm level requires that research be articulated with other activities. The Institutional Development Support Program (IDSP) and the Bean Program will encourage the strengthening of these linkages at the national level. National and regional institutions will be assisted to become self-sufficient in training on-farm researchers, technicians, and extension workers.

Activity 2. Foster more autonomous operation of regional networks

These networks provide national programs with the opportunity for joint planning and implementation of research, training, and germplasm and information exchange. They also encourage the sharing of responsibilities among national programs and effective tapping of regional expertise. CIAT's coordinating role will gradually decrease so that, by the end of the decade, the Bean Program will be a peer member rather than the coordinating hub of the networks.

Activity 3. Provide specialized training for mid-career bean scientists.

Strategic Priority: Africa

Although Latin America remains the world's largest producer and consumer of beans, it is in the highlands of eastern and southern Africa that beans make their greatest contribution to nutrition. Despite the fact that demand for beans is growing fastest in that area, growth in production is drastically lagging. Consequently, a major effort is being undertaken to improve bean productivity in Africa.

Strategic research at CIAT headquarters in Colombia contributes directly to overcoming worldwide disease problems, improving BNF, coping with edaphic stresses, and increasing yields. Nonetheless, strategic research is also required to address major regional constraints in Africa, including, for example, the different species of bean flies, scab, and local strains of bean common mosaic virus (BCMV) and halo blight. Fertility maintenance in African cropping systems also poses unique challenges.

In addition to this strategic research, CIAT is utilizing complementary resources to strengthen regional institutions, train national scientists, and assist in applied research. Emphasis is placed on fostering regional networks to maximize coordination and mutual assistance among national programs facing common problems. Although training is oriented toward research scientists, on-farm research capacity is encouraged, and research/transfer linkages are reinforced.

Although core staff would be concentrated at one location, these complementary activities would be decentralized in accordance with national program needs. Complementary activities in crop systems research, socioeconomics, and training would be undertaken in close collaboration with other CGIAR entities in the region.

Resource Allocation and Requirements

The expected evolution of resource utilization in the Bean Program during 1992-1996, expressed in terms of "activities" as defined by the CGIAR (see Appendix), appears in Table 1. Table 2 shows the Senior Staff positions scheduled for executing the Bean Program's operational plan during the same period.

Table 1. Bean Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	–	2.0	2.0	–	–	2.0	3.0	–	–	4.0	4.0	–
6. Soils, conservation and management	–	1.5	1.5	–	–	3.0	2.0	–	–	4.0	2.0	–
II. Crop productivity research												
1. Germplasm improvement												
a. Varietal development	0.5	6.0	9.0	0.5	0.5	5.0	6.0	0.5	0.5	4.0	3.0	0.5
b. Germplasm enhacement	0.5	5.0	6.0	0.5	0.5	6.0	11.0	0.5	0.5	10.0	16.0	0.5
2. Crop systems	–	1.0	1.0	–	–	0.5	0.5	–	–	–	–	–
3. Plant protection	–	5.0	11.0	–	–	6.0	9.0	–	–	6.0	8.0	–
4. Plant nutrition	–	2.0	5.0	–	–	3.0	6.0	–	–	5.0	6.0	–
5. Seed technology and production	–	–	2.0	–	–	1.0	2.0	–	–	1.0	–	–
VIII. Socioeconomic and policy research												
1. Economic and social analysis at micro level	–	2.0	2.0	–	–	2.0	1.0	–	–	1.0	1.0	–
2. Market analysis	–	1.0	1.0	–	–	0.5	0.5	–	–	0.5	0.5	–
4. Research on impact	–	1.0	2.0	–	–	0.5	2.5	–	–	1.0	1.0	–
IX. Institution building and networking												
1. Training	–	7.0	6.0	–	–	7.0	5.0	–	–	5.0	4.0	–
3. Documentation and dissemination of information	–	2.0	2.0	–	–	2.0	2.0	–	–	2.0	2.0	–
5. Strengthening national research systems	–	3.0	3.0	–	–	3.0	2.0	–	–	2.0	2.0	–
6. Networks	–	3.0	3.0	–	–	3.0	1.0	–	–	2.0	1.0	–
Total	1.0	41.5	56.5	1.0	1.0	44.5	53.5	1.0	1.0	47.5	50.5	1.0
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 2. Bean Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Headquarters												
Office of Leader	1	297	1	297	1	297	1	297	1	297	1	297
Breeding (Black-seeded)	1	228	1	228	–	–	–	–	–	–	–	–
Breeding (Small, colored)	1	274	1	274	–	–	–	–	–	–	–	–
Breeding (Large-seeded)	1	199	1	199	–	–	–	–	–	–	–	–
Germplasm enhancement (Andean Region)	–	–	–	–	1	233	1	233	1	233	1	233
Germplasm enhancement (Mesoamerica)	–	–	–	–	1	234	1	234	1	234	1	234
Genetics	–	–	–	–	1	234	1	234	1	234	1	234
Applied biotechnology	–	–	–	–	–	–	–	–	–	–	1	184
Pathology	1	241	1	241	1	241	1	241	1	241	1	241
Entomology	1	189	1	189	1	189	1	189	1	189	1	189
Microbiology	1	152	1	152	1	152	1	152	1	152	1	152
Plant nutrition	1	164	1	164	1	164	1	164	1	164	1	164
Physiology	1	189	1	189	1	189	1	189	1	189	1	189
Cropping systems	1	150	–	–	–	–	–	–	–	–	–	–
Agronomy (international trials)	1	244	1	244	1	244	1	244	1	244	1	244
Economics	1	163	1	163	1	163	1	163	0.5	120	0.5	120
Outposted												
Africa – Pan-African coordination	1	252	1	252	1	252	1	252	1	252	1	252
Africa – Germplasm improvement	1	252	1	252	1	252	1	252	1	252	1	252
Africa – Plant protection	1	252	1	252	1	252	1	252	1	252	1	252
Africa – Fertility management	1	251	1	251	1	251	1	251	1	251	1	251
Africa – Cropping systems	1	215	–	–	–	–	–	–	1	–	–	–
Africa – Economics	1	215	–	–	–	–	–	–	1	–	–	–
Africa – Social science	1	215	–	–	–	–	–	–	1	–	–	–
Central America – Regional coordination	1	318	1	318	–	–	–	–	1	–	–	–
Central America – Germplasm improvement	–	–	–	–	1	318	1	318	1	318	1	318
Southern Cone – Regional coordination	1	184	1	184	1	184	1	184	1	184	–	–
Andean Region – Regional coordination	1	254	–	–	–	–	–	–	1	–	–	–
Total	22	4,898	17	3,849	17	3,849	17	3,849	21.5	3,806	16.5	3,806

Description of Senior Staff Positions

Office of Leader. Provides overall guidance and coordination in design of interdisciplinary, interinstitutional research and training; principally responsible for developing and implementing strategies for research and institutional strengthening, and for coordinating activities with national programs and other CIAT organizational units.

Breeding (black-seeded). Develops advanced lines and populations in small-seeded black bush beans; assists national program breeding in southern Brazil, Central America, and coastal Mexico. Priority on overcoming major production constraints in these regions, including bean golden mosaic virus, bacterial blight, and web blight.

Breeding (small, colored). Develops advanced breeding lines and populations in colored, small-seeded bush beans; assists national program breeding in central Mexico, northeast Brazil, and West Asia-North Africa. Priority on overcoming major production constraints in these regions, including anthracnose, angular leaf spot, and water deficits.

Breeding (large-seeded). Develops advanced breeding lines and populations in colored, large-seeded bush and climbing beans; assists national program breeding in the Andean region and sub-Saharan Africa. Priority on overcoming major production constraints in these regions, including halo blight, BCMV, and Ascochyta.

Germplasm enhancement (Andean region). Develops methods and parental materials for use by national breeders, principally in Africa and the Andean region, with emphasis on adaptation and yield, especially in climbers, BNF, tolerance to low-fertility soils, and resistance to subtropical diseases and pests. Conducts genetic studies to design breeding strategies, introduces useful traits from other gene pools, and obtains high expression of desirable characters from within a gene pool.

Germplasm enhancement (Mesoamerica). Develops breeding methods and parental materials for use by national breeders, principally in Central America, Brazil, Mexico, and Africa, with emphasis on yield and architecture, tolerance to water deficits, and resistance to tropical diseases and pests. Introgresses desirable characters from other gene pools, develops high expression of useful traits from within a gene pool, and undertakes genetic studies to design efficient breeding strategies.

Genetics. Improves understanding of *Phaseolus* gene pool through development of molecular markers, contributing to construction of saturated maps; and then uses these markers, including RFLPs (DNA restriction fragment length polymorphisms), in combination with the program's ongoing agronomic evaluations of resistance to diseases and pests, tolerance to nutrient stresses, and improved BNF. Helps pyramid desirable traits and encourages use of markers by CIAT and national programs.

Applied biotechnology. Broadens genetic base of the common bean through transfer of traits principally from within the *Phaseolus* genus and potentially from exotic sources; applies embryo rescue, in vitro culture, regeneration, and transformation systems to exploit specific traits identified in other *Phaseolus* species such as drought tolerance, efficient use of phosphorus, and resistance to Ascochyta, leafhoppers, and bacterial blight.

Pathology. Works closely with breeders and biotechnologists to identify, study, and use

durable disease resistance mechanisms; monitors and improves understanding of pathogen diversity as relates to host resistance; emphasizes identification and utilization of the broadest genetic diversity in the bean plant. Develops methodologies, emphasizing pathogen diversity and screening.

Entomology. Works to overcome global pest constraints, including leafhoppers and bruchids, and regional pest constraints in the Americas, i.e., pod weevil, whiteflies, and leaf miners. Major priorities are host-plant resistance and increased assistance to national programs in devising integrated control systems.

Microbiology. Improves plant nutrition through symbiosis with soil microorganisms; focuses on identifying plant traits associated with good BNF and develops screening methods; supports CIAT and national program breeding activities to combine BNF and associated components in appropriate genotypes; selects competitive and highly effective *Rhizobium* strains for final testing as inoculants at regional and national levels; and assesses potential--for use and manipulation--of other plant-growth-promoting microorganisms, such as VAM and *Pseudomonas* sp.

Plant nutrition. Develops screening methodologies to identify superior genetic adaptation to edaphic constraints; studies physiological mechanisms conferring such adaptation; develops appropriate agronomic technologies to sustain or improve fertility of bean production systems.

Physiology. Characterizes physiological factors limiting yield potential; develops screening methodologies to identify superior yield potential and genetic adaptation to meteorological constraints (drought, flooding, chilling, and high temperatures); elucidates physiological mechanisms conferring superior yields and adaptation to meteorological constraints; and develops agronomic technologies to improve bean yields in favorable bean production systems.

Cropping systems. Conducts research and assists national programs to prioritize production constraints, orient technology design, and evaluate prototype technology on-farm with farmer participation in order to develop more productive, sustainable bean production systems.

Agronomy (international trials). Designs and operationalizes ecologically stratified global network of germplasm evaluation and exchange; characterizes genetic-by-environmental interactions in order to refine targeting of germplasm; develops database on germplasm performance; assists national programs in managing genetic-by-environmental interactions, especially in agroecosystems not covered by CIAT's RMRPs.

Economics. Monitors world bean production and consumption trends; defines priorities for bean research; conducts micro-level assessments of technological changes in bean production and consequences for research directions; assists national programs in evaluating participatory experiments; and coordinates and supports impact and adoption studies.

Africa-Pan-African coordination. Coordinates research, training and information, and germplasm exchange activities in Africa; liaises with national program research directors to ensure consistency of CIAT's activities with national and regional priorities; liaises with regional networks and steering committees for effective articulation and coordination among

regional networks; plans and supervises regional research and training activities.

Africa-Germplasm improvement. Identifies sources and studies genetics of resistance to major African biotic constraints; develops populations, parents, and methods for combining multiple traits for utilization by African breeders; and develops strategies for improving traditional mixtures. Emphasis on bean fly, scabs, and African strains of BCMV and halo blight.

Africa-Plant protection. Leads strategic research and assists national programs in overcoming major disease constraints, focusing on problems unique to the region such as BCMV, angular leaf spot, halo blight, and anthracnose, as well as scab, which is not present in the neotropics; characterizes pathogen diversity; develops screening techniques; and appraises management strategies with emphasis on deploying genetic mixtures.

Africa-Fertility management. Conducts strategic research in the region and assists national programs in fertility management in bean-based cropping systems; characterizes major fertility constraints and appraises effect of farmers' practices on nutrient cycling and erosion; and designs improved fertility management systems integrating adapted bean genotypes and improved BNF into multicrop and agroforestry systems to improve sustainable bean productivity.

Africa-Cropping systems. Conducts strategic research on improving overall productivity of bean-based polyculture systems including intercropping with maize, bananas, cassava, and sorghum; assists national programs in designing cultural practices to increase system productivity and sustainability; and assesses interactions between bean genotype and cropping system.

Africa-Economics. Studies African bean production systems and their amenability to improved bean production technology; takes active role in testing improved technologies and their transfer to national programs, and executes adoption studies; monitors interactions between bean production technology research and resource management research.

Africa-Social science. Conducts research and develops methods to assist national programs in adjusting technology design and evaluation to objectives and needs of African growers; emphasizes farmer participation in research and facilitates farmer feedback to scientists on technology design parameters and performance.

Central America-Regional coordination. Facilitates regional planning and implementation of research, training, and information exchange activities; and supports development of regional coordinating institutions with a view to the future devolution of this function.

Central America-Germplasm improvement. Conducts strategic research on major regional problems, emphasizing those not easily researchable at CIAT, including BGMV, pod weevil, Mn, toxicity and low P; coordinates generation and distribution of genetic variability in the region; and assists national programs and the regional network.

Southern Cone-Regional coordination. Assists national programs in bean improvement while conducting strategic research on major regional problems, including Brazilian strains of BGMV, Al

toxicity, low P, and water deficits; and coordinates generation and distribution of genetic variability in the region.

Andean region-Regional coordination. Facilitates regional planning and implementation of research, training, and information exchange activities; supports development of regional coordinating institutions with a view to the future devolution of this function.

Complementary Activities

The Bean Program proposes to complement its core activities with a series of Senior Staff positions which are to accelerate progress at the regional level. Table 3 shows the financial resources implied by these complementary activities. The Senior Staff positions involved are the following:

Africa-Cropping systems. See description, p. 19.

Africa-Economics. See description, p. 19.

Africa-Social science. See description, p. 19.

Africa-Entomology. Conducts strategic research and assists national programs in dealing with regional pest problems. Emphasizes the development of methods to improve host-plant resistance; priorities include the bean fly species complex, aphids, and oothecae.

Africa-Breeding, biotic constraints. Assists national programs in their applied breeding and conducts strategic research to develop breeding lines and segregating populations with improved adaptation and multiple disease and pest resistance; introduces and evaluates germplasm from CIAT HQ and elsewhere. Primarily responsible for increasing the levels of resistance to bean fly and incorporating BCMV and halo blight resistance into elite African breeding lines and commercial cultivars.

Africa-Breeding, abiotic constraints. Conducts strategic research and assists national programs in developing breeding lines and populations with improved adaptation to water deficits and low-fertility soils (including low P and high Al), and with improved BNF.

Africa-Agronomy. Assists national programs in conducting strategic research on crop management in bean-based cropping systems, focusing on optimal management of bean genetic mixtures, disease and pest control, and fertility management.

Snap bean breeding. Develops improved parents, populations, and lines with better adaptation to tropical conditions and stresses; works with both bush and climbing bean types to improve disease resistance and productivity; maintains product quality; develops worldwide networks for snap bean germplasm and information exchange; and assists national programs in selected countries.

Andean region-Regional coordination. See description above.

Andean region-Agronomy. Conducts research and assists national programs to prioritize production constraints, orient technology design, and evaluate prototype technology on-farm with farmer participation in order to develop more productive, sustainable bean production systems in the region.

Bean biotechnology network. Jointly coordinated by the Bean Program, the BRU,

Table 3. Bean Program. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Africa – Cropping systems	–	–	1	300	1	300	1	300	1	300	1	300
Africa – Economics	–	–	1	245	1	245	1	245	1	245	1	245
Africa – Social science	–	–	1	300	1	300	1	300	1	300	1	300
Africa – Entomology	1	360	1	360	1	360	1	360	1	360	1	360
Africa – Breeding, biotic constraints	1	360	1	360	1	360	1	360	1	360	1	360
Africa – Breeding, abiotic constraints	1	360	1	360	1	360	1	360	1	360	1	360
Africa – Agronomy	1	360	1	360	1	360	1	360	1	360	1	360
Africa – Breeding	1	360	1	360	–	–	–	–	–	–	–	–
Biotechnology network	–	–	–	300	–	300	–	300	–	300	–	300
Snap bean breeding	–	–	–	–	1	255	1	255	1	255	1	255
Andean Region – Regional coordination	–	–	1	254	1	254	–	–	–	–	–	–
Andean Region – Agronomy	1	150	–	–	–	–	–	–	–	–	–	–
Central America – Network	–	562	–	–	–	–	–	–	–	–	–	–
Phaseolus germplasm	–	217	–	120	–	–	–	–	–	–	–	–
Total	6	2,729	9	3,319	9	3,084	8	2,840	8	2,840	8	2,840

and participating institutions. Starting in 1992, it is expected to function for five years. Its aims are to identify new initiatives in bean-related biotechnology; coordinate activities such as scientific meetings, training of national program scientists, and communications; and provide financial support for initiating or continuing research projects that will advance bean biotechnology.

Soybean research. As described for the Savanna Program (see Agroecosystems Programs), CIAT will be engaging in soybean research in cooperation with national programs. The Bean Program will be able to provide support for this effort, which is specifically focused on germplasm for acid soils.

Expected Outputs

The expected output of the Bean Program can be assessed both in terms of projected impact at the farm level and progress in intermediate research products aimed at increasing research efficiency and output.

In comparison to 1990, it is projected that by 1996 from 70 to 85 new varieties with CIAT-identified genes or parentage will have found their way into commercial production by small farmers (around 12% of the world bean area). If historic trends continue, each of these varieties can be expected to be planted on an average area of 10,000 ha, contributing a value of roughly US$1 million to the yearly impact of the program. This would then suggest that by 1996 the program would have achieved an additional US$70 million of yearly impact, for a yearly total of US$120 million. Even if the area planted or the yield advantage per variety falls, it is safe to expect a yearly impact of more than US$100 million per year by 1996. This impact refers only to genetic improvement and does not consider impact through management practices.

Specific outputs in relation to the program's five objectives are as follows:

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

* More efficient breeding
* Applied molecular techniques for plant modification
* Identification of sources of useful traits
* Transgenic parental material for use in breeding

Objective 2. Reduce losses to diseases and pests

* Increased diversity of sources of resistance in parental materials
* Improved knowledge of diseases and pests
* Targeted gene deployment for more sustainable resistance
* Modeling of integrated control strategies for major pests and diseases

Objective 3. Increase yield potential

* Improved knowledge of physiology and genetics of yield potential
* New plant types with increased yield potential, suitable as parents for national program breeding

Objective 4. Improve adaptation to edaphic stresses

* Bean genotypes enhanced for BNF
* Selected, improved strains for symbiosis

* Parental material adapted to edaphic stresses

Objective 5. Strengthen national capacity to improve bean productivity

* More effective national research and technology transfer
* Efficient horizontal transfer of skills and technologies in regional networks
* Increased effectiveness of national scientists

Cassava Program

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.

Objectives

The Cassava Program seeks to achieve its goal through interacting with its partners in a global network dedicated to the promotion of cassava as an important rural and urban food and to the development of new forms of utilization suitable for changing economic circumstances. Within this context, the program pursues four basic objectives:

* Improve productivity and yield stability of cassava genetically

* Develop crop management practices for sustainable cassava production in selected agroecosystems

* Improve the quality of cassava for diverse end uses

* Strengthen the research and technology transfer capabilities of national cassava R & D systems

Strategies and Corresponding Activities

The following three strategies are contemplated to achieve the above objectives: strategic research, institution strengthening through regional activities, and supporting African programs by collaborating with IITA.

Strategy 1. Conduct strategic research at headquarters (HQ).

Strategic research is carried out at HQ by an interdisciplinary team. The principal areas of activity are management of the world's cassava germplasm collection; research contributing to the body of knowledge on the crop; and development of component technologies, including improved varieties, crop management practices, and utilization and marketing alternatives. These activities are carried out in close cooperation with the GRU, BRU, VRU, Resource Management Research Division, and Institutional Development Support Program (IDSP). Links with advanced laboratories are maintained and fostered through the Cassava Biotechnology Network (CBN).

Three areas of activity are contemplated: germplasm management, building the knowledge base, and developing component technologies.

Activity 1. Germplasm management

This includes the collection, conservation, characterization, and documentation of cassava and wild *Manihot* species. In

collaboration with the GRU, the following activities will be carried out:

* Incorporation into the germplasm collection of additional existing Latin American and Asian materials and new accessions collected in field expeditions, mainly in Brazil

* Selection and study of representative subsets of the collection as a means of streamlining the conservation and characterization of genetic variation within *M. esculenta*

* Establishment of a wild *Manihot* collection and evaluation of its potential contribution to cassava improvement

* Continued, more precise characterization of cassava germplasm including agronomic, biochemical, and molecular traits

Activity 2. Building the knowledge base

This activity generates widely applicable knowledge about cassava that can be subsequently employed to develop component production and utilization technologies. In coordination with the BRU, VRU, CBN, and Land Use Program, the following activities will be undertaken:

* Refinement of diagnostic methods for gender-sensitive characterization of client groups (farmers, processors, consumers) as a means of defining research needs and priorities

* Refinement of the physical, biological, and socioeconomic definitions of cassava-growing environments to facilitate region prioritization for targeted development of germplasm, crop management, and utilization technology

* Crop physiology research on:

  - Manipulation of the unique cassava photosynthetic system as a means to improve production

  - Mechanisms of drought tolerance; effects of drought tolerance on other agronomic traits; and feasibility of pyramiding water-use efficiency mechanisms for maximizing drought tolerance through breeding

  - Temperature and photoperiod interactions for cassava production in the subtropics

  - Development of more effective screening methods for nutrient-use efficiency and basic research on the physiological mechanisms operating in efficient genotypes

* Root quality studies on:

  - Development of selection methods for specific root-quality traits such as low hydrogen cyanide (HCN) and use-dependent amylose/amylopectin ratios

  - Identification of the physicochemical root tissue characteristics that determine good eating quality

  - Investigation of HCN's role in pest and pathogen resistance and the perceived relation between HCN content and quality characteristics (e.g., texture) of some cassava products in order to weigh the

benefits of cyanogenesis against its costs

* Crop protection research on:

  - Biology and ecology of important but still under-researched arthropod pests, root-rot pathogens, viruses and their vectors, and mycoplasmalike diseases; also on pest and pathogen problems in dried, stored cassava

  - Pest and disease tolerance mechanisms, with emphasis on those that operate against more than one pest or pathogen

  - Methods for detecting resistance/tolerance breakdown

  - Screening of wild cassava species for sources of resistance to recalcitrant organisms such as mealybugs and root-rot fungi

  - Interactions among host-plant resistance, cultural practices, and biological control to optimize the effectiveness of crop protection technologies

* Interactions of genotype with major cropping system components, such as tillage methods, intercropping, fertilization, and weed control practices, for more effective selection based on farmers' needs

Activity 3. Development of component technologies

Sound knowledge of the crop and the environments in which it is grown is the basis for developing component technologies. Three areas of technology development can be identified: genetic improvement, crop management, and utilization and market research.

* *Genetic improvement* activities will include:

  - Continued development of broadly based gene pools targeted to regional needs

  - Provision of basic and improved germplasm in seed and vegetative form to complement national program genetic improvement methodology research

  - Incorporation of molecular tools and methodologies resulting from activities developed by the CBN

  - Interdisciplinary activities for determining the feasibility of commercial production of cassava from true seed

  - Basic genetic and breeding methodology research

* *Crop management* tends to be location specific; however, certain components can be applied over a broad range of conditions. Research in this area is undertaken mostly in close collaboration with national programs in specific but representative sites. Activities cover:

  - Further development of soil fertility management and erosion control practices in selected ecosystems

  - Integrated pest and disease management, emphasizing root-rot

pathogens, the chinch bug, and dry-season pests such as mites, mealybugs, and whiteflies

- Rotation and mixed cropping of cassava with other species, focusing on the evaluation of new varieties of cassava and associated crops across different environments

- Integration of soil fertility and erosion management, crop protection, and cropping systems research to ensure efficiency and effectiveness of new technology

* *Utilization and market research* has been key to obtaining impact through identifying and developing alternative uses for cassava. Although CIAT's core resources dedicated to this area will be reduced as research on quality-related activities is increased, close links with the National Resources Institute (NRI) in London and the Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical (CEEMAT) in Montpellier will be maintained through the hosting of visiting scientists from these institutions to work on process and product development issues of mutual interest. During the planning period, the principal activities in this area will include:

- Identification of appropriate national institutions with which to undertake and integrate market and consumption, processing, and quality research aimed at developing cost-competitive, consumer-acceptable products

- Monitoring of advances in cassava processing and product development by other research institutions

- Continued input into R & D of appropriate cassava flour and starch processing technology with developed- and developing-country institutions

Strategy 2. Strengthening national programs through regional activities

The results of HQ research are integrated into the activities of national cassava R & D programs in the Americas and Asia through collaborative projects, regional networks, and staff training. These activities provide important feedback to orient HQ research. The program maintains an Asian regional office in Bangkok. In the Americas, activities with national programs are handled through HQ.

The Cassava Program and the IDSP act together in a number of ways to strengthen and support national cassava R & D systems:

Activities. The priority activities in this area will be:

* Continued information exchange through *Abstracts on Cassava*, *Cassava Newsletter*, and regional conferences and seminars

* Joint generation of knowledge and technology with national programs, emphasizing genetic improvement, crop management, and utilization and market research

* Assistance to national programs in the design and organization of integrated cassava R & D projects

* Development of appropriate cassava seed-supply systems

* In-service, discipline-oriented training in advanced research techniques

* Intensification of efforts in:

  - Training of trainers
  - Improving diagnostic skills
  - Developing cassava research methods
  - Conceptualization, formulation, execution, and evaluation of integrated cassava projects

* Continued support for the consolidation of existing collaborative regional research and information networks, as well as the establishment of new ones

* Ex ante and ex post analyses of impact for priority setting at national and Cassava Program levels

Strategy 3. Supporting African national programs through collaboration with IITA

The program maintains close liaison with IITA on the research needs for cassava in Africa. This liaison is achieved through the stationing of a CIAT/IITA scientist at IITA HQ. The centers collaborate to support African national programs through the following principal activities:

Activities

* Introduction from the Americas, and subsequent evaluation and selection, of germplasm appropriate for the principal cassava agroecosystems in Africa

* Classical biological control of mealybug and cassava green spider mite

* Development of a varietal screening methodology for tolerance to water stress

* Participation in collaborative socioeconomic studies of cassava in Africa

Resource Allocation and Requirements

Table 4 shows the expected evolution of resource utilization in the Cassava Program during 1992-1996. This resource utilization is shown in terms of "activities" as defined by the CGIAR (see Appendix).

Table 5 shows the Senior Staff positions required for executing the Cassava Program's operational plan during 1992-1996 and the costs associated with the various research sections.

Description of Senior Staff Positions

Office of Leader. Coordinates and supervises all research activities of HQ and outposted team members; liaises with CIAT's research support units and Resource Management Research Division, with IITA, and other international and national centers in cassava-related areas.

Physiology. Conducts research on genotype responses and underlying response mechanisms to factors such as low soil fertility (emphasizing phosphorus and potassium nutrition), water-use efficiency, and stress tolerance; studies production of true seed including flowering mechanisms, dry-matter partitioning, and plant architecture, thereby improving selection

Table 4. Cassava Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	1.0	–	4.0	–	1.0	–	4.0	–	–	–	5.0	–
6. Soils, conservation and management	4.0	–	2.0	–	4.0	–	2.0	–	4.0	–	2.0	–
7. Water conservation and management	1.0	–	2.0	–	1.0	–	2.0	–	2.0	–	2.0	–
9. Development of production systems for sustainable resource management	1.0	–	2.0	–	1.0	–	1.0	–	1.0	–	1.0	–
II. Crop productivity research												
1. Germplasm enhancement and breeding												
a. Enhancement	8.0	6.0	9.0	–	10.0	9.0	8.0	–	12.0	11.0	8.0	–
b. Breeding	2.0	–	5.0	–	2.0	–	4.0	–	2.0	–	4.0	–
2. Crop systems	2.0	–	2.0	–	2.0	–	2.0	–	2.0	–	2.0	–
3. Plant protection	1.0	2.0	4.0	–	1.0	2.0	3.0	–	1.0	2.0	2.0	–
4. Plant nutrition	1.0	1.0	2.0	–	1.0	1.0	2.0	–	1.0	1.0	2.0	–
VI. Commodity conversion and utilization research												
1. Crops	2.0	–	5.0	–	2.0	–	4.0	–	2.0	–	3.0	–
VII. Research on human linkages												
2. Other linkages	1.0	–	1.0	–	–	–	2.0	–	–	–	1.0	–
VIII. Socioeconomic and policy research												
2. Market analysis	1.0	–	2.0	–	1.0	1.0	2.0	–	1.0	–	1.0	–
4. Research on impact	1.0	–	3.0	–	–	–	3.0	–	–	–	2.0	–
IX. Institution building and networking												
1. Training	2.0	–	8.0	–	2.0	–	6.0	–	3.0	–	4.0	–
2. Conferences and seminars	1.0	–	4.0	–	1.0	–	3.0	–	1.0	–	3.0	–
3. Documentation and dissemination of information	1.0	1.0	1.0	–	1.0	1.0	1.0	–	1.0	1.0	1.0	–
5. Strengthening national research systems	1.0	–	3.0	–	2.0	–	1.0	–	2.0	–	1.0	–
6. Networks	1.0	–	1.0	–	2.0	–	2.0	–	3.0	–	3.0	–
Total	32.0	10.0	58.0	–	34.0	14.0	52.0	–	38.0	15.0	47.0	–
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 5. Cassava Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Headquarters												
Office of Leader	1	239	1	239	1	239	1	239	1	239	1	239
Physiology	1	226	1	226	1	226	1	226	1	226	1	226
Pathology	1	265	1	265	1	265	1	265	1	265	1	265
Entomology	1	248	1	248	1	248	1	248	1	248	1	248
Breeding	1	379	1	379	1	379	1	379	1	379	1	379
Economics	1	198	1	198	1	198	1	198	0.5	140	0.5	140
Quality/Utilization	1	245	1	245	1	245	1	245	1	245	1	245
Outposted												
Americas – Agronomy	1	213	1	213	1	213	1	213	1	213	1	213
Asia – Breeding	1	175	1	175	1	175	1	175	1	175	1	175
Asia – Agronomy	1	170	1	170	1	170	1	170	1	170	1	170
Africa – IITA/CIAT	1	146	1	146	1	146	1	146	1	146	1	146
Total	11	2,504	11	2,504	11	2,504	11	2,504	10.5	2,446	10.5	2,446

criteria and contributing to increased efficiency in cassava breeding and to sustainable cropping systems research by the Resource Management Research Division; establishes linkages with advanced research institutions to investigate further and exploit the potential of cassava's unique metabolic system and photosynthetic efficiency.

Pathology. Conducts research on fungal and bacterial disease complexes in key cassava ecological zones, emphasizing identification of disease-tolerant cultivars for use in cassava breeding and the development of a framework for applying integrated disease control methodologies; conducts maintenance research on the safe and efficient international transfer of germplasm; establishes linkages with the BRU and advanced laboratories to develop probes for previously unreported diseases such as mycoplasmalike microorganisms.

Entomology. Conducts research on major cassava pests, emphasizing dry-season pests and including germplasm evaluation for resistance, and on biological control through identification, rearing, and distribution of beneficial insects; coordinates with IITA the biological control of major cassava pests in Africa; links with the BRU and CBN to determine the presence of pest biotypes

and strains and their natural enemies. Identifies pest-tolerant materials and develops screening methodologies for cassava breeding.

Breeding. Conducts genetic improvement of cassava through evaluation of germplasm collection and incorporation of tolerant or resistant sources to abiotic and biotic factors; collaborates with decentralized breeding and selection activities of Latin American national programs and of outposted CIAT scientists in Africa and Asia; coordinates breeding activities by the Brazilian national and state agricultural research agencies (EMBRAPA and EMPASC, respectively) for semiarid and subtropical ecosystems, as well as the program's true-seed propagation efforts; liaises with the GRU on germplasm conservation and wild species collection and management and with other program disciplines and support units, especially the GRU and BRU, and, through the CBN, with advanced laboratories.

Economics. Supports national programs in benchmark surveys to determine production constraints and research priorities; participates with program scientists in developing efficient and effective production technologies and technology diffusion methodologies; provides an economic framework for integrated cassava projects in Latin America; assesses ex post impact of component technologies in Latin America and Asia, and ex ante socioeconomic research alternatives (e.g., true seed); assembles and maintains a cassava socioeconomic database; liaises with socioeconomic research in Asia and Africa to provide the basis for setting research priorities and redirecting program strategies.

Quality/Utilization. Defines biochemical and physicochemical quality parameters, and develops screening techniques for discrimination among genotypes; develops methodologies for quality improvement during processing; promotes regional networks for cassava utilization and marketing; supports integrated cassava projects in Latin America during transition period; liaises with CIRAD/CEEMAT, NRI, and other food research institutes to develop existing and new processing systems; collaborates with the BRU for work on starch and manipulation of the amylose-to-amylopectin ratio for different end uses.

Americas-Agronomy. Responsible for collaborative activities with national programs to develop crop management technologies within framework of integrated cassava projects; for catalyzing subregional research networks; and for supporting national programs in the preparation of research proposals for obtaining external funds in order to strengthen and better integrate national programs.

Asia-Breeding. Coordinates Asian regional program; provides guidance to national programs on breeding and selection methodologies; supports regional cassava research network as secretary to its Advisory Committee in order to increase the competence of national cassava breeding programs and consolidate the regional cassava breeders' network for effective and safe exchange of improved germplasm.

Asia-Agronomy. Assists national programs in developing production technologies that reduce erosion and maintain soil fertility; collaborates with regional farming system

initiatives for promoting research-extension-farmer linkages specific to cassava-based cropping systems in order to integrate the technology generation and transfer processes of fertility maintenance and soil conservation.

Africa-CIAT/IITA. Broadens African germplasm base by introducing materials from tropical America; participates with IITA scientists in evaluating and selecting promising materials and giving feedback to HQ on performance; undertakes drought-stress physiology research; liaises between CIAT and IITA on matters of mutual interest, thereby responding better to the research needs of the African cassava-producing countries.

Complementary Activities

Special project funds will be sought for the following activities in support of the aforementioned core activities. Each activity envisages the requirement of a principal scientist at the senior staff, senior research fellow, or visiting scientist level. Table 6 shows the budget proposed for these positions.

Activity 1. Genetic improvement. Collection, characterization, and evaluation of germplasm for semiarid and subtropical ecosystems and the development of improved gene pools for these environments. Decentralized activities will be based at CNPMF (semiarid) and EMPASC (subtropical), Brazil (5 years).

Activity 2. Soil fertility and conservation. Research on the basic mechanisms controlling nutrient-use efficiency in cassava and identification of plant characteristics related to nutrient use that may be employed as selection criteria for cassava improvement. Development of appropriate soil fertility maintenance and erosion control measures. Focus will be on hillside, subhumid, and semiarid ecosystems (5 years).

Activity 3. Cassava green spider mite (CGM). Research with IITA on the implementation of integrated management of the CGM, including diagnosis of farmers' pest control practices, augmentation and conservation of natural enemies, classical biological control, and effect of cropping systems on pest populations (5 years).

Activity 4. Cassava Biotechnology Network (CBN). Joint coordination with the BRU and research institution members of the CBN to identify new initiatives in cassava-related biotechnology (5 years).

Activity 5. Cassava propagation from true seed. Overall coordination of interdisciplinary research, with emphasis on biotechnological techniques, to define an appropriate genetic structure for cassava propagation from true seed (5 years).

In addition, there are four complementary activities of a regional nature:

Activity 6. Germplasm for eastern and southern Africa. Collaboration with IITA in the introduction and evaluation of germplasm, adapted to mid-altitude and seasonally dry environments, from homologous areas in the Americas (5 years).

Activity 7. Socioeconomic research in Asia. Establishment of a regional macroeconomic database for ongoing evaluation of the dynamics of cassava

Table 6. Cassava Program. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

Senior Staff Position	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Genetic improvement *	–	187	–	224	–	224	–	224	–	224	–	224
Soil fertility and conservation *	–	98	–	98	–	130	–	130	–	130	–	130
Green spider mite	–	120	1	180	1	180	1	180	1	180	1	180
Biotechnology network *	–	190	–	323	–	305	–	298	–	285	–	159
Propagation from true seed *	–	–	–	130	–	130	–	130	–	130	–	130
Africa – Germplasm (E. and S.)	–	–	1	255	1	255	1	255	1	255	1	255
Asia – Socioeconomic research *	–	–	–	170	–	170	–	170	–	–	–	–
Asia – Utilization and marketing *	–	–	–	170	–	170	–	170	–	–	–	–
Integrated projects in tropical America	1	560	2	560	2	560	2	560	–	–	–	–
Total	1	1,155	4	2,110	4	2,124	4	2,117	2	1,204	2	1,078

* Positions to be filled with senior research fellows or visiting scientists.

development in Asia and promotion of farm-level research to determine the effectiveness of new production technology (3 years).

Activity 8. Cassava and sweet potato utilization and marketing in Asia. Joint activity with the Centro Internacional de la Papa (CIP) to establish a regional information exchange network and define regional research priorities and opportunities for horizontal cooperation (3 years).

Activity 9. Integrated cassava projects in tropical America. Transfer of knowledge to national programs on project conceptualization, design, execution, and evaluation, together with preparation of training materials and guidelines for R & D personnel working on projects (3 years).

Expected Outputs

The principal outputs resulting from the foregoing activities will be as follows:

* Broader and better characterized germplasm that will provide the basis for more efficient, sustainable progress in cassava breeding

* Improved socioeconomic diagnostic methods and characterization of cassava-growing environments in order to identify research needs more precisely and better orient technology development

* Quicker and more reliable germplasm screening methods that will allow the evaluation of the range of genetic variability present in the germplasm

collection, with emphasis on drought tolerance, nutrient-use efficiency, HCN and starch content, tolerance to major arthropod pests, root-rot pathogens, viruses and their vectors, and mycoplasmalike microorganisms, as well as genotype/cropping system component interactions

* Gene pools with a higher frequency of favorable recombinants for selection by national program breeders

* Greater technical, economic, and social understanding of the potential for the commercial exploitation of true seed

* Crop management practices that permit the fuller expression of the potential of improved germplasm in selected ecosystems, with emphasis on soil fertility maintenance, soil conservation, and integrated pest and disease management

* Improved small-scale processes for producing cassava flour and starch

* Methodologies and training materials for implementing integrated cassava R & D projects and, within these projects, for the in situ testing of improved cassava production and processing technologies

* Regional and national capacity for providing training on cassava production and utilization to technology intermediaries

* Trained cadres of national program personnel in advanced cassava research techniques

* Effective national cassava research programs more closely integrated with extension and development activities

* Increased attention to the cassava research needs of African countries

Rice Program

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.

Objectives, Strategies, and Activities

The program has five basic objectives, each of which is discussed with its corresponding strategy and major activities.

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

Strategy

New characters mediating adaptation to Latin American conditions will be incorporated into irrigated rice populations to expand their core base. Only 14 landraces comprise 70% of the background of currently grown varieties. New genetic backgrounds with high yield potential and good grain quality will be developed as a supplemental genetic core base. Sources for desired traits will include improved upland germplasm from the acid-soil, upland breeding pool, as well as introductions from Asia and Africa. Priority characters will be resistance to or tolerance of regionally important biotic stresses such as rice blast, "hoja blanca" virus (RHBV), grain discoloration, the *Sogatodes oryzicola* planthopper, and the rice water weevil. Other important abiotic characters will be

earliness, tolerance of low temperatures, iron toxicity, and saline soils.

An important research thrust will be to combine the upland-rice root system of the savanna dwarf with the high-yielding, modern, irrigated plant type. This should reduce the water demands of the rainfed lowland crop, increase fertilizer-use efficiency, and possibly decrease the crop's flooded, anaerobic period during which the greenhouse gas methane is produced.

Activities

Donor materials for desired traits will be identified from exotic germplasm and traits transferred to base populations by using population improvement techniques. New breeding techniques, such as molecular markers, will be adopted; these will allow the identification and tagging of specific genes for manipulation and transfer. The direct monitoring of multiple gene inheritance, whose expression is difficult to evaluate with classical techniques, offers hope of tracking the inheritance of quantitative traits. Tissue culture will be used to accelerate molecular marker analysis for combining genes and to increase efficiency of population improvement.

As genes of interest are combined in new backgrounds, regionwide experiments will be conducted to assess the genotype-environment interaction and to ensure that the new backgrounds obtained are suitable for the entire region. Implicit in this approach is the expectation that national programs will have the capacity to meet all their own needs for line advancement for variety development. To this end, the Rice Program will help develop and diffuse the required methods early in the decade.

Routine breeding for developing fixed lines for immediate release by national programs will be phased out by the end of 1996. Those few programs still requiring fixed lines will receive lines produced by population improvement schemes. Germplasm exchange within the region will take place primarily through the International Network for Genetic Enhancement of Rice (INGER), assuming that the projected adjustment to include segregating materials is implemented.

Over this planning period, a greater-than-usual workload will be placed on the crossing facilities as recurrent selection and characterization are added. Further investment in germplasm storage capability will be required for maintaining collections and population backups. Appropriate investment will have to be made for the program to have access to a fully operational molecular markers laboratory, with adequate, well-trained support staff.

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

Strategy

Full yield potential can be achieved by reducing losses to pests and providing a favorable environment for growth. The identification and transfer of stable resistance to the principal biotic and abiotic constraints referred to above will be essential for realizing this objective. Equally important, however, will be a shift from a strictly plant orientation toward an environment orientation, comprising biotic, abiotic, and socioeconomic factors.

In addition to understanding the mechanisms of resistance and their effects on pests and pest population dynamics, the biology of key pests and their interaction with the rice plant and environment will be quantified. Ultimately, this will permit the formulation of integrated management components. Understanding the interaction among these components, together with critical socioeconomic parameters, will provide the basis for formulating integrated management strategies at the regional level. Although CIAT will not be developing integrated pest management (IPM) or integrated crop management (ICM) packages, this approach and the knowledge and experience acquired will permit the development of IPM/ICM approaches at the national level.

Activities

Research will be conducted on the mechanisms and inheritance of resistance to and tolerance of the important regional biotic and abiotic constraints within Rice Program populations: rice blast, RHBV, *S. oryzicola*, grain discoloration, rice water weevil, iron toxicity, and low temperatures. For the first three, particular emphasis will be placed on clarifying the variability of the organisms in relation to the rice plant and the effect on pest epidemics and population dynamics.

Considerable use will be made of advanced biological tools, such as RFLP, DNA fingerprinting, and monoclonal antibodies. Important issues will be the determination of the causes of resistance breakdown for blast and of the risk resistance breakdown poses for other important organisms. Such understanding is expected to lead to crop improvement and management strategies for more durable resistance. The management of pest resistance to agrochemicals, particularly herbicides, will receive increasing attention.

The program will monitor the occurrence of pests on a regional basis and support national programs in determining their priority pests. Modest efforts to explore the compatibility of new fertilizer delivery systems with existing and proposed management alternatives will be carried out.

Research will also be carried out to understand both the functioning of the upland root system in combination with the irrigated plant type, and the mechanisms responsible for adaptation to upland, acid-soil conditions. Such an understanding will help form the basis of modified management practices for the upland rice plant.

The interaction of particular management components and their effects on the rice plant and principal pests will be used to define interaction patterns for local modification. A clear understanding of the socioeconomic factors governing farmer adoption of IPM and ICM will guide the establishment of integrated approaches by national programs. Because the adoption of IPM and ICM alternatives by Latin American farmers is among the principal desired outcomes and is usually site specific, the program will give national programs the necessary support through collaborative research projects. In particular, limited research into cropping systems that increase water-use efficiency in irrigated systems will be carried out. A network for IPM-related research may be formed to address common issues.

The Rice Program will need to maintain a full complementary approach in the crop management/protection area over the entire planning period. Strong socioeconomics support will be required both by CIAT and national programs to develop ICM/IPM research approaches. Because technology transfer is key to the successful

implementation of ICM/IPM, CIAT will support training of technology transfer trainers. This activity will require major investment from the IDSP and substantial backup by the Rice Program. Research in crop protection will demand considerable effort, both in understanding the biology of pests within the regional context and in the routine application of advanced biological tools (e.g., DNA fingerprinting and monoclonal antibodies). Strong linkages with both the VRU and BRU will be required throughout the period, as well as with the Bean Program in the area of rice-bean production systems.

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

Strategy

The relatively high-yielding, upland rice population adapted to the acid soils of Latin America will be broadened by the continued incorporation of exotic materials and improved through continued selection and breeding. To improve research efficiency and population enhancement, a high priority will be to understand the mechanisms of adaptation of this material to those harsh soils. The material's interaction with the biota--both beneficial and noxious--of upland environments will be researched. Likewise, understanding the biology of key pests specific to upland systems will be sought.

Activities

A breeding program for continued population improvement of upland materials will be the core activity. Upland materials from Asia, Africa, and the Americas, identified as having useful characters, will be incorporated into the breeding populations. Genetic markers identified for irrigated populations will also be applied to upland populations because many of their biotic stresses are the same. A strong breeding activity will be required for these populations. Anther culture will play an important role in breeding for acid-soil upland conditions, because these rice materials respond well to this technique.

Upland-rice root characteristics will be further analyzed. Specific studies on the mechanisms of adaptation to low pH, low phosphorus availability, high aluminum saturation, and moderate drought will be undertaken. Understanding adaptation and inheritance mechanisms will facilitate the transfer of upland-rice root systems to irrigated populations and suggest strategies for developing sustainable systems for the savannas. Such studies suggest the need for support in plant nutrition and physiology.

Obtaining information on pests and beneficial organisms will demand a high level of interaction with plant protection expertise to provide the foundations for management alternatives within savanna cropping systems. As upland rice will certainly be an important crop, very close interaction with CIAT's Savannas and Forest Margins programs will be required to develop appropriate materials and to use the information on pests fully. Many of the key sustainability issues will ultimately revolve around the successful management of rice pests.

The range of grain characteristics within the upland germplasm and the strong effect of upland environment on grain quality suggest that alternative uses of rice grain should be explored. Entering processed food and animal feed industries at a significant level could help establish stable floor prices and stabilize the overall rice market.

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

Strategy

In-service training, focusing on specific requirements of national programs and their scientists, will be the cornerstone of this strategy. Training will become increasingly sophisticated as more mid-career scientists seek to upgrade their skills. Courses will address specific areas of breeding, crop protection, and socioeconomics. Graduate students from national programs and postdoctoral fellows will play an increasingly prominent role; in both cases, problems of particular regional or national importance will be addressed.

Activities

Specific courses and workshops on breeding methodologies--such as recurrent selection, anther culture, and RFLP gene tagging--will be conducted regularly, alternating with crop management and protection courses that focus on IPM and specific biotic constraints such as rice blast, RHBV, and red rice. Regional conferences on topics of particular interest will be organized on a triennial basis, possibly coinciding with INGER meetings. A core curriculum for rice training will have to be developed for the region to support the national programs' training activities.

As CIAT moves toward more specific training, its role in entry-level training will decrease, assuming that the national programs will be able to absorb it. Yet, considerable backup from CIAT will be required; over the planning period substantial IDSP resources will have to be dedicated to such tasks as adapting, to Latin American conditions, the large volume of training materials available from IRRI, including written documents and computer software. Support will also be needed for developing teaching abilities in national programs so that they can deliver meaningful instruction to their scientists.

Objective 5. Promote effective information exchange among and within national programs

Strategy

A fundamental strategy will be to build on the current network of rice breeders to establish effective communications within the entire rice research and production community. This implies the creation of new, or the expansion of existing, information exchange mechanisms. Existing crop improvement and agronomic data will be made available to the region as a whole.

Activities

A Latin American rice research newsletter will be launched, and regular conferences and workshops on issues of regional importance will be held, with proceedings compiled and distributed on a timely basis. Databases on germplasm performance and key agronomic and agroecological characteristics will be maintained and made available to national programs in a usable form. In both cases, the Rice Program will depend heavily on the IDSP for effective and timely communication mechanisms and on the Information Management Systems Unit for the development and maintenance of databases. Likewise, the Program will work closely with INGER to develop the information network and databases for the region.

Resource Allocation and Requirements

The expected evolution of resource utilization in the Rice Program during 1992-1996, in terms of "activities" as defined by the CGIAR (see Appendix), appears in Table 7.

Senior Staff positions required for executing the Rice Program's operational plan during 1992-1996 and the costs associated with the various research sections appear in Table 8.

Description of Senior Staff Positions

Office of Leader. Coordinates rice research and training activities to ensure continuous relevance and complementarity with the activities of other national and international programs; and provides administrative support to the research scientists for the efficient use of resources assigned to the program.

Breeding (Upland). Manages the entire upland breeding program, expanding it from the present population and including the development of upland dwarf populations suitable for crossing to transfer useful upland traits to irrigated lines; conducts research on physiology of adaptation to acid soils with high aluminum saturation; manages crossing program and germplasm collection; interfaces with Resource Management Research Division in providing adapted materials for cropping system development and agronomic support in upland rice production technology for acid soils.

Breeding (Irrigated). Responsible for main breeding activities for tropical and temperate irrigated systems; focuses on expansion of the genetic base, incorporating new sources of resistance or tolerance to priority biotic and abiotic constraints, and implementing recurrent selection program; handles entry of upland x irrigated material into populations for the ultimate creation of new, tropical, irrigated base populations.

Breeding (Temperate). Assesses nontraditional breeding methods as a means to speed up the germplasm improvement process; combines high yield potential and superior grain quality traits existing in tropical and temperate gene pools; coordinates collaborative activities with the temperate rice research programs.

Pathology. Focuses on priority diseases for the region: rice blast, RHBV, grain discoloration, and sheath rots, emphasizing pathogen variability, characteristics of resistance, interactions with vectors, interactions among pathogens, resistance, and environment; applies findings to epidemiology of key diseases and consequent development of management strategies; collaborates closely with breeding to tag resistance genes and devise methodologies for accumulating and deploying resistance genes.

Entomology. Focuses on priority insects in the region responsible for direct economic losses or excessive insecticide applications: panicle bugs, *Sogatodes* planthopper, water weevils, and leaf miners; orients research toward characterization and manipulation of resistance, where feasible, and population dynamics, to reduce insecticide applications and production costs; contributes to developing management strategies that may be adapted by national programs to local conditions; in this respect, interacts closely with socioeconomics; quantifies consequences of excessive insecticide use on target and nontarget organisms as part of overall

Table 7. Rice Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	-	-	2.0	-	-	-	2.0	-	-	-	2.0	-
6. Soils, conservation and management	-	-	4.0	-	-	-	1.0	-	-	-	1.0	-
7. Water conservation and management	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
II. Crop productivity research												
1. Germplasm enhancement and breeding	-	-	22.0	-	-	-	20.0	-	-	-	20.0	-
2. Crop systems	-	-	6.0	-	-	-	5.0	-	-	-	5.0	-
3. Plant protection	-	-	24.0	-	-	-	26.0	-	-	-	27.0	-
4. Plant nutrition	-	-	5.0	-	-	-	7.0	-	-	-	9.0	-
VII. Research on human linkages												
2. Other linkages	-	-	2.0	-	-	-	2.0	-	-	-	1.0	-
VIII. Socioeconomic and policy research												
2. Market analysis	-	-	3.0	-	-	-	2.0	-	-	-	1.0	-
3. Policy analysis	-	-	2.0	-	-	-	2.0	-	-	-	1.0	-
IX. Institution building and networking												
1. Training	-	-	12.0	-	-	-	12.0	-	-	-	12.0	-
2. Conferences and seminars	-	-	3.0	-	-	-	4.0	-	-	-	4.0	-
5. Strengthening national research systems	-	-	2.0	-	-	-	2.0	-	-	-	2.0	-
6. Networks	-	-	8.0	-	-	-	10.0	-	-	-	10.0	-
Total	-	-	100.0	-	-	-	100.0	-	-	-	100.0	-
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 8. Rice Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Headquarters												
Office of Leader	1	196	1	228	1	242	1	252	1	260	1	260
Breeding (Upland)	1	258	1	258	1	258	1	258	1	258	1	258
Breeding (Irrigated)	1	212	1	212	1	258	1	258	1	258	1	258
Breeding (Temperate)	1	201	1	201	–	–	–	–	–	–	–	–
Pathology	1	228	1	228	1	228	1	228	1	228	1	228
Entomology (IPM)	1	154	1	154	1	154	1	154	1	154	1	154
Agronomy	1	162	1	162	1	162	1	162	1	162	1	162
Economics	1	156	0.75	145	0.75	145	0.5	105	0.5	105	0.5	105
Outposted												
Caribbean – Regional coordination	–	90	–	–	–	–	–	–	–	–	–	–
Collaborative plant nutrition research (with IRRI)	–	–	–	–	–	70	–	70	–	70	–	70
Total	9	1,657	7.75	1,588	6.75	1,517	6.5	1,497	6.5	1,495	6.5	1,495

strategy to convince national policy makers on the importance of crop management policies for the rice sector.

Agronomy. Develops management strategies for reducing losses to weeds, while reducing herbicide application; adapts concepts of loss assessment, economic thresholds, and population monitoring applicable to insect management for irrigated rice in Latin America; quantifies consequences of continuous herbicide use on target species--particularly in terms of herbicide resistance--and develops management strategies; explores implications of new fertilizer delivery systems on overall crop management alternatives; quantifies agronomic implications of the new upland x irrigated rice lines and establishes management parameters; works with national programs in integrated crop management approaches for research and technology transfer, including emphasis on pesticide use awareness.

Economics. Provides essential socioeconomic data and approaches for integrated pest and crop management programs; develops methodologies to orient crop protection research and technology transfer toward critical problems; engages in ex ante and ex post analyses of the rice sector for monitoring progress in IPM; assists national programs with diagnostics and follow-up of rice sectors for developing

national and collaborative research and technology transfer plans; continuously monitors regional rice economic environment for long-term implications for research activities, particularly alternative uses of rice in agroindustry.

Caribbean-Regional coordination. Supports the Caribbean Rice Improvement Network (CRIN), promoting the sharing of technology among countries and the upgrading of training and collaborative research activities; liaises between the CIAT Rice Program and the Caribbean national rice research systems.

Collaborative plant nutrition research (with IRRI). Analyzes mechanisms of adaptation to acid soils of rice plant with upland root characteristics; supports breeding efforts to combine upland root systems with high-yielding irrigated backgrounds, as well as to develop moisture-use-efficient irrigated plant types.

Complementary Activities

The program sees as an essential complement to its activities the continued existence of both INGER and CRIN. INGER-Latin America, although part of the global INGER system administered by IRRI, is headquartered at CIAT and managed within the region. This network serves as an efficient means of communication and germplasm exchange within the region and between CIAT and the numerous Latin American rice improvement programs.

CRIN is an externally supported network, intended to strengthen weak Caribbean rice programs and to realize an economy of scale by sharing special strengths and comparative advantages among the programs. The requirements of the region are such that they cannot be met with only the present Rice Program core resources.

CIAT will move to selected strategic research areas that have global implications. These have been, and will continue to be, worked out in close consultation with IRRI and the West Africa Rice Development Association (WARDA). IRRI and CIAT will seek joint supplemental funding for areas of mutual high priority, such as upland-rice root physiology and architecture. The Rice Program will also develop collaborative projects with IRAT, (Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres) in upland-rice breeding and cropping systems.

The Rice Program will provide some complementary support to sorghum research for acid soils as outlined in the Savanna Program (see Agroecosystems Programs). The level of support will depend upon the contributions of the other partners, including ICRISAT and INTSORMIL.

The budget for the proposed complementary activities is found in Table 9.

Expected Outputs

* Breeding populations with new backgrounds for the irrigated sector will be created by the end of 1996 for evaluation by national programs across environments. Potential parental lines will be available with precise information on the RHBV and blast resistance gene(s) they carry, and fixed lines combining irrigated plant type and yield potential with upland root systems will be under evaluation by national programs by the

Table 9. Rice Program. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Caribbean improvement network	1	532	1	622	1	622	1	622	1	622	1	622
Joint upland: rice root physiology and architecture	–	26	0.25	76	1	200	1	200	1	200	1	200
Total	1	558	1.25	698	2	822	2	822	2	822	2	822

mid-1990s. A first approximation of an assessment of the usefulness of recurrent selection in rice breeding for Latin America will be available, and lines carrying specific useful traits in a desirable background will be distributed to the national programs.

* Well-adapted, high-yielding germplasm appropriate for incorporating into savanna cropping systems will be in production by the year 2000. Expected contributions are on the order of 5 million additional tons per year. Progress in understanding the mechanisms of adaptation and inheritance will facilitate the transfer of rooting systems to the irrigated populations and suggest strategies for developing sustainable systems for the savannas.

* Combining understanding of the mechanisms of resistance/tolerance to principal constraints and understanding of factors mediating variability of biotic constraints and population dynamics with information on interaction of components and probable stability of resistance will provide the basis for establishing broad guidelines for ICM and IPM approaches at the national level. Alternative IPM components, or proto-components, will be available for application at the national level. Strategic deployment of resistance as part of an overall ICM approach will be implemented by 1996. It is expected that most of the programs in the tropical zone will adopt an integrated approach to their research and, as a consequence, develop IPM technology for farmers. Adoption of IPM will reduce toxic agrochemical use in the region, beginning by the mid-1990s.

* National programs will benefit from advanced training opportunities for their staff, who will be in a position to address a broader range of issues related to rice improvement and production. The strengthening of these scientists will make it possible to conduct the research needed for implementing an ICM/IPM approach at the national level. They will also be able to assume a greater role in training of entry-level scientists in the basics of rice research.

* By 1996, strong information exchange mechanisms--in the form of networks, a rice research newsletter, and databases on rice-growing agroecological zones, biotic/abiotic constraints, and germplasm development--will be in place among the national programs and at CIAT, enabling the programs to benefit from advances made elsewhere and to monitor their investment in rice research.

Tropical Forages Program

Goal

The goal of the Tropical Forages Program is to increase the supply of beef and milk for human consumption, and to enhance the natural resource base for sustainable agriculture.

The program has a worldwide mandate for herbaceous, leguminous, and grass species adapted to low-fertility acid soils of the lowland tropics. The program's germplasm mandate now includes pasture species for mid-altitudes (1000-1800 m.a.s.l. at the equator, 18 °C annual mean temperature) and woody forage species for both lowlands and mid-altitudes.

Strategies and Activities

Strategy 1. Develop productive herbaceous and woody forage germplasm

Germplasm development is based on the exploitation of natural genetic variability among and within forage species and screening in major ecosystems. Therefore, continuing acquisition of as wide a collection of relevant germplasm as possible will be important. In all cases, first priority will be assigned to exploiting natural genetic variability in order to identify superior accessions in adapted species. Breeding will be restricted to key herbaceous species for the lowlands to resolve discrete, well-identified constraints that cannot be overcome by other means.

Consequently, the four existing major screening sites (Carimagua, Colombia; Planaltina, Brazil; Pucallpa, Peru; and Costa Rica) that serve the Red Internacional de Evaluación de Pastos Tropicales (RIEPT) will remain active throughout the planning period. Wherever possible, efforts will be made to make these sites compatible with those selected for the agroecosystems programs, especially in the case of the Forest Margins Program. Nevertheless, there will be a gradual reduction in screening for the Llanos ecosystem, which implies phasing out the respective senior position. A fifth site for mid-altitude environments will be established over the period 1992-1993 for mid-altitude environments, which will provide a natural link with the Hillsides Program.

Given the worldwide mandate for herbaceous species for acid soils in the lowland tropics, the program will outpost a senior agronomist in West Africa, and a complementary position will be sought for Southeast Asia in order to implement a major screening site for each region until a core position is created in 1996.

Activity 1. Germplasm acquisition and evaluation

Germplasm acquisition, screening, and development, which constitute the major focus of the Tropical Forages Program, comprise the following specific activities:

* Expansion of the collection of key herbaceous species for the lowland acid soils. The existing germplasm collection of some key genera is too narrow. The genetic base of important genera such as *Arachis*, *Calopogonium*, and *Paspalum* will be enlarged through strategic exchange and collection.

* Acquisition of herbaceous forage germplasm for mid-altitude acid soils. The program will screen the existing germplasm collection for this environment and will complement it with strategic collection and acquisition by exchange. This will require identification and development of a representative screening site beginning in 1992. The main criteria for screening and evaluating this germplasm will be adaptation to low-fertility acid soils (but not necessarily allic), high nutritional quality and carrying capacity, and high soil cover and soil-enhancing properties.

* Acquisition of multipurpose forage tree and shrub (MPFTS) germplasm. CIAT has a limited collection of shrub and tree species. Although initial screening has shown that some species are adapted to poor acid soils, some seem to have low nutritional value. Germplasm is also being evaluated by the Nitrogen Fixing Tree Association (NFTA) in Hawaii and by the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica--but not on acid soils. Consequently, even with the addition of these collections, there may still be insufficient variability.

Beginning in 1992, the program, in cooperation with the GRU and the International Council for Research in Agroforestry (ICRAF), will acquire existing MPFTS collections from other institutions. Only promising germplasm species with limited genetic variability will be collected directly. The collection will be characterized at the major screening sites in tropical America, with initial emphasis on mid-altitude hillsides and humid tropics. Minimum criteria for screening MPFTS will be adaptation to infertile acid soils, forage value, nitrogen-fixing ability, and ease of propagation. Parallel work will be conducted to adapt and develop appropriate methodologies for agronomic evaluation and assessment of nutritional quality.

Activity 2. Genetic improvement of key herbaceous forage species

The program will continue genetic improvement, through plant breeding and advanced biotechniques, to solve major limitations of key herbaceous species for the lowlands. During the planning period, the main activities will be with the genera *Brachiaria* and *Stylosanthes*, with the possible addition, toward the end of the period, of *Centrosema* spp., *Panicum maximum*, and *Desmodium ovalifolium*.

In *Brachiaria*, the major breeding objectives are to incorporate resistance to spittlebug in materials showing good adaptation to low-fertility acid soils and to improve their nutritional quality. The program will initiate a breeding project in the Brazilian Cerrados to improve seed yields and disease resistance of selected promising accessions of *S. guianensis*, as well as to study host resistance and pathogen variation for anthracnose in *S. capitata*.

Among the tropical legumes, *Centrosema* is regarded as a key genus. The potential of combining highly desirable traits between species is being documented, but a full-

fledged breeding project would require additional resources, which are not contemplated in the current plan.

Activity 3. Phenology and biology of seed production

Forage plants are primarily developed for high biomass production and high quality but they frequently have low seed yields, particularly in newly domesticated species. High seed yields are essential if they are to persist in pastures and to be adopted rapidly by farmers; therefore, the program will conduct strategic research to identify and resolve constraints on seed crop production, recovery, quality, and supply. This knowledge will provide the basis for the efficient location and management of seed production for a range of potential multipliers. Experimental seed will be provided and effective links maintained with the IDSP's Seed Supply Systems, national programs, and advanced institutions.

Strategy 2. Understanding mechanisms for ecological compatibility of pasture components

Deep-rooted, grass-legume pastures, which provide a high degree of soil cover and effectively recycle nutrients, are a key component in pasture productivity. They are also the foundation of sustainable farming systems because they can maintain and improve soil conditions. The study of these processes requires a multidisciplinary team, which was assembled by the former Tropical Pastures Program. The team will remain in the program until 1994, but with increasing responsibilities for activities with the Savannas Program, to which the ecophysiology and nitrogen cycling positions will be formally transferred in 1995. The plant nutrition and animal nutrition positions will remain in the program because of their essential contribution to germplasm development. To maintain the existing *Rhizobium* collection, the program will retain the required lab staff and facilities, with technical support from senior scientists in the Savannas Program.

Continuing important activities are as follows:

Activity 1. Nitrogen fixation and cycling

Nitrogen limits dry-matter and protein production in tropical pastures. BNF and nitrogen cycling are therefore essential components of sustainable production where other inputs such as fertilizers are restricted. These processes will be quantified, and suitable management options developed for improved nitrogen cycling within the soil/plant/animal system.

Activity 2. Soil/plant interactions

Plant adaptation to acid soils involves morphological, physiological and biochemical mechanisms in both shoots and roots. These mechanisms will be studied to understand plant/soil interactions better and to identify those responsible for adaptation to nutrient-poor acid soils.

Activity 3. Influence of grazing management on plant/plant relations

Legumes are key elements in both nitrogen cycling and animal production, but their C3 photosynthesis puts them at a disadvantage when they are grown with C4 tropical grasses. Cattle prefer to consume grasses, but using different management systems to offset the grasses' advantage requires understanding of their ecological effects. Research will be carried out to understand

how differential defoliation and consumption of growing points affect competition and population dynamics of the sward components.

Activity 4. Animal intake, selectivity, utilization, and production

The behavior of grazing animals affects nutrient cycling through the pasture utilization process, including selectivity and forage intake. This process will be studied, together with the effects of soil fertility, pasture attributes, and grazing management on animal behavior and performance.

Activity 5. Integrated crop/pasture systems

Legume-based pastures enhance the levels of soil organic matter and available nutrients, particularly nitrogen, in contrast to crops, which remove soil nutrients and reduce organic matter. A key factor in creating stable systems, therefore, is to integrate pastures and crops. The success of such systems depends on the rates of accumulation and losses of nutrients and organic matter in the pasture and cropping phases and their influence on soil physical and biological characteristics. Research will be directed toward determining these effects and seeking appropriate methodologies to describe them.

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

To meet this objective, the program will build upon existing network activities and develop new ones to collaborate in strategic research.

Activity 1. Stimulating RIEPT's autonomy

Although the program will continue the technical coordination of the RIEPT by ecosystems, it will actively stimulate the network to become increasingly self-sufficient. This will be achieved through (a) development of statutes for a self-governing advisory committee; (b) the strengthening of independent leadership within the network by supporting efforts to procure funds for financing advanced degree training for selected national scientists; and (c) identification of outside financial support for key experiments in pasture evaluation and seed multiplication.

The program will play an important supporting role by providing a problem-solving perspective to RIEPT research in pasture development. This implies maintaining a clear user-oriented approach by both the program and RIEPT.

Activity 2. Pasture germplasm screening in West Africa

To extend and strengthen the activities initiated in West Africa in collaboration with ILCA/AFRNET and CIRAD/IEMVT, the program will outpost a senior agronomist to the region in order to implement a major screening site. ILCA and national programs are expected to provide the required perspective in pasture utilization and farming systems.

Activity 3. Cooperation with advanced institutions

Over the planning period, the program will develop collaborative links with advanced research institutions, both in the region and in developed countries, as well as expand collaborative research with the BRU. The program will act as a liaison between developed countries and national programs in tropical America.

Links will be established in the areas of plant pathology and entomology, plant breeding, seed technology, root and plant physiology, ruminant animal nutrition, and mathematical modeling. Facilities for advanced training of national scientists will be provided in those areas.

Resource Allocation and Requirements

The expected evolution of resource utilization in the Tropical Forages Program during 1992-1996, in terms of "activities" as defined by the CGIAR (see Appendix), appears in Table 10.

Senior Staff positions required for executing the Tropical Forages Program's operational plan over the five years, together with the costs associated with the various research sections, appear in Table 11. Based on the assumption that the program will receive feedback from Resource Management Research Division senior economists with expertise in livestock economics, the program will retain only two experienced economists at the associate level. A summary description of each Senior Staff position proposed for the planning period under consideration follows.

Description of Senior Staff Positions

Office of Leader. Responsible for providing supervision, coordination, and guidance in the establishment of priorities and implementation of pasture and forage germplasm research; promoting multidisciplinary activities; and establishing links with other CIAT programs and with national and international institutions.

Germplasm (Hillsides). Responsible for acquiring forage germplasm through exchange and direct collection in collaboration with the GRU; carrying out the initial greenhouse and field characterization; and, depending upon the location of the major screening site in the mid-altitudes, for the agronomic evaluation of the collection, either alone or in cooperation with the Central American agronomist.

Breeding. Responsible for genetic enhancement of specific characters of key herbaceous species and for producing advanced progenies for decentralized testing.

Pathology. Carries out surveys to detect and identify pathogens in the collection; conducts research on the epidemiology of the main pathogens affecting key grass and legume species; and develops reliable screening criteria.

Entomology. Surveys the insect pests affecting the forage germplasm collection and carries out research on plant/pest interactions to identify appropriate screening criteria for key species.

Screening-Llanos. Responsible for the agronomic evaluation of forage germplasm in the Llanos ecosystem and for coordinating and analyzing multilocational trials in the region.

Plant nutrition. Conducts research on the mechanisms of acid-soil adaptation in contrasting selected species of grasses and herbaceous legumes; contributes to the development of reliable screening indices and to multidisciplinary research on plant/soil interrelationships.

Quality/Ruminant nutrition. Responsible for the nutritional characterization of promising forage species; conducting research on the plant/animal interface aimed at developing

Table 10. Tropical Forages Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
6. Soils, conservation and management	–	–	12.6	–	–	–	7.6	–	–	–	5.4	–
III. Livestock productivity research												
2. Livestock systems	3.0	8.0	50.4	–	5.0	12.0	53.4	–	7.0	15.0	50.6	–
VII. Research on human linkages												
1. Analysis of human nutrition	–	–	1.0	–	–	–	1.0	–	–	–	1.0	–
VIII. Socioeconomic and policy research												
1. Economic and social analysis at micro level	–	–	2.0	–	–	–	–	–	–	–	–	–
2. Market analysis	–	–	2.0	–	–	–	2.0	–	–	–	2.0	–
4. Research on impact	–	–	1.0	–	–	–	1.0	–	–	–	1.0	–
IX. Institution building and networking												
1. Training	1.0	1.0	7.0	–	1.0	1.0	6.0	–	2.0	2.0	3.0	–
2. Conferences and seminars	–	1.0	1.0	–	1.0	1.0	1.0	–	1.0	1.0	1.0	–
5. Strengthening national research systems	–	–	1.0	–	–	–	–	–	–	–	–	–
6. Networks	2.0	2.0	4.0	–	1.0	2.0	4.0	–	2.0	2.0	4.0	–
Total	6.0	12.0	82.0	–	8.0	16.0	76.0	–	12.0	20.0	68.0	–
Total Year	100.0				100.0				100.0			

a. SSA = Sub–Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 11. Tropical Forages Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position [a]	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Headquarters												
Office of Leader	1	324	1	324	1	324	1	324	1	324	1	324
Germplasm (H)	–	–	1	230	1	230	1	230	1	230	1	230
Breeding	1	185	1	185	1	185	1	185	1	185	1	185
Pathology	1	181	1	181	1	181	1	181	1	181	1	181
Entomology	1	183	1	183	1	183	1	183	1	183	1	183
Screening – Llanos	1	230	–	–	–	–	–	–	–	–	–	–
Plant nutrition	1	198	1	198	1	198	1	198	1	198	1	198
Quality/Ruminant nutrition	1	280	1	280	1	280	1	280	1	280	1	280
Seed biology	1	278	1	278	1	278	1	278	1	278	1	278
Ecophysiology	1	227	0.75	170	0.75	170	0.5	114	–	–	–	–
BNF/N recycling	1	201	0.75	151	0.75	151	0.5	101	–	50	–	50
Livestock systems	1	234	–	–	–	–	–	–	–	–	–	–
Economics	1	177	–	–	–	–	–	–	–	–	–	–
Tropical forages network	–	180	–	120	–	120	–	120	–	120	–	120
Integration of systems	1	199	–	–	–	–	–	–	–	–	–	–
Llanos-based research	–	200	–	180	–	180	–	160	–	140	–	140
Outposted												
Screening – Cerrados (S)	1	180	1	180	1	180	1	180	1	180	1	180
Screening – Forest margins	1	168	1	168	1	168	1	168	1	168	1	168
Screening – Central America (H + FM)	1	203	1	203	1	203	1	203	1	203	–	–
Screening – West Africa	–	–	1	190	1	190	1	190	1	190	1	190
Screening – Southeast Asia	–	–	–	–	–	–	–	–	–	–	1	203
Recycling – Humid tropics	1	107	–	–	–	–	–	–	–	–	–	–
Reclamation – Cerrados (S)	1	183	–	–	–	–	–	–	–	–	–	–
Total	18	4,118	13.5	3,221	13.5	3,221	13	3,096	12	2,910	12	2,810

a. (FM) = Forest margins; (H) = Hillsides; (S) = Savannas.

predictive models of animal performance; and participating in multidisciplinary research to elucidate the dynamics of grazed plant populations and soil conditions in grazed pastures.

Seed biology. Conducts strategic research on factors affecting flowering, seed set, and seed quality; supports national programs on seed research issues; provides experimental seed; and maintains effective links with the IDSP's Seed Supply Systems, national programs, and advanced institutions.

Ecophysiology. Conducts research on plant competition with the aim of developing predictive models of plant population dynamics in grazed pastures; participates in research designed to study plant/soil and plant/animal interactions; and contributes to the development of screening indices.

BNF/N recycling. Responsible for research aimed at quantifying nitrogen recycling in selected grass-legume associations under grazing; maintaining the *Rhizobium* collection for key forage legumes and supplying inoculants for agronomic evaluations; participating in multidisciplinary research on nutrient recycling and development of mechanistic models of plant/soil/animal systems.

Livestock systems. Analyzes pasture components for cattle production in long-term experiments and under farm production conditions.

Economics. Analyzes economic performance of pasture-based systems; surveys adoption of improved pasture technology; contributes to the program's strategic planning; and devises feedback methodologies from existing farming systems to pasture researchers.

Tropical forages network. Coordinates activities within the four RIEPT subnetworks and maintains the database on RIEPT trials and results.

Integration of systems. Responsible for the agronomic evaluation of components of crop-pasture systems in the Llanos and the synthesis of stable systems of crop production.

Screening-Cerrados (Savannas). Responsible for the agronomic evaluation of forage germplasm in the Cerrados ecosystem and for coordinating and analyzing multilocational trials in the region.

Screening-Forest Margins. Responsible for the agronomic evaluation of forage germplasm in the ecosystem and for coordinating and analyzing multilocational trials in the region.

Screening-Central America (Hillsides + Forest Margins). Responsible for the agronomic evaluation of forage germplasm as well as for coordinating and analyzing multilocational trials in the region.

Screening-West Africa. Responsible for establishing a major screening site for initial agronomic evaluation in cooperation with an appropriate national program; and for coordinating the exchange of germplasm and information across the region and with IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux) and ILCA.

Screening-Southeast Asia. Responsible for establishing a major screening site for initial agronomic evaluation in cooperation with an appropriate national program; and for coordinating the exchange of germplasm and information across the region and with the

Commonwealth Scientific and Industrial Research Organisation (CSIRO).

Recycling-Humid tropics. Conducts studies to increase productivity of pastures invaded by weeds and dominated by native grass species of low productivity and nutritive value.

Reclamation-Cerrados (Savannas). Studies pasture establishment and management on the Brazilian Cerrados, with emphasis on renovating lands degraded by cropping as well as degraded pastures; and maintains contact and collaborates with Brazilian pasture research groups.

Complementary Activities

* *Pasture germplasm screening in Southeast Asia*. The program will seek special project funds to begin screening pasture germplasm. In 1996, this will become a core activity.

* *Stability of savanna resources*. The program will continue to research the dynamics of savanna vegetation in the Colombian Eastern Plains when they are subjected to more intensive use. The aim is to understand the ecological processes and to develop methodologies for their study. Over the period 1992 to 1995, these activities will be gradually transferred to the Savannas Program.

Table 12 contains the revised and projected budgets for these complementary activities.

Expected Ouputs

The activities encompassed by the first objective will provide an expanded germplasm base that will include MPFTS and lowland and mid-altitude herbaceous species collected for and characterized in the low-fertility acid soils of the American savannas, hillsides, and forest margins. Characterization of this wide range of germplasm will include a better understanding of plant-pathogen and plant-pest interactions in a reduced number of key species. In the American lowland tropics, further collection and evaluation of important genera will identify new key species, and improved progenies of *Brachiaria* spp. and S. *guianensis* will be under advanced multilocational testing. More detailed knowledge will be available on the effect of environment, genetics, and management on flowering and seeding in key herbaceous species, which will provide the basis for higher yields of better quality seed.

At the end of the period, a number of herbaceous legumes and grasses will also have been evaluated in the lowland tropics of West Africa, and progress will have been made in the identification of key species for that region. A similar initiative will have begun in Southeast Asia.

The various mechanisms through which selected key pasture species adapt to acid soils will begin to be understood, and progress in identifying genetically determined traits within species is anticipated. Significant progress will have been made in identifying soil/plant/animal factors that can be managed to increase the effectiveness of both endogenous and exogenous nutrients and to reduce their loss from the system. An improved understanding of the mechanisms involved, gradually incorporated into relevant models, will contribute to the formulation of stable production systems, including

Table 12. Tropical Forages Program. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Ecology (Savanna)	–	–	0.75	161	0.75	161	0.5	108	–	–	–	–
Screening – Southeast Asia	–	–	1	203	1	203	1	203	1	203	–	–
Improved native grassland	–	81	–	65	–	65	–	65	–	–	–	–
Charact. and comp. of isolates	–	72	–	–	–	–	–	–	–	–	–	–
Total	–	153	1.75	429	1.75	429	1.5	376	1	203	–	–

forages and crops. Another outcome of these studies, to be carried out in conjunction with the Agroecosystem Programs, will be the identification of soil and plant indicators of system degradation and sustainability.

With the existence and implementation of appropriate policies, stronger and more independent national pastures and forages research programs will be expected in Latin America, and an expanded body of national and regional partners will also be available. The RIEPT network will have matured and achieved a great degree of technical self-sufficiency. In subhumid West Africa, a large number of multilocational trials operating as part of a network are anticipated, and a major screening site will be fully operational. Subject to the availability of complementary funds, a similar initiative will begin to operate in Southeast Asia.

Chapter 3

RESOURCE MANAGEMENT RESEARCH DIVISION

Powerful social and economic forces drive agricultural development in tropical America. The region as a whole has abundant land, but 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 undergoing rapid, sometimes catastrophic, change.

Natural vegetation is inevitably replaced by cultivated land as the area under agriculture expands. This rapid clearance of natural forest in tropical America in recent years has brought only ephemeral gains in food production, with cleared areas turning to bush a few years later. Although both decision makers and the general public in tropical America are aware that environmental protection is vital to the region's future, the drive for economic development has frequently devalued environmental considerations. The futile destruction of its natural resource base is the region's most eloquent argument in favor of effective land use strategies and policies.

Forest clearance and expansion of cultivated areas have been traditional sources of economic growth in the region. During the 1980s, about 20% to 30% of production increases resulted from area expansion, mainly in the Brazilian Cerrados and seasonal forest areas. Tropical America is home to the world's largest surviving tropical forest, a resource under increasing pressure from shifting cultivators and migrant landless poor, as well as from speculators and commercial entrepreneurs. Both within and outside the region, there is growing concern about the environmental consequences of these increasing pressures.

In addition to land speculators attracted by policy incentives, many immigrants to the forest are resource-poor farmers from the Andean hillsides, forced to abandon their holdings because of soil degradation or lack of adequate water supply. Others have chosen to leave overcrowded, poverty-stricken areas in Brazil, joining voluntary resettlement schemes in search of a better life. Technologies for the permanent settlement of shifting cultivators are necessary to reduce their encroachment on the forest.

An attractive alternative to clearing more forest for commercial exploitation is to develop the acid-soil savannas, which cover vast, currently underexploited areas of tropical South America. However, for most areas, the right policy incentives and infrastructure, as well as the right technologies, have yet to be put in place if the viable and stable development of the savannas is to be accomplished.

As stated in CIAT's strategic plan for the 1990s, the goal for research in this area is

> "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 social returns to agriculture under different trade-off scenarios between production and conservation. These land use options 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 and economically viable production systems.

"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 interdisciplinary research team. 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 programs will work in close cooperation with each other, with the Land Use Program calling on the research findings of the Agroecosystems Programs and providing them with comparative studies.

Land Use Program

Goal

To contribute to the lasting productivity of land resources in tropical America. This will be achieved through improved understanding of the impact of human activities on the resource base and consequent appropriate policy formulations and technology design.

Strategy

Degradation of the natural resource base and long-term sustainability of agriculture are both determined by a complex interaction among changes in production technology, socioeconomic trends, and policy environment. Therefore research on agricultural production alone cannot be expected to handle trade-offs between resource maintenance and productivity.

Land Use Program research on the impact of policy and technology on resource management will be a direct input to the Forest Margins, Hillsides, and Savannas programs. By concentrating on the analysis of resource use at the ecosystem, regional, and continental levels, it will complement the Agroecosystem Programs, which focus on resource productivity relations at the farm level, and the commodity programs, which emphasize improvement of system components.

Land Use Program studies of land use patterns and their interactions with policy and socioeconomic trends will provide a perspective both for designing production technology in light of its ecological consequences and for identifying appropriate land use strategies and policies. While the Land Use Program's major expertise will be an analysis of resource management, it will have sufficient internal capacity on agriculture to complement effectively the agroecosystems and commodity programs, whose principal expertise will be on agricultural technology. The program will work in partnership with natural resource and agricultural research institutions in tropical America, as well as with international organizations such as FAO (Food and Agriculture Organization of the United

Nations), the International Food Policy Research Institute (IFPRI), and the new CGIAR forestry initiative.

Objective 1. Understand the dynamics of land use in tropical America

Frontier settlement, disturbance of natural environments, introduction of new crops and technologies, massive population movements, and rapid economic change all combine to make land use in tropical America an extraordinarily dynamic process. These patterns of change in land use have not been systematically characterized; neither are the determinants of rates and direction of change well understood.

Activity 1. Identify trends in land use patterns

Land use over time, the physical environment, the development of economic infrastructure, and demographic pressures will be characterized, with strong emphasis on developing geographical information systems. The existing CIAT agroecological database on tropical climates, soils, and crops will be expanded, making use of primary and secondary data and remote sensing.

The program will assist the Agroecosystem Programs in selecting regions for case studies and in prioritizing problems across agroecosystems. It will also assist germplasm development programs in agroecological analysis and definition of environmental homologues.

Activity 2. Analyze causal relations among agricultural technology, socioeconomic trends, policy, and land use

Geographical and economic modeling will be utilized to elucidate the historical determinants of land use patterns. The influence of the physical resource base on land use, changes in production technology, development of infrastructure, direct land tenure policies, and indirect policies such as exchange rates will be assessed.

This research will help determine the relative importance of factors determining land use and the optimal methods for modifying it. Priority will be given to the Agroecosystem Programs' target regions.

Activity 3. Measure social costs of land use practices

A broad range of existing land use practices are contributing to degradation of natural resources with widely varying social costs and at highly variable rates. The program will examine these practices and the discrepancies among values for social and private use of natural resources. These studies will show which natural resources are at greatest risk and which land use practices are most deleterious, and suggest where interventions are most needed to adjust imbalances between social and private costs. Conventional economic evaluation of resources will need to be complemented with innovative measurements of environmental impact. These results will contribute to prioritization of research issues in the Agroecosystem Programs.

Objective 2. Appraise policy alternatives for improved land use

Policy is often the crucial determinant of resource utilization; it largely determines access to natural resources and influences the

level of returns to private exploitation of land resources. Much of the policy affecting resource use is framed within objectives that lead to unexpected and unintended land use implications. Attention will be paid to policies regulating access to land as well as those affecting prices, credit, and infrastructure investment.

Activity 1. Conduct comparative and historical studies of policy impact on land use

Inter-country comparisons of policy impact on land use and technology adoption, as well as studies of impact over time on the same environment of different policies, will provide insight into policy and land use relationships.

Understanding the behavior and objectives of farmers as land resource managers will help clarify the links between policy and resource use. Likewise, agricultural technology has a major impact on land use, and policy is often key in determining the economic advantages of alternative technologies.

Policies must be understood not only with respect to their impact on land use but also in terms of the socioeconomic forces and objectives underpinning them. These may constitute more important priorities for policy makers than land use outcomes; thus, such factors must be taken into account when devising sound land use policies.

Spatial models will be developed to reflect the costs and benefits of policy and technology alternatives. These models will require innovative interdisciplinary inputs to integrate crop and farm systems with regional environmental impact and socioeconomic variables.

Activity 2. Support national and regional entities to design alternative land use outcomes

Both natural resource management and agricultural policy institutions are responsible for policies affecting land use. The program will identify institutions interested in participating in land use policy studies; although the program will not make policy recommendations, it will focus on methodologies to assist national policy analysts in presenting policy makers with a range of options and assessment of their probable impact on land use. Different policy implications for technology design and transfer will be examined, particularly in reference to the environmental impact of agricultural production.

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

New crops, plant varieties, management practices, and spatial and temporal arrangements of production systems greatly influence land use and resource degradation. Agricultural production techniques have been changing rapidly in tropical America, with minimal attention to their impact on the resource base. Thus ongoing research to increase agricultural productivity should take into account the ecological impact of new technology.

Activity 1. Orient design of new agricultural technology to optimize land use practices

Based on studies of land use trends and the social cost of existing land use practices, the program will assist in designing parameters for new agricultural technology. Together with the agroecosystem and germplasm programs, as well as the national research

institutions, the program will help evaluate the expected environmental impact of prototype technologies to ensure that they are designed to increase productivity while at the same time conserving the resource base.

Activity 2. Monitor effects of new technologies on the resource base

Ex ante assessment of the impact of new technology on natural resources is a highly imperfect art. In the context of rapid technical change, the program will assist in adoption studies of new technology, focusing on changes in land use patterns and environmental impact within a regional framework.

Objective 4. Strengthen national capacity to improve land resource management

Land in tropical America is the resource on which people depend for their well-being. They are principally responsible for the proper management of this resource. Consequently, the enhanced capacity of institutions and people in tropical America to manage technical and socioeconomic change is the most important determinant of sound management of the region's land resources.

Activity 1. Develop human and institutional resources through collaborative research and information exchange

The bulk of research will be carried out by the program in collaboration with national institutions. All partners will have distinct comparative advantages, and all will profit from working together. The program will conduct strategic research to elucidate priority issues and develop methodologies, whereas national partners will focus on solving country-specific problems. The program will encourage the exchange among national programs of lessons learned from these collaborative experiences.

Activity 2. Facilitate articulation among agricultural research, resource management, and policy institutions

Land use is affected by the actions of many entities, which often do not operate in a coordinated fashion. Information exchange through workshops, publications, and other media will help bring together the major actors in land use--both to increase their understanding of the complex issues involved and to provide a forum for initiating actions to solve common problems.

Resource Allocation and Requirements

The expected evolution of resource utilization in the Land Use Program during 1992-1996, in terms of "activities" as defined by the CGIAR (see Appendix), appears in Table 13.

Senior Staff positions scheduled for the execution of the Land Use Program's operational plan during 1992-1996, and the costs associated with the various research sections, appear in Table 14.

Description of Senior Staff Positions

Office of Leader. Responsible for providing overall guidance and coordination in design and implementation of interdisciplinary, interinstitutional research on land use; principally responsible for developing and implementing strategy to strengthen capacity for land use analysis in national and regional institutions, as well as for coordinating with other CIAT units.

Table 13. Land Use Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
2. Ecological characterization	-	-	35.0	-	-	-	25.0	-	-	-	20.0	-
4. Natural forest ecology and management	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
8. Land use management	-	-	20.0	-	-	-	20.0	-	-	-	20.0	-
VII. Research on human linkages												
2. Other linkages	-	-	-	-	-	-	5.0	-	-	-	5.0	-
VIII. Socioeconomic and policy research												
3. Policy analysis	-	-	15.0	-	-	-	15.0	-	-	-	22.5	-
4. Research on impact	-	-	5.0	-	-	-	5.0	-	-	-	2.5	-
IX. Institution building and networking												
1. Training	-	-	-	-	-	-	5.0	-	-	-	5.0	-
2. Conferences and seminars	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
5. Strengthening national research systems	-	-	10.0	-	-	-	10.0	-	-	-	10.0	-
6. Networks	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
Total	-	-	100.0	-	-	-	100.0	-	-	-	100.0	-
Total Year			100.0				100.0				100.0	

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 14. Land Use Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993[a]		1994[a]		1995[b]		1996[b]	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Office of Leader	–	–	1	160	1	160	1	200	1	200	1	200
Agricultural land use	–	–	1	217	1	217	1	217	1	217	1	217
Environmental geography	–	–	1	225	1	225	1	225	1	225	1	225
Environmental impact	–	–	1	225	1	225	1	225	1	225	1	225
Information management	–	–	–	100	–	100	–	100	–	85	–	–
Resource economics	–	–	1	200	1	200	1	225	1	225	1	225
Economic policy	–	–	1	200	1	200	1	225	1	225	1	225
Sociology	–	–	–	30	–	85	1	225	1	225	1	225
Land use policy (Visiting senior fellow)	–	–	–	–	[1 C]	110	[1 C]	110	[1 E]	–	[1 E]	–
Total	–	–	6	1,357	6	1,522	7	1,752	7	1,627	7	1,542

a. [C] = Core funded.
b. [E] = Endowment funded.

Agricultural land use. Assesses patterns of agricultural land use over space and time; characterizes relations between changes in agricultural technology and land use; and monitors technical change and its impact on land use dynamics. Scientist will have sufficient practical knowledge of agricultural production to interact with agronomists in the Agroecosystem Programs.

Environmental geography. Develops and interprets Geographic Information System (GIS) database on climate, soils, vegetation, and topography; and studies impact of these environmental variables on land use patterns, with particular emphasis on soils and topography under different resource use intensities.

Environmental impact. Appraises effect at regional level of changes in agricultural technology and land use on environment; monitors environmental impact of new technologies and orients design of technology to prevent ecological degradation.

Information management. Manages and integrates unified GIS databases, including environmental variables (climate, soils, vegetation), agricultural variables (crop and land use distribution, technology, rotations, input levels), economic variables (infrastructure, transport costs, land, and other factor costs), and social variables (human settlement, migration, population growth). Develops systems to merge these databases at different levels of aggregation for analysis, ranging from continental to local.

Resource economics. Analyzes land use patterns from an economic perspective,

focusing on influence of land prices and infrastructure development on land use; assesses social costs of resource degradation under varying land uses and agricultural technologies; and identifies regional comparative advantages.

Economic policy. Studies effects of policies--including taxation, credit, infrastructure investment, and subsidies--on land use patterns and agricultural technology, and appraises effect of alternative policy scenarios on land use patterns.

Sociology. Analyzes relations among social variables (migration, settlement, urbanization, demography, population growth), land use patterns, and agricultural technologies; develops database systems on social variables and understand their effect on resource utilization and degradation.

Land use policy (visiting senior fellow). Distinguished decision makers and/or researchers will be invited to study the politics of decision making behind policies related to land use patterns for one year.

Expected Outputs

The information generated by the Land Use Program research is an intermediate output that enhances the productivity of the Agroecosystem Programs, commodity research, and policy formulation. Management strategies or policies that improve natural resource management can have an economic impact measured in hundreds of millians of dollars, and Land Use Program research can make a significant contribution to achieving such success.

The principal outputs of the program within the next five years will include problem prioritization and site selection for the Agroecosystem Programs; development of information and methods of analysis about trends in land use management in Latin America; improved understanding of policy options; and improved efficiency of national institutions working on resource management. The specific outputs expected for the program's four objectives are as follows:

Objective 1. Understand the dynamics of land use in tropical America

* Improved understanding of interactions between human activities and the land resource base
* Better appreciation of social and environmental costs of alternative land resource uses
* Methodological frameworks and information for further land use studies

Objective 2. Appraise policy alternatives for improved land use

* Improved understanding of policy impact on land use
* Alternative policy scenarios to improve land use management

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

* Improved understanding of implications of technical change for natural resources
* Inputs for designing technology for sound land use

Objective 4. Strengthen national capacity to improve land resource management

* Strengthened institutional capacity for land use management
* Tighter linkages among institutions influencing land use

Agroecosystem Programs

Agroecosystem research will be the responsibility of three multidisciplinary programs, working in close association with the Land Use Program. Although each program will focus on a particular ecosystem with its own objectives, it is expected that the program teams will follow a common methodological approach to their work of developing prototypes for sustainable production systems. This common approach will combine farm experimentation in selected catchment areas with specific observations across the ecosystems within a network structure. Site-specific experimentation and observations will produce empirical agroecological and socioeconomic data. These are then analyzed to derive principles in the form of stochastic and deterministic models. Agroecosystem databases are then constructed to interface with regional and global databases. These will be used via GIS to study the relationships between theoretical and field studies with "layers" of information used to test hypotheses on the impact of land use on production and conservation at different levels of aggregation.

Objectives

Each of the three Agroecosystem Programs and the Land Use Program has its own specific objectives (see Box 3), which are highly complementary and closely interlinked with those of the other CIAT programs. It is expected that these objectives are also highly complementary with those of sister centers, particularly those working in forestry and agroforestry.

Operational Stages

Once the program teams are assembled, strategic objectives for each team will be pursued through activities carried out in four main stages: (1) inventory and analysis of ongoing activities for observational studies; (2) selection of research sites for detailed experimentation; (3) diagnosis of land use systems and design of management alternatives; and (4) generation of prototype technologies. Although these four stages are presented as a logical sequence of steps, it is recognized that the process is dynamic and iterative. A multi-institutional approach to resource management, as proposed here, will promote the integration of the R & D experiences of different actors working under diverse conditions within each of the agroecosystems in order to assure that continuous monitoring of rapidly changing production systems provides adequate feedback. Program activities follow the stages described for the three agroecosystems. Available knowledge for each stage differs across ecosystems; thus, efforts to achieve expected outputs will differ.

Stage 1. Characterize land use systems

Preliminary characterization of existing farming systems in terms of productivity, equity, and conservation is the first step in the process of identifying and designing sustainable production alternatives. This will be done mainly through the collection, analysis, and interpretation of primary data as well as existing published and secondary information. Information management systems for selected areas will be organized so that the interrelationships between

Box 3. Objectives of the Land Use and Agroecosystem Programs.

Land Use	Forest Margins	Hillsides	Savannas
1. Understand the dynamics of land use.	1. Assess the possible social and environmental impact of technological innovation on shifting cultivation.	1. Characterize the mechanisms leading to resource degradation and assess technological options.	1. Identify key agricultural sustainability problems and development opportunities in the acid-soil savannas.
2. Appraise policy alternatives for improved land use.	2. Reduce the destructive effects of shifting cultivation.	2. Generate agroecologically and economically viable components, acceptable to farmers, for soil and water conservation and management practices.	2. Design technological interventions tailored to savanna environments to increase productivity, while preventing or reversing resource degradation.
3. Assess the impact on land use of new technologies and policies.	3. Assist in the development of improved land use strategies in humid forest areas.	3. Strengthen the capacity of national systems to generate and transfer resource-enhancing technology.	3. Understand the biophysical aspects of savanna production systems and their management for sustainable production.
4. Strengthen national capacity to improve land resource management.	4. Strengthen national capabilities for improving forest-margin production systems.		4. Strengthen national capacities for designing and monitoring savanna productions systems.

SOURCE: CIAT in the 1990s and Beyond: A Strategic Plan.

pressure on the resource base and land use patterns can be understood, with particular reference to existing constraints and opportunities for system intervention. These information systems will catalog any existent sustainable land use technologies by areas of potential application.

Activities

Activities should be classified according to broad agroecological and socioeconomic parameters. This information will provide the following overall framework:

* Environmental--climate, soil type, and topography
* Socioeconomic--population pressure and marketing opportunities
* System--on-farm and off-farm components and spatial arrangements (structure)
* Technological--inputs, management, and outputs, including their evolution over time

Land use inventories within agroecosystems will be built upon the agroecozone characterization work done by the Agroecological Studies Unit for CIAT's strategic planning exercise. They include the inventory of land management research done by governmental and nongovernmental organizations, as well as by the informal farm sector. The following information will be required:

* Further characterization of the most important land use systems within the ecosystem, as determined by the combination of land units (set by the physical environment) with management units (production objectives and resources)
* Identification of land use-related institutions and/or projects or communities operating in each agroecozone
* Assembling and coordinating teams of interested parties that can be contracted to characterize resource management components and practices by using a common methodology

Stage 2. Select research study areas

The land use systems described in the inventory stage constitute the subject of interinstitutional activities seeking to identify experimental sites. Because land use studies examine the ecological implications of technologies on the environment, the experimental sites used must include several farms within a catchment context, their selection being guided by a set of criteria that include:

* Size of the area
* Perceived urgency of problems and opportunities identified
* Extent to which possible solutions are researchable and can be extrapolated to other regions and countries
* Available knowledge about the region
* In-house expertise
* Presence of potential institutional partners
* Logistical aspects such as accessibility and security

Selection of research areas entails a number of interrelated processes to identify specific sites (catchments) and institutional partners for each of the three main agroecosystems. Such processes include institutional reconnaissance and area selection studies, which will run concurrently. Activities in

this area will be carried out jointly with the Land Use Program and concurrently with those activities described under Stage 1.

Research policy, organization, and interinstitutional arrangements are the main components in developing ecoregional mechanisms for sustainable agriculture. Two distinguishing features of this approach are institutional *participation* throughout the whole process, ranging from technology design to application; and *complementarity* among partners in the generation and transfer stages within a comparative-advantage framework. The process implies a common research agenda with complementary activities pursued independently but in concert.

Careful selection of a few partner institutions is key to the proposed integrated approach. Selection criteria will depend on the stage of research; e.g., for the planning stage, a combination of institutions having diagnostic expertise and abilities to articulate farmers' perceptions, interpret policy makers' decisions, and detect researchable issues would be needed. The implementation stage, in turn, requires mature institutions that combine proven expertise in the planned activities with full commitment to the researchable issues selected.

Institutional reconnaissance will be carried out to identify and establish effective links with institutions interested in joint resource management activities. Discussion and identification of common interests, objectives, and working hypotheses will determine a preliminary research agenda to be agreed upon on the basis of comparative advantage and resources.

Logistical considerations indicate that only two experimental sites should be selected for each agroecosystem. They should comprise a minimal number of contrasting situations, depending on differing pressures on the resource base, farmers' responses to these pressures, and available technologies. Because CIAT is international in nature, the sites for each agroecosystem will be located in at least two different countries. It would be advisable for one site for each agroecosystem to be in Colombia, on the basis of proximity to headquarters and opportunity for use as a training grounds. However, the Caquetá area in Colombia is not representative of the forest margins ecosystem. In the case of savannas, the second choice is clearly Brazil, given the relevance of the Cerrados for that agroecosystem. Central America appears particularly suitable as a second location for forest margins and hillsides, given their relevance for the subregional economy and their influence on prevailing land use patterns.

In principle, sites may be located in:

* The Brazilian Amazon and Central America for forest margins
* Central America and the Colombian Andes for hillsides
* The Colombian Llanos and Brazilian Cerrados for savannas

Another principle is to use, as experimental sites, the existing stations managed by national partner institutions. Although major investments will be avoided, additional capital will be required to adapt or improve facilities at these stations.

Activities

Savannas Program. Activities are at the technology generation stage, although most of those planned for site selection have not been developed.

Forest Margins and Hillsides programs. Activities related to Stages 1 and 2 will be developed together for both ecosystems. This is based on the hypothesis that land use issues in the two ecosystems are interrelated and that there will be spillover effects in terms of social behavior and ecological relationships. Moreover, the synergism expected from such joint analyses and activities and the similarity in expertise required would result in a more efficient and effective use of scarce human resources.

Stage 3. Diagnose land use systems and design management alternatives

Diagnosis should precede the design of appropriate technologies. First, land use problems are identified at the farm level, e.g., food shortages, inadequate or unreliable income, or soil degradation. Parallel to these problems, there may also be problems at the catchment level, beyond the control of the individual farmers, e.g., downstream silting, lack of adequate marketing facilities for cash crops, or land ownership patterns.

Potential for removing constraints in existing technologies or for new land management patterns leads to the design of specifications for appropriate technological interventions in the system. On the basis of such specifications, design starts with technology appraisal, based on technical knowledge from CIAT's commodity programs, partner research institutions, and farm experience. Technology design per se combines selected technologies to improve land use systems. Identifying the private and social costs and benefits of such systems is essential if production technologies and land use patterns are to reduce discrepancies between often-conflicting social and private interests.

Production technologies for improving productivity in specific areas should exploit natural biological processes to both make efficient use of endogenous nutrients, light, and water and increase protection against pests. By exploiting biological processes, technologies should reduce economic risks and protect the resource base. Multispecies combinations or polycultures, by imitating natural vegetation complexes, could accomplish such ecological functions, but at the cost of the higher yields obtained in monoculture systems. Combinations of two or more technologies in land use patterns may be the optimal selection. The application of different technologies within agroecosystems, each focusing on microareas and adapted to farmers' constraints, would result in a landscape mosaic of mutually sustainable production systems.

CIAT, as an international center, should avoid the risk of location specificity by encouraging the Agroecosystem Programs to research the relationships from which ecological principles can be derived, and then apply those principles to the design of prototype models adapted to particular landscapes. The following relationships seem relevant:

* Species diversity in space or time (e.g., agroforestry, ley farming) with landscape stability
* Natural biological processes with crop yields
* Economic production with ecological protection

Diagnoses will be undertaken for each of the three agroecosystems after study areas have been selected.

Activities

Activities for this stage will involve the assessment of farming systems problems and opportunities, leading to the development of hypotheses for more sustainable land use patterns and corresponding production systems in accord with the programs' main strategic objectives (see Box 3). They will involve:

* Exploratory rapid appraisals to develop simple, empirical models for ex ante analysis of alternative farming/land use systems

* Analysis of the various technological components in production alternatives in order to understand soil/plant interactions as affected by resource management alternatives

* Workshops, one for each ecosystem, to discuss with partner institutions problems and opportunities of agroecosystems research for the purpose of identifying alternative research approaches, common hypotheses and research agendas, appropriate division of labor, and potential experimental sites

* Preparation of interinstitutional research projects for submission to appropriate donors

Stage 4. Generate prototype technologies

Although institutional responsibilities will result from concerted efforts with partner institutions, CIAT's comparative advantage lies in strategic research aimed at understanding soil/water/plant relationships and farmer behavioral patterns.

* Soil/water/plant relationships

  - Descriptions of nutrient levels, organic matter, biota, and hydrologic and physical characteristics of representative soils in land units within each ecosystem in order to document changes in the dynamics of nutrient cycling and plant growth in relevant production systems under prevailing management options and different land use intensities

  - Identification of key processes and their functional relationships for increasing productivity while conserving the resource base of each ecosystem

  - Construction of models to describe the dynamics of soil organic matter, nutrients, water, and plant growth in multispecies technologies and land use patterns for sustainable production

* Farmer behavioral patterns

Frequently, management practices leading to degradation of the natural resource base are influenced by socioeconomic forces at the farm level. Agroecosystem studies should therefore attempt to understand farmer decision making and its relationship to the depletion of the resource base, the socioeconomic environment, and ecological change. Research will be carried out jointly by the Land Use and Agroecosystem Programs and will focus on the forest margins and hillside zones. The following activities are envisaged:

- Research on land allocation patterns within and across farms in catchment areas; research on different land use intensities among food/cash crops, fallow areas, pasture, and natural vegetation

- Research on time allocation patterns between on- and off-farm activities

- Understanding of the choices made by individual farmers under differing conditions

- Analysis of circumstances behind land use decisions, including, *inter alia*, staple food production, cash surpluses, and risk avoidance

Activities

It would be premature to indicate activities at this stage because sites have not been selected, partners identified, nor common research agendas drawn up.

Staffing Patterns

Staffing of the programs must take into account the specific program, development stage, team deployment, location, and area of expertise:

* For the two-site approach, an unbalanced model will be followed, that is, two-thirds to three-quarters of the staff positions will be based at the main site and the rest at the complementary site, where they will work jointly with other institutions in the same ecosystem.

* The Colombian Llanos, the Brazilian Amazon, and Central America are proposed as main sites for savannas, forest margins, and hillsides, respectively, the first two for obvious reasons, and the third for country and regional balance. In Central America, because of geographical proximity of hillsides (main site) and forest margins (complementary site), time allocations across programs for most fields of expertise will result in economies of scale.

* Research sites are envisaged as arenas for joint national and international land use studies. The international team will be staffed mainly by CIAT personnel, supported by expertise from other CGIAR centers, such as in agroforestry/forest ecology (ICRAF and the CGIAR forestry initiative); in livestock and resource management in Central America (CATIE); or in cropping systems (CIMMYT on Central American and Andean maize).

* The combination of permanent and temporary appointments of international staff will change over time, the reason being changing expertise requirements.

* There will be only one team for the first two stages of Forest Margins and Hillsides program development during 1992-1993, which will operate in close relationship with the Land Use Program. The team will operate under a temporary coordinator, which should provide an opportunity for natural leaders to emerge from among the recruited senior staff. By 1994, the

three agroecosystem program leaders are expected to be working in their respective main bases.

* Socioeconomic analyses of land use trends and policies require complementing economic policy and resource economics with expertise in political analysis of related land use policies. A permanent senior fellowship position in the Land Use Program is proposed for distinguished decision makers and/or scholars who wish to make one-year studies of particular policy issues.

Resource Allocation and Requirements

The expected evolution of resource utilization in the three programs during 1992-1996, in terms of "activities" as defined by the CGIAR (see Appendix), appears in Tables 15 to 17.

Tables 18 to 20 show the Senior Staff positions scheduled for the execution of the operational plan of the three programs during 1992-1996, and the costs associated with the various research sections.

Description of Senior Staff Positions*

Office of Leader. Provides guidance and coordinates design and implementation of research on farming systems at the agroecosystem level; promotes and coordinates multidisciplinary and interinstitutional activities; and establishes links with the land use and commodity programs and with other institutions.

Economics. Studies economic performance of alternative farming systems; contributes to development and testing of appropriate models; participates in multidisciplinary characterization of farming system, and their microeconomic, market, and other constraints, and in the prioritization of alternative research strategies; and collaborates in the design and testing of bioeconomic research at the farming system level.

Cropping systems. Studies contribution of selected crops to the performance of alternative farming systems and their requirements, and identifies appropriate niches within the systems; contributes to multidisciplinary characterization of farming systems and design and testing of alternative systems; establishes links with comparable areas of expertise in commodity programs and elsewhere; and participates in selected, highly focused strategic research on soil/plant relations in farming systems.

Soils, management, Forest Margins. Studies physicochemical soil dynamics under a variety of cropping systems and agronomic practices; and determines long-term trends in organic matter, mineral nutrients, and soil structure in terms of viability of sustainable systems.

Soils, management, Hillsides. Studies physicochemical soil dynamics under different management techniques; and determines long-term trends in organic matter, nutrients, and soil structure, with particular attention to erosion control.

* Common to the three programs, except as indicated.

Table 15. Forest Margins Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
2. Ecological characterization	-	-	10.0	-	-	-	-	-	-	-	-	-
6. Soils, conservation and management	-	-	-	-	-	-	20.0	-	-	-	25.0	-
8. Land use management	-	-	10.0	-	-	-	-	-	-	-	-	-
9. Development of production systems for sustainable resource management	-	-	-	-	-	-	15.0	-	-	-	25.0	-
VII. Research on human linkages												
2. Other linkages	-	-	30.0	-	-	-	20.0	-	-	-	15.0	-
VIII. Socioeconomic and policy research												
1. Economic and social analysis at micro-level	-	-	25.0	-	-	-	15.0	-	-	-	10.0	-
2. Market analysis	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
4. Research on impact	-	-	5.0	-	-	-	5.0	-	-	-	5.0	-
IX. Institution building and networking												
1. Training	-	-	-	-	-	-	5.0	-	-	-	5.0	-
5. Strengthening national research systems	-	-	15.0	-	-	-	10.0	-	-	-	5.0	-
6. Networks	-	-	-	-	-	-	5.0	-	-	-	5.0	-
Total	-	-	100.0	-	-	-	100.0	-	-	-	100.0	-
Total Year			100.0				100.0				100.0	

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 16. Hillsides Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
2. Ecological characterization	–	–	10.0	–	–	–	–	–	–	–	–	–
6. Soils, conservation and management	–	–	–	–	–	–	20.0	–	–	–	25.0	–
8. Land use management	–	–	10.0	–	–	–	–	–	–	–	–	–
9. Development of production systems for sustainable resource management	–	–	–	–	–	–	20.0	–	–	–	30.0	–
VII. Research on human linkages												
2. Other linkages	–	–	25.0	–	–	–	15.0	–	–	–	10.0	–
VIII. Socioeconomic and policy research												
1. Economic and social analysis at micro-level	–	–	25.0	–	–	–	15.0	–	–	–	10.0	–
2. Market analysis	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
4. Research on impact	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
IX. Institution building and networking												
1. Training	–	–	–	–	–	–	5.0	–	–	–	5.0	–
5. Strengthening national research systems	–	–	20.0	–	–	–	10.0	–	–	–	5.0	–
6. Networks	–	–	–	–	–	–	5.0	–	–	–	5.0	–
Total	–	–	100.0	–	–	–	100.0	–	–	–	100.0	–
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 17. Savannas Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
6. Soils, conservation and management	–	–	30.0	–	–	–	30.0	–	–	–	25.0	–
7. Water conservation and management	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
9. Development of production systems for sustainable resource management	–	–	40.0	–	–	–	30.0	–	–	–	30.0	–
VII. Research on human linkages												
2. Other linkages	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
VIII. Socioeconomic and policy research												
1. Economic and social analysis at micro-level	–	–	5.0	–	–	–	5.0	–	–	–	10.0	–
2. Market analysis	–	–	–	–	–	–	5.0	–	–	–	5.0	–
4. Research on impact	–	–	–	–	–	–	5.0	–	–	–	5.0	–
IX. Institution building and networking												
1. Training	–	–	–	–	–	–	5.0	–	–	–	5.0	–
5. Strengthening national research systems	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
6. Networks	–	–	10.0	–	–	–	5.0	–	–	–	5.0	–
Total	–	–	100.0	–	–	–	100.0	–	–	–	100.0	–
Total Year			100.0				100.0				100.0	

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 18. Forest Margins Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Office of Leader	–	–	–	–	–	–	1	200	1	200	1	200
Economics	–	–	0.5	113	0.5	113	1.25	281	1.25	281	1.25	281
Cropping systems	–	–	0.5	128	0.5	128	0.5	130	1	255	1	255
Soils, management	–	–	–	–	0.25	150	0.25	150	0.25	150	1.25	319
Agroecology/Agroforestry	–	–	–	–	–	–	1	225	1	225	1	225
Livestock systems	–	–	0.5	108	0.5	108	0.75	191	0.75	191	0.75	191
Anthropology	–	–	0.5	113	0.5	113	1.5	338	1.5	338	1.5	338
Total	–	–	2.0	462	2.25	612	6.25	1,515	6.75	1,640	7.75	1,809

Table 19. Hillsides Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Office of Leader	–	–	–	–	–	–	1	200	1	200	1	200
Economics	–	–	0.5	113	0.5	113	0.75	169	0.75	169	0.75	169
Cropping systems	–	–	0.5	128	0.5	128	0.5	130	1	255	1	255
Soils, management	–	–	–	–	0.75	191	0.75	191	0.75	191	0.75	191
Agroecology/Agroforestry	–	–	–	–	–	–	1	225	1	225	1	250
Livestock systems	–	–	0.5	108	0.5	108	0.25	64	0.25	64	0.25	64
Anthropology	–	–	0.5	113	0.5	113	0.5	180	0.5	180	0.5	180
Total	–	–	2.0	462	2.75	853	4.75	1,159	5.25	1,284	5.25	1,309

Table 20. Savannas Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Office of Leader	–	–	1	180	1	200	1	200	1	200	1	200
Economics	–	–	0.25	120	0.25	140	0.5	180	0.5	180	1.5	300
Cropping systems	–	–	1	255	1	255	1	255	1	255	1	255
Soils, organic matter	–	–	–	–	–	–	–	–	1	255	1	255
Nitrogen cycling	–	–	0.25	51	0.25	51	0.5	101	1	201	1	201
Nutrient cycling	–	–	1	255	1	255	1	255	1	255	1	255
Livestock systems	–	–	1	255	1	255	1	255	1	255	1	255
Ecophysiology	–	–	0.25	57	0.25	57	0.5	114	1	227	1	227
Crop/Pasture systems	–	–	1	200	1	220	1	255	1	255	1	255
Llanos-based research	–	–	–	20	–	20	–	40	–	60	–	60
Total	–	–	5.75	1,373	5.75	1,453	6.5	1,656	8.5	2,143	9.5	2,263

Soils, organic matter, Savannas. In collaboration with other program members, studies long-term trends in physicochemical dynamics of soils under various cropping and grazing systems, with particular emphasis on soil hydrology and physics; describes changes in soil hydrology and physical condition of acid soils of varying textures and slopes as affected by different cropping systems and crop and pasture sequences; and relates changes to measurable soil parameters.

Agroecology/Agroforestry. Participates in system characterization studies and identification of research priorities for arboreal species; carries out interdisciplinary research on integration of crops, livestock, and trees at system level, and contributes to strategic research on biological interrelationships of above components; and establishes links with specialists in other advanced institutions and the Tropical Forages Program.

Nitrogen cycling, Savannas. Studies cycling of nitrogen in tropical acid soils as essential component of sustainable production where inputs are restricted; determines efficiency of nitrogen fixation and nitrogen losses in tropical production systems in order to design stable, economically viable systems; studies processes that control biological fixation, sizes of nitrogen pools in soils and plants, and the fluxes among them; and determines effects of cropping sequences--particularly transfer of legume nitrogen to nonleguminous crops--and of strategic applications of fertilizer nitrogen to crops in the nitrogen cycle, particularly the effects on the fixation process.

Nutrient cycling. Studies mechanism of nutrient cycling in contrasting cropping systems; evaluates nutrient pools and fluxes under contrasting soil systems, crop-pasture rotations, input levels, and crop sequences; and develops and adjusts methodologies and techniques for nutrient cycling research.

Livestock systems. Participates in characterization of existing farming systems and their constraints and opportunities; collaborates in design and testing of alternative farming systems, and investigates interrelationships between fodder crops and livestock at system level; and establishes links with Tropical Forages Program regarding plant/animal interactions.

Anthropology, Forest Margins. Collaborates in multidisciplinary characterization of farming systems, particularly decision-making processes at farm level under different land use intensities; assists in identification of socioeconomic research priorities; and contributes to participatory design and testing of alternative farming systems with emphasis on management implications of new technologies.

Anthropology, Hillsides. Collaborates in multidisciplinary characterization of farming systems; and elucidates decision making at farm level as it relates to varying social systems and land pressures.

Ecophysiology, Savannas. Studies factors influencing relations among plants and their changes caused by variations in soil and aerial environments, especially in perennial agropastoral and silvopastoral systems. Seeks to understand the physiological processes responsible; and, based on this understanding, develops models in association with other team specialists to predict the outcome of particular management strategies.

Crop/Pasture systems, Savannas. Collaborates in design and implementation of characterization studies, and elaborates appropriate database management tools; and, with other team specialists, develops simulation models to describe and test alternative farming systems.

Resource Management Research: Complementary Activities

Forestry-related research

CIAT's strategy in the area of resource management follows a land use approach in order to optimize social returns in the use of the resource base for agriculture. In this land use context, a multiplicity of combinations in time and space among agriculture, agroforestry, and forestry components is found within agroecosystems. Research on both agroecosystems, and combinations of components has been traditionally carried out by separate institutions, making it difficult to analyze their ecological relationships in different landscape arrangements.

In making resource management strategies operational for 1992-1996, CIAT hypothesized that, when designing sustainable land use systems, the objectives of farmers and society should be considered and harmonized so to develop landscape arrangements that combine polycultures and monocultures in space and time. The forestry component should be an integral part in any land use approach in the tropics, particularly for agroecologies such as the humid forests and the hillsides, where trees

play important productive and protective roles.

Trees can make contributions to sustainable land use in a self-sufficient context in three main areas: (1) agroforestry at the farm level, (2) watershed management, and (3) use of natural forest.

Agroforestry (i.e., growing trees on the farm). Activities for the planning period will incorporate expertise from both the Hillsides and Tropical Forages programs: the former will focus on the role of trees in polyculture systems and their management, whereas the Tropical Forages Program will concentrate on selecting forage trees and shrubs for mid-altitude hillsides. Even at this modest level, it is expected that, in order to reach a critical mass, the programs will need the expertise on soils, plants, and socioeconomics available in the Germplasm Development and Resource Management Research divisions, except in the case of forestry aspects.

Watershed management. Research will focus on reducing soil erosion and downstream losses by identifying and quantifying upstream and downstream interrelationships.

Use of natural forest. Tropical rain forests in Latin America constitute the world's richest source of plant and animal life, constituting a vital reservoir of genetic resources. Widespread forest clearance is disrupting these ecosystems and contributing to the loss of global biological diversity and, possibly, to global warming. Research must relate to more effective conservation of tropical forest ecosystems through the development of sustainable management systems, including by-product extraction.

For both watershed and forest management, there is a need to strengthen research on the linkages among forestry and other development sectors.

Although it may not be comparatively advantageous for CIAT to develop expertise in each of these areas, there is a need for a minimal cadre of in-house experts who can interact with outside colleagues in developing a land use approach, and tap available knowledge and expertise. In this context, it is envisaged that ICRAF and the CGIAR forestry initiative could second staff to CIAT's Resource Management Research Division; otherwise, other sources will have to be explored for the expertise required for research on land use in tropical America.

The corresponding budget for this minimal research cadre appears in Table 21. Descriptions of these positions follow.

Tree expertise. Does seed collection and storage, as well as measures performance of provenance trials of native and exotic species.

Silviculture. Studies nursery practices, tree establishment in adverse sites, and afforestation and reforestation techniques.

Forest ecosystems. Establishes ecological foundations for sound and sustainable management practices, maintaining the biological diversity within the natural forest and improving the quality of life for the population living there.

Forest policy. Studies land use regulations, land and tree tenure policies, pricing policies, and administrative reforms.

Network coordination. Promotes complementary research activities by national institutions, provided they have access to resources that enable them to participate.

Table 21. Resource Management Division. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position [a]	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Tree specialist (H)	–	–	1	225	1	225	1	225	1	225	1	225
Silviculture (H)	–	–	1	225	1	225	1	225	1	225	1	225
Forest ecosystems (FM)	–	–	0.25	56	0.25	56	0.5	113	1	225	1	225
Forest policy (LU)	–	–	1	225	1	225	1	225	1	225	1	225
Network coordination (FM)	–	–	–	–	–	200	–	200	–	200	–	200
Soybean (S)	–	–	–	–	1	350	1	350	1	350	1	350
Sorghum (S)	–	–	–	–	1	320	1	320	1	320	1	320
Total	–	–	3.25	731	5.25	1,601	5.5	1,658	6	1,770	6	1,770

a. (FM) = Forest margins; (H) = Hillsides; (LU) = Land use; (S) = Savannas.

Research in strategic commodities

In CIAT's strategic plan, the critical importance of sorghum and soybeans for tropical and subtropical Latin America was identified. In particular, the future potential of these two crops as components of sustainable cropping systems for the acid and moderately acid soils of the tropical savannas was emphasized.

Activity 1. Research on sorghum for the Latin American savannas

Sorghum research in Latin America and the Caribbean has not developed in line with the present and future potential of the crop. International and national research are underfunded, and regional cooperation needs to be strengthened. CIAT plans to participate in a future effort through its contribution to integrating modern sorghum technology into production systems for the savannas. ICRISAT, INTSORMIL, and national programs in Central and South America will all be important actors in any subregional effort that is developed. CLAIS (Comisión Latinoamericana de Investigación en Sorgo) may well be the umbrella under which a savanna program materializes. The contribution of CIAT to this agroecosystem-focused program is projected to be equivalent to one Senior Staff position and associated support. The role of the scientist will be defined more clearly once the shape and size of the effort have been decided. The focus of CIAT's work will be to ensure that sorghum becomes a key component of tropical acid-soil savannas. In view of the fact that the CIAT Rice Program is already involved in very similar research for upland rice, it is proposed that this complementary activity be associated operationally with that program, as well as with that of the Savannas.

Activity 2. Research on soybeans for Latin American savannas

Like sorghum, soybeans have not received international or national attention commensurate with their potential in the region. Brazil and Colombia have developed national research efforts, but regional cooperation is just beginning. CIAT proposes to develop a complementary activity that would involve leading national programs in the region, specifically designed to strengthen research on tropical soybeans focusing on acid-soil savannas. The proposed level of CIAT contribution to this effort would be equivalent to one Senior Staff position and associated support. The focus of the CIAT contribution will specifically be directed at integrating soybean technology into sustainable cropping systems for the savannas. In view of the fact that the CIAT Bean Program is developing acid-soil tolerance in *Phaseolus*, there will be definite complementarity between these activities. The outcomes of soybean research will be integrated closely with the ongoing activities of the Savannas Program.

Expected Outputs

Stage 1. Characterization of land use systems for better selection of study areas, by the end of 1992, including:

* Identification and description of representative agroecozones and prevailing land use patterns, including preliminary understanding of their structure and function.

* Identification of institutional partners and definition of their commitments.

Stage 2. Selection of study areas:

* In the savannas, to be ready by the end of 1992, counting on the vast accumulated knowledge and institutional relations

* In the forest margins and hillsides, to have been selected by the end of 1993.

Stage 3. Diagnosis and design: Technological hypotheses in the form of:

* Alternative models for sustainable land use patterns in space and time, indicating prospective components, arrangements, and their succession.

* Sets of management technologies that alone, or combined with others, would improve productivity and conserve or even enhance the resource base.

* Components, arrangements, and management systems for the savannas will be developed by mid-1993 as other alternatives to ley-farming rice-pastures technologies that have been designed and are being tested in the field.

* Design of alternative land use patterns and technology will be completed by the end of 1994. The weight of political and social issues affecting farmers' behavior in the forest margins will require thorough socioeconomic analysis before technological alternatives can be designed.

* Assessment of resource degradation and evaluation of corrective efforts to design alternatives for hillsides should be accomplished by the end of 1993. In contrast to the other agroecosystems, hillsides have already been the subject of massive research and development efforts to counteract resource degradation. Their problems, however, continue to worsen.

Stage 4. Prototype technologies

The operational objective is to initiate on-station and on-farm experiments by 1995 at all six sites across the agroecosystems, relating them to experiments in three subregional networks. For the savannas, this should occur early in 1993, with activities continuing and expanding elsewhere in the Cerrados and Llanos. In the hillsides, this would be achieved early in 1994, and in the forest margins late in 1994.

Chapter 4

INSTITUTIONAL DEVELOPMENT

CIAT's strategic plan for the 1990s describes two interrelated basic shift underlying the center's approach to technology development. They are: an increased emphasis on the context, or system, in which agricultural development occurs; and the realization that integrated solution models require the participation of many actors. In the case of commodity research, the systems approach focuses on germplasm development and component technologies for specific agroecological production environments. In the case of resource management research, this perspective focuses on selected, important agroecosystems within which resource management problems can be coherently approached. The second shift in approach implies that technology generation is a highly participatory endeavor in which interinstitutional coordination and mutual support are as important as the research activities themselves.

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 other institutions' 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.

Consequently, the center plans to contribute to interinstitutional work by engaging in various roles that would advocate the need for research and development in CIAT's commodity and agroecosystem domains; develop international information support mechanisms; and provide training in areas of CIAT research.

Although the various institutional development roles are assumed by the respective research programs and the center as a whole, a well-defined support program -described below- assists them to exercise these roles effectively.

Institutional Development Support Program (IDSP)

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.

Objectives and Strategies

1. Strengthen national research institutions by means of advanced training of scientists and delivery of specialized information through documentation systems, library-based services, and publications

2. Enhance the efficiency of national research systems and facilitate their linkages with development activities through multi-institutional collaborative projects

3. Contribute to the development of seed supply systems for small farmer circumstances by assisting in the formation of small seed enterprises

4. Contribute to the formation and strengthening of national and regional training bodies to train professionals dedicated to commodity production and adaptive research

Activities

Activity 1. Training

Human resource development through training is required for the achievement of the above objectives, especially as it relates to numbers 1 and 4. For Strategy 1, the main objective is to move gradually from a general to a specialized focus; specialized training on introductory research will be phased out as it is taken over by national or regional institutions. At the same time, individualized training at headquarters will become highly specialized, focusing on mid-career scientists, and master's and doctoral candidates. As many as one hundred such trainees would be expected every year once the shift from introductory to advanced training is accomplished.

Group training will also become more advanced and specialized. In this process, the number of courses will decrease from the former four or five to three advanced courses per year for about 60 participants.

Activity 2. Training of trainers

With respect to Strategy 4, the objective is to phase out training of technology intermediaries and entry-level researchers. A two-pronged approach will be followed: encouraging institutionalization of national and regional training bodies for entry-level researchers and technology intermediaries; and training trainers in research and production methods, course organization, and adult education. These efforts will be accompanied by the development of training materials to be used by the new trainers.

A major effort in training trainers will be made in 1992-1994. It will focus on commodity-specific training programs at subregional levels where a cadre of commodity specialists exists and there is political support for such efforts. This is the case in Central America and the Caribbean for beans, the northern Andes for rice, and the Southern Cone for cassava.

As the training trainers effort gathers momentum, support to in-country commodity production courses will gradually decrease. While they coexist, training trainers and in-country training will require a slight increase in support staff and operating funds.

Activity 3. Conferences

Conferences are a major tool to facilitate interactions among CIAT, its partners, and other stakeholders in the form of information exchange, discussion of research issues, and interinstitutional cooperation. The program's support for conferences includes planning, logistics, and assistance in facilitating participant interaction.

During the last decade, CIAT held an average of four "large" and four "small" conferences per year, each with approximately 80 and 15 participants, respectively. During the planning period, the number of conferences for the Germplasm Development Division is likely to stay at that level. The reduction in applied and adaptive research meetings will be offset by an

increase in advanced research network meetings. In addition, the Resource Management Research Division will convene about eight meetings per year; thus, an increase in conference resources will be needed.

Activity 4. Communications

Information gathering and dissemination are, respectively, an input to and an output of CIAT's program strategies. Communication media production for both purposes is the responsibility of the IDSP. The main communication objective will be to serve a larger and more diversified audience with products targeted to specific audience subgroups.

A new audience will join the traditional commodity research audience: that of natural resource researchers and technology intermediaries and professionals in higher education. In addition, CIAT's shareholders, national and international decision makers, and public opinion groups at large must be informed on the center's activities with a view to sustaining and strengthening their favorable attitude toward CIAT.

The contents of communication media will include, *inter alia*, consolidated research results, research methods, commodity trends, sustainable agriculture, management characteristics of technologies, seed-embodied technologies, collaborative research activities, and scientific events. Formats and types of communication media will include bulletins, monographs, reports, manuals, proceedings, catalogs, newsletters, audiovisual units, videotapes, and diskettes.

Activity 5. Bibliographic information services

Rapid access to worldwide bibliographic information is essential for CIAT scientists: this is the central responsibility of the program's Information Unit. These services are shared with national program colleagues, thus contributing to Strategies 1 and 2. Other contributions are networking with national program libraries, training their staff in advanced information management, and assisting national program scientists in accessing bibliographic sources.

CIAT's bibliographic information services have been recently modernized. Future activities will seek to keep CIAT at the forefront of information management developments; to further facilitate access by national program members to CIAT's information resources; and to enhance national program information systems through networking, training, and role modeling.

Information products and services are current awareness publications (on paper or diskette); national, commodity-oriented bibliographies; quick bibliographies on current commodity-related topics of interest; bibliographic searches in the center's databases (CATAL, CINFOS, SERIAD) and CD-ROM databases; worldwide on-line searches in external databases; and photocopy services.

Activity 6. Support through interinstitutional mechanisms

CIAT has a strong record of successful networking and interinstitutional cooperation. Collaboration in this area will increase, particularly in resource management research.

Interinstitutional efforts will be supported by the IDSP with partner identification, project

design, and establishment of effective interinstitutional linkages. Each collaborative project will therefore receive enhanced performance planning and monitoring that will contribute to increasing the project's accountability. Interinstitutional projects will be used as training grounds for national program scientists and decision makers.

To carry out interinstitutional activities, the IDSP will set up a Project Design Office, having a project design specialist and expertise on interinstitutional mechanisms.

Activity 7. Institutional information system

To support the program's strategies, an information system on partner and collaborating institutions will be established. This system will also assist other CIAT programs' collaborative efforts and help prioritize and target the center's institutional development activities. The system, which will be built upon existing databases and with the cooperation of other programs and units, should be fully operational by 1994.

Activity 8. Development of new seed supply systems

New seed supply systems, based on small enterprises, are necessary to serve the small-farm sector, whose needs are not met by large public or private enterprises. The IDSP, in close collaboration with CIAT's research programs and other international, regional, national, and nongovernmental organizations, will contribute to meeting this need.

Activities will center on developing and promoting new organizational arrangements, based particularly, but not exclusively, on small-farmer organizations. Pilot projects will be established in representative locations in Latin America. Beans and cassava will serve as models for seed enterprises for sexual (grain) and asexual planting materials, respectively. Special attention will be paid to integrating enterprise models with sources of improved germplasm. Organizational innovations will be supported with preharvest, postharvest, and quality-control technologies appropriate for small-scale seed enterprises.

The absence of seed supply organizations is perceived as the limitation to adequate seed supply. The development of these systems will emphasize the design and management of seed supply organizations rather than seed technology per se. Training on this new approach and on results of pilot projects will be offered to approximately 20 professionals each year. Later on, subregional training teams may be trained. Support will be given to an international master's program in seed systems offered by the Colombian National University, Palmira branch.

Resource Allocation and Requirements

The expected evolution of resource utilization in the Institutional Development Support Program during 1992-1996, in terms of "activities" as defined by the CGIAR (see Appendix), appears in Table 22.

Senior Staff positions scheduled for the execution of the operational plan of the Institutional Development Support Program during 1992-1996, and the costs associated with the various research sections, appear in Table 23. A summary description of each Senior Staff position proposed for the planning period under consideration follows.

Table 22. Institutional Development Support Program. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
II. Crop productivity research												
5. Seed technology and production	–	–	10.0	–	–	–	10.0	–	–	–	10.0	–
III. Livestock productivity research												
2. Livestock systems	–	–	1.4	–	–	–	1.4	–	–	–	1.4	–
IX. Institution building and networking												
1. Training	1.0	1.0	31.0	–	1.0	1.0	30.0	–	1.0	1.0	29.0	–
2. Conferences and seminars	1.0	–	6.0	–	1.0	–	7.0	–	1.0	–	7.0	–
3. Documentation and dissemination of information	1.0	1.0	40.0	–	1.0	1.0	40.0	–	1.0	1.0	41.0	–
5. Strengthening national research systems	–	1.0	5.6	–	–	1.0	5.6	–	–	1.0	5.6	–
Total	3.0	3.0	94.0	–	3.0	3.0	94.0	–	3.0	3.0	94.0	–
Total Year	100.0				100.0				100.0			

a. SSA = Sub–Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 23. Institutional Development Support Program. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

Senior Staff Position	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Office of Leader	1	136	1	136	1	136	1	136	1	136	1	136
Training	–	1,038	1	1,173	1	1,173	1	1,173	1	1,173	1	1,143
Conferences	–	204	–	264	–	290	–	290	–	290	–	290
Communications media	1	723	1	723	1	748	1	773	1	773	1	773
Information and documentation	1	552	1	552	1	552	1	552	1	552	1	552
Public affairs	1	218	1	218	1	218	1	218	1	218	1	218
Project design*	–	–	1	–	1	–	1	–	1	–	1	–
Seed supply systems	2	516	2	516	2	516	2	516	2	516	2	516
Total	6	3,387	8	3,582	8	3,633	8	3,658	8	3,658	8	3,628

* = Paid from indirect costs recovery.

Description of Senior Staff Positions

Office of Leader. Gives strategic leadership to the program in close collaboration with CIAT's research programs and units.

Training and conferences. Responsible for coordination of postgraduate training and training in adult education, group dynamics, and interpersonal communication skills; and for supervising training support staff.

Communications media. Responsible for developing, producing, and distributing CIAT's research and information output through appropriate communication media.

Information and documentation. Responsible for maintaining bibliographic information services at the technological forefront and for providing necessary guidance and supervision.

Public affairs. Responsible for public information through international media, and for information strategies designed to promote interest in international agricultural research among policy-making groups.

Project design. Provides expertise on project design and development.

Seed supply systems. Develops new seed supply systems and related organizational aspects.

Complementary Activity

CIAT will seek special project funds to undertake a major effort in support of Strategy 1 and corresponding activities, particularly those of training trainers. This effort aims to consolidate national programs' capacity to train their own technology transfer cadres. The resulting training teams will undertake responsibilities that were traditionally carried out by CIAT staff, thus relieving the center of a heavy training load.

This activity will be jointly carried out by CIAT and collaborating research and development institutions. It seeks to (1) identify and analyze national and regional training needs and resources for technology transfer; (2) provide groups of qualified professionals with opportunities for training in the planning, execution, and evaluation of training programs and events for technology transfer personnel; and (3) follow up and evaluate the ultimate effect of such training on agronomic practices by farmers and technology transfer agents.

The proposed budget for this complementary activity appears in Table 24. Part of the resources will be for developing training materials that can be used as teaching aids by trainers and as a technology transfer tool by technicians.

Expected Outputs

The IDSP's general output, to be achieved in collaboration with the other CIAT programs, will be national research institutions with an increased technical capacity to perform their role, and more effective and efficient national and regional research systems for sustainable agriculture.

Component outputs for this research institution and systems enhancement will be:

* Trained researchers. Individualized and group training will open about 800 training opportunities for researchers during the planning period. However, the actual number of persons involved

Table 24. Institutional Development Support Program. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

Senior Staff Position	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Training trainers	–	600	–	600	–	100	–	100	–	–	–	–
Total	–	600	–	600	–	100	–	100	–	–	–	–

will be 400-500 because some individuals will participate in sequences of events.

* Subregional training bodies for entry-level researchers and technology intermediaries, endowed with well-prepared trainers and appropriate training materials. Three subregional teams will be formed, with 25 trainers each, equipped with 20 instructional units consisting of written and visual aids and evaluation instruments, and 15 audiovisual units. These training teams are expected to offer commodity-specific production training to about 1400 technology transfer professionals over the planning period.

* Improved access of national professionals to relevant information and greater use of it; national programs supported by a stronger network of agricultural libraries, especially in Latin America and the Caribbean; improved access to information by scientists; and increased information use by research systems.

* Improved communication of CIAT achievements to a larger and more diverse audience, with products targeted to specific subgroups; additional writing and audiovisual production expertise incorporated; and publication facilities upgraded to include desk-top and electronic publishing and printing equipment as required by increasing demand for publications and other media. Production volume is expected to increase by 50% over the planning period.

* Interinstitutional research and development projects.

* New seed supply systems, particularly for small farmers. First, the development of prototypes of small seed enterprises linking germplasm development to farmers who are, at present, not served by existing large-scale enterprises; and, second, professionals trained to adapt and diffuse the prototype models in new locations.

Chapter 5

RESEARCH SUPPORT

Presented here are the Biotechnology Research Unit (BRU), the Genetic Resources Unit (GRU), and the Virology Research Unit (VRU). Within the description of each unit, there are separate tables showing the allocation of resources in terms of "activities" as defined by the CGIAR (see Appendix). Research Support also includes Visiting Scientists and Postdoctorals, Research Services, Research Stations, and Information Management Systems.

Table 25 provides an overall summary of projected budgets for the research support core activities during the planning period. Although the activities are not described in this table, their nature is implicit in the listing under Senior Staff Positions.

Biotechnology Research Unit

Goal

To apply modern biological methods for increasing the efficiency and cost-effectiveness of CIAT's germplasm research. This research aims to assist in developing productive, stress-tolerant germplasm adapted to the agroecosystems where CIAT programs operate. The unit's research priorities are established in relation to those constraints that are best approached through biotechnology.

Strategies

Strategy 1. Integrating biotechnology research at CIAT

Biotechnology methods and tools will be made available to CIAT research programs once the respective technologies have reached operational level. The unit will work on methods and techniques likely to have wide application to CIAT crops, for example, gene mapping and tagging, genetic transformation, wide crossing, and haploid induction. Research to identify the factors involved in selected plant and biotic/abiotic stress interactions aims to develop more efficient techniques for understanding mechanisms and screening for resistances or tolerances. Interaction with advanced research networks will be essential to implement this strategy.

Strategy 2. Networking

Scientists from both developed and developing countries will be consulted to determine priorities for biotechnology research. This exercise will lead to the establishment of international cooperative networks to conduct biotechnology research on specific crops.

Strategy 3. Technology and information transfer

Bridging biotechnology with the national research programs of developing countries will provide training opportunities in biotech methods and techniques. These training activities may take the form of short- and medium-term in-service training, short-term study leave for members of advanced laboratories, and advanced thesis research.

Strategy 4. Awareness of biotechnology issues and research

Table 25. Research Support. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Genetic resources	1	558	1	570	1	570	1	600	1	600	1	600
Biotechnology research												
Office of head/Plant physiology	1	200	1	200	1	200	1	200	1	200	1	200
Biochemistry	1	199	1	199	1	199	1	199	1	199	1	199
Molecular genetics	–	–	1	255	1	255	1	255	1	255	1	255
Virology research												
Virology I	1	173	1	173	1	173	1	173	1	173	1	173
Virology II	1	172	1	172	1	172	1	172	1	172	1	172
Research services	–	315	–	365	–	365	–	365	–	365	–	365
Research stations												
Headquarters	1	568	1	568	1	568	1	568	1	568	1	568
Carimagua – Llanos	–	413	–	413	–	413	–	413	–	413	–	413
Substations in Colombia	–	301	–	301	–	301	–	301	–	301	–	301
New substations for resource mgt.	–	–	–	–	–	–	–	100	–	200	–	200
Information management												
Information mgt. systems												
Coordination	1	279	1	355	1	355	1	355	1	355	1	355
– Microcomputer support	–	75	–	75	–	75	–	75	–	75	–	75
– LAN administration	–	–	–	30	–	50	–	50	–	50	–	50
– Mainframe operation	–	46	–	46	–	46	–	46	–	46	–	46
Support to info. domains	–	65	–	120	–	120	–	120	–	120	–	120
Biometrics	–	140	–	140	–	140	–	140	–	140	–	140
Visiting scientists and postdoctorals	–	506	–	556	–	626	–	626	–	726	–	726
Agroecological studies	2	237	–	–	–	–	–	–	–	–	–	–
Research contracts	–	169	–	–	–	–	–	–	–	–	–	–
Total	9	4,416	8	4,538	8	4,628	8	4,758	8	4,958	8	4,958

The unit will be responsible for keeping CIAT and national program scientists aware of developments on such issues as biosafety, interactions with private sector biotechnology research, and intellectual property protection of plant biotechnology products and processes.

Activities

Activity 1. Genetic resource conservation and management

* Use tissue culture and cryopreservation methods to conserve cassava and selected tropical species such as *Brachiaria* spp.

* Characterize germplasm variability and associated microbial populations genetically by using molecular fingerprinting techniques

Activity 2. Crop productivity research

* Increase the number of molecular markers for the bean molecular map

* Develop molecular linkages (e.g., gene tagging) with important traits for all CIAT crops, especially beans, cassava, and rice

* Broaden the genetic base of CIAT crops through wide crossing (beans and tropical forages) and haploid induction (cassava), focusing on adaptation traits, tolerance and resistance to abiotic and biotic stresses, and important food and feed quality traits

* Identify factors involved in insect and fungal pathogen resistance (e.g., bruchids in beans), plant metabolism by-products (HCN in cassava), photosynthesis intermediates (C3-C4 in cassava), and nutrient uptake efficiency (P in tropical pastures and beans)

Activity 3. Institution building

* Consult with biotechnology scientists from developed and developing countries to organize biotechnology research networks for CIAT crops

* Train national program personnel on applications of biotechnology methods and techniques

* Inform national programs on issues such as biosafety and intellectual property protection and related activities of the international centers

Resource Requirements

The BRU's requirements for core resources are listed in Table 25. A description of the three Senior Staff positions funded with core resources follows:

Head of Unit/Plant physiology. In charge of cell and tissue culture research for wide hybridization, haploid induction, and regeneration of transformed plants; as Head of Unit, responsible for assisting CIAT commodity programs with the organization and initial coordination of the respective biotechnology networks, as well as for coordinating biosafety guidelines and biotechnology training activities.

Plant biochemistry. Provides basic research support to commodity programs in the characterization of plant biotic and abiotic interactions at biochemical and molecular levels, with the aims of identifying the factors involved and helping screening and breeding activities with the use of

immunoassays, genetic probes, and biochemical assays. Provides necessary technical support for genetic manipulation of CIAT crops.

Plant molecular genetics. Develops and exploits the use of molecular genetic markers and maps in plant breeding and germplasm characterization for CIAT's commodity species in order to facilitate gene tagging of important traits and genetic fingerprinting of selected germplasm. Links the unit's and programs' biotechnology activities.

The proposed utilization of the core resources in terms of the CGIAR's definitions of activities (see Appendix) is shown in Table 26.

Complementary Activities

CIAT will seek extra-core resources for the unit as listed in Table 27. Included in these resources is a Senior Staff position for microbial genetics. The principal responsibility of this scientist will be to characterize the genetic mechanisms of plant-microbial associations, with special attention to the rhizosphere. The purpose is to improve uptake and cycling processes of CIAT crops, as well as develop safe biocontrols for pests and pathogens. This scientist will interact closely with CIAT research programs in the areas of microbiology, pathology, entomology, and soil/plant nutrition.

With the availability of the complementary resources described here and those for coordinating advanced research networks (as described under the Bean and Cassava programs), the unit will be in a position to engage in the following additional activities:

Activity 1. Genetic resource conservation and management

* Use molecular markers to characterize, in cooperation with the Rice Program, rice fungal pathogens and, with the Bean Program, bacterial and fungal pathogens in *Phaseolus*

* Use tissue culture techniques to facilitate exchange and conservation of MPFTS in cooperation with the GRU

Activity 2. Crop productivity research

* Develop the molecular linkage map for *Phaseolus* species other than the common bean, beginning with *P. acutifolius*

* Identify and clone economically important common bean genes

* Develop a molecular linkage map for cassava

* Develop and utilize genetic transformation techniques for beans, rice, and tropical forages such as *Brachiaria* and *Arachis*

* Study plant/microbe interactions, especially as they relate to efficient nutrient uptake and cycling and to biocontrol of pests and pathogens

Activity 3. Institution building

* Coordinate network meetings, research projects, training, and production of network communication media

* Conduct short-term advanced training courses on biotechnology methods,

Table 26. Biotechnology Research Unit. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	5.0	10.0	10.0	–	5.0	5.0	10.0	–	5.0	5.0	10.0	–
II. Crop productivity research												
1. Germplasm enhancement and breeding	10.0	10.0	10.0	–	10.0	14.0	21.0	–	10.0	15.0	20.0	–
3. Plant protection	–	5.0	5.0	–	–	5.0	5.0	–	–	5.0	5.0	–
4. Plant nutrition	–	–	5.0	–	–	–	5.0	–	–	–	5.0	–
IX. Institution building and networking												
1. Training	3.0	2.0	5.0	–	5.0	–	5.0	–	5.0	–	5.0	–
2. Conferences and seminars	2.0	1.0	2.0	–	2.0	1.0	2.0	–	2.0	1.0	2.0	–
6. Networks	5.0	5.0	5.0	–	–	–	5.0	–	–	–	5.0	–
Total	25.0	33.0	42.0	–	22.0	25.0	53.0	–	22.0	26.0	52.0	–
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 27. Biotechnology Research. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

Senior Staff Position	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Microbial genetics	–	–	1	215	1	215	1	215	1	215	1	215
DNA fingerprinting	–	100	–	100	–	100	–	100	–	100	–	100
Bean genetic improvement	–	–	–	298	–	298	–	298	–	298	–	298
Total	–	100	1	613	1	613	1	613	1	613	1	613

longer term in-service training, and advanced degree theses

Expected Outputs

* Genetic resources conservation and management

  Methodology for cryopreservation of cassava is well advanced and will allow long-term germplasm conservation that is labor-, space-, and cost-effective, as well as maintenance of the genetic integrity of the world collection with no external influence. This technology will also be implemented for other CIAT crops such as *Brachiaria* spp.

  Fingerprinting techniques, once established, will allow gene pool characterization and phylogenetic studies for both CIAT crops and associated diseases, without having to go through tedious field experimentation or pathogen challenge.

* Crop productivity research

  Research in the area of molecular markers will lead to an accurate localization of agronomic traits of interest within a genetic map of the corresponding crop, with the concomitant utilization of this knowledge in breeding programs. Research on mechanisms will allow efficient screening and better manipulation of traits.

* Institution building

  A two-way bridge between developed country institutions and national programs will be established.

Genetic Resources Unit

Goal

To assemble, conserve, and characterize all critical germplasm resources in *Phaseolus*, *Manihot*, and several genera of tropical forages, and to research those collections so that they can be utilized more fully by international organizations and national programs.

Strategy and Activities

All research activities will focus on aspects of strategic value for future research purposes in collaboration with CIAT's programs and units. The unit's research covers a wide field that includes taxonomy, reproductive biology, evolution, genetic diversity, germplasm conservation methodology, and seed physiology. Ultimately, the unit is responsible for increasing knowledge on germplasm, which, in turn, will help improve efficiency in germplasm management and enhance germplasm use.

Activity 1. *Phaseolus* (bean) germplasm

* Acquisition and introduction

  - *Backlog germplasm.* There are about 6000 bean accessions that were introduced to CIAT but have not passed through the quarantine process and are thus not available for use. This backlog germplasm, introduced mainly from other continents, will be processed under quarantine regulations established by the Instituto Colombiano Agropecuario (ICA). A new quarantine greenhouse in Bogotá will become available early in 1992.

- *Wild* Phaseolus *species*. Even though CIAT does not have a world mandate for wild *Phaseolus* species, this germplasm will become important to the center's strategic research, especially in light of recent biotech developments.

- *Bean genetic stock collection*. The use of genetic stocks--such as biochemical and morphological mutants, isogenic lines, and aneuploids--has been instrumental in modern biology advances. The use of such mutants will become increasingly important for strategic research on common bean germplasm.

* Duplicating the collection and long-term storage capacity

  - *Duplication*. Safe duplication of the collection is being carried out under agreements with CATIE in Costa Rica and the Centro Nacional de Recursos Genéticos (CENARGEN) in Brazil. Thus far, 17,390 and 3019 accessions, respectively, have been sent to these two centers.

  - *Storage*. The GRU has a cold room (-20 °C) for long-term storage of germplasm; however, only 3250 accessions are now stored because of lack of seeds.

* Health status of the collection. Preserving the seed health of germplasm for international exchange is a major concern of the international germplasm community. The unit will soon implement a new system of seed production under strict quarantine conditions and proper pathological checking.

* Core collection. Passport information for germplasm from centers of primary genetic diversity has been updated and will be used as a base for selecting accessions for the core collection, to be established early in 1991. The value of the core collection will be assessed in subsequent years.

* Germplasm research

  - *Outcrossing (allogamy) frequency*. All of CIAT's common bean accessions are grown in the field for seed increase. If outcrossing occurs during seed increase, some of the seeds harvested will be genetically contaminated. Thus, research on allogamy frequency was recently initiated as part of a collaborative project between CIAT and the IBPGR.

  - *Genetic diversity*. Understanding the genetic structure of bean germplasm is key to the efficient management and use of germplasm. Biochemical markers have been successfully used, contributing to better understanding of gene pools and the origin of bean species. In collaboration with the BRU and other advanced laboratories, germplasm will continue to be analyzed, especially with new molecular markers.

  - *Linkage maps of all cultivated bean species*. The use of three cultivated bean species (*P. acutifolius, P. coccineus*, and *P. lunatus*) as sources of important traits for common bean

improvement has been of major interest to bean geneticists. The recent development of an RFLP map for *P. vulgaris* is an opportunity to develop RFLP maps for related species. The maps will provide better understanding of the mechanisms underlying cytogenetic barriers that have prevented the effective use of those species. This work will be carried out in collaboration with the Bean Program and the BRU through complementary funding.

Activity 2. Tropical forage germplasm

* Acquisition and introduction. There are already large comprehensive collections of key tropical legume and grass species. Their growth will diminish in the future, being limited to germplasm essential for filling known genetic or geographic gaps. About 400 accessions from the joint collection missions in the African countries by CIAT and ILCA have yet to be introduced to CIAT. Given the new orientation of CIAT's Tropical Pastures Program (now Tropical Forages Program), new herbaceous germplasm with adaptation potential for higher altitude acid soils will be acquired.

* MPFTS, adapted to acid soils, will also be introduced in collaboration with national and international institutions, such as the International Council for Research in Agroforestry (ICRAF) and the IBPGR. The GRU will assist the Tropical Forages Program in the introduction of material in such aspects as joint collection, coordination with national and international institutions, and quarantine.

* Duplicating the collection and long-term storage. In the past, more than 2300 samples were prepared for safe duplicate deposit even though CIAT had no agreements for safe duplication with other institutions. At present, about 3600 samples are under long-term storage; monitoring of their seed viability will be started. Further efforts for seed increase of key genera will be made.

* Characterization of key genera. CIAT has assembled large collections of grass genera such as *Brachiaria, Hyparrhenia,* and *Panicum*, which play a key role in pasture improvement. However, they still lack proper characterization.

* Documentation and data management

  - *Plant descriptors*. CIAT should take a leading role in developing and establishing plant descriptors for tropical forage germplasm, taking advantage of existing considerable expertise in germplasm characterization and preliminary evaluation.

  - *Characterization and passport data.* Although tropical forage germplasm was characterized by the former Tropical Pastures Program and the GRU, these data are not easily accessible. Passport data of many accessions registered since the 1970s are incomplete.

  - *Computing germplasm management.* For more efficient germplasm management, data on seed increase, distribution, and inventory, as well as from field collections, need to be

correlated with each other and with the general database.

* Germplasm research

  - *Reproductive biology*. A clear understanding of reproductive biology is critical for the proper management of germplasm. In collaboration with the Tropical Forages Program and the BRU, the GRU will investigate reproductive biology (allogamy frequencies, pollination mechanisms, and apomixis) in key species.

  - *Seed physiology*. At present, about 700 species are conserved in the collection; little is known about their seed physiology in short- and long-term storage.

Activity 3. Cassava (*Manihot*) germplasm

The GRU takes responsibility for in vitro cassava germplasm management, whereas the Cassava Program manages the field gene bank and characterization. The unit's tissue culture laboratory has responsibilities for (a) germplasm conservation, (b) pathogen eradication by thermotherapy and meristem culture, and (c) exchange of in vitro germplasm.

* Acquisition and introduction. By 1996, the cassava field gene bank (4677 accessions at present) will have been increased by about 1500 accessions. CIAT will receive about 800 accessions from Brazil in 1991, which will make the collection comprehensive in terms of germplasm from centers of primary genetic diversity.

* Health status of the collection. Germplasm exchange of clonally propagated crops needs extra care. Frog skin disease is of special concern because it is endemic to Colombia and adjacent countries and there is no reliable serological method for detecting it. In collaboration with the VRU, the GRU will "clean" and index all accessions in the gene bank.

* Establishment of a comprehensive wild *Manihot* collection. Although the potential value of wild *Manihot* species as a new source of useful traits for cassava cultivar improvement has been well established, there is no gene bank holding an adequate comprehensive number of wild *Manihot* accessions. At CIAT, only 31 species with a few accessions per species are available even though more than 100 wild species have been reported.

* Duplicating the collection. CIAT's cassava collection is maintained in two gene banks: field and in vitro. Thus, technically speaking, the collection is duplicated and no major worries exist for loss of important germplasm. However, both gene banks are located at CIAT and are not conserved in other places. Two approaches are being considered: first, the Cassava Program will collect open-pollinated true seeds from the field collection to be used as a means of gene conservation; and second, the BRU is developing a cryopreservation technology for cassava, which, if successful, will facilitate duplication of the collection in other places at reduced costs, compared with the meristem culture system.

* Fingerprinting the collection with isozymes. In the past two years, 3239 accessions have been characterized by

esterase isozyme; this will be completed for the remaining accessions by early 1992. Additional isozymes will be analyzed for those accessions suspected to be duplicates.

Resource Requirements

Table 25 shows the resources allocated to the Genetic Resources Unit in terms of Senior Staff positions.

Table 28 describes the expected utilization of resources for the planning period in terms of "activities" as defined by the CGIAR (see Appendix).

Complementary Activities

CIAT will seek extra-core resources for the unit as shown in Table 29. With the availability of complementary resources, as described here, the GRU will be able to implement the following complementary projects:

Activity 1. Sorghum and soybean germplasm

The GRU will assist in the introduction of highly selected (for potential adaptation to acid soils) sorghum and soybean germplasm. Additional resources (greenhouse workers and new quarantine screenhouses) will be added through complementary projects in this area.

Activity 2. Forage germplasm biology

A clear understanding of reproductive biology is very important for managing germplasm. In collaboration with the Forage Germplasm Program, the GRU will investigate reproductive biology (allogamy frequency, pollination mechanisms, apomixis, and genetic structure) in key species.

Activity 3. In vitro management of forage germplasm

In vitro culture is an essential tool for supporting forage genetic resources activities and for overcoming constraints in the provision of forage germplasm. The objective of this complementary project is to develop and establish in vitro culture techniques for the proper management of specific tropical forage germplasm, with special emphasis on some grass and MPFTS species.

Activity 4. *Phaseolus* bean germplasm

Better understanding of the genetic structure of *Phaseolus* spp. is crucial for its effective use in strategic germplasm development. There is a strong need to study further (a) founder effects; (b) origin and gene pools of the four cultivated species in *Phaseolus*; (c) allogamy frequency of bean accessions; (d) genetic structure of wild bean populations; (e) effects of different management practices on gene frequency changes; and (f) application of highly variable DNA markers for fingerprinting of the collection.

Activity 5. Wild cassava germplasm

The potential value of wild *Manihot* spp. as new sources of useful traits for cassava cultivar improvement has been well recognized; however, there is no gene bank holding an adequate comprehensive number of wild *Manihot* accessions. This complementary project aims to (a) establish a comprehensive wild cassava gene bank; (b) develop broad knowledge on crossability of

Table 28. Genetic Resources Unit. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	20.0	20.0	40.0	5.0	20.0	20.0	40.0	5.0	20.0	20.0	40.0	5.0
IX. Institution building and networking												
1. Training	1.0	1.0	2.0	–	1.0	1.0	2.0	–	1.0	1.0	2.0	–
2. Conferences and seminars	1.0	–	4.0	–	1.0	–	4.0	–	1.0	–	4.0	–
6. Networks	2.0	–	4.0	–	1.0	1.0	4.0	–	1.0	1.0	4.0	–
Total	24.0	21.0	50.0	5.0	23.0	22.0	50.0	5.0	23.0	22.0	50.0	5.0
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 29. Genetic Resources. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

Senior Staff Position	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Sorghum and soybean germplasm	–	–	–	80	–	50	–	50	–	–	–	–
Forage germplasm biology	–	–	–	91	–	76	–	76	–	76	–	76
Forage in vitro management	–	–	–	134	–	125	–	134	–	–	–	–
Phaseolus bean germplasm	–	–	–	80	–	80	–	80	–	80	–	80
Wild cassava germplasm	–	–	–	–	–	90	–	80	–	80	–	80
Total	–	–	–	385	–	421	–	420	–	236	–	236

species in the gene bank; and (c) evaluate potential traits in wild species accessions.

Expected Outputs

Activity 1. *Phaseolus* (bean) germplasm

* About 3500 backlog accessions processed and incorporated into the existing collection
* The world's largest collection of wild *Phaseolus* germplasm assembled at CIAT
* The bean genetic stock collection established and seeds distributed to bona fide users; all accessions available for distribution duplicated at CATIE by 1994; and a total of 12,000 accessions duplicated at CENARGEN by 1996
* All accessions with CIAT G number under long-term storage at the end of the planning period
* Availability of approximately 4200 accessions free of bean common mosaic and bean southern mosaic viruses
* Allogamy frequencies estimated for a sample of bean accessions
* Better understanding of the genetic structure of bean populations in nature and in the gene bank
* RFLP maps established, for *P. acutifolius* and two other species, if time permits
* Better knowledge on how to improve efficiency in germplasm introgression

Activity 2. Tropical forage germplasm

* Completion of the collection of key genera as gaps are filled; about 9000 accessions, with emphasis on key genera, duplicated at a reliable institution
* Availability of forage germplasm adapted to tropical acid-soil environments from sea level to 1800 m.a.s.l.
* A collection of MPFTS for tropical acid soils assembled through germplasm exchange and direct collection
* Accessions of key genera conserved in long-term storage; seed viability of samples in long-term storage ascertained
* CIAT's *Brachiaria* and *Panicum* collections characterized for morphological traits
* Publication of plant descriptors for key tropical legume and grass genera in collaboration with the IBPGR; documentation of characterization data for tropical forage germplasm; completion of passport data for accessions registered until 1990, and publication (in collaboration with the Tropical Forages Program) of several regional germplasm catalogs
* Implementation of a computerized system for germplasm management in collaboration with CIAT's Information Management Systems Unit
* Estimation of the allogamy frequencies of key species at CIAT's multiplication sites

* Better understanding of pollination mechanisms; characterization of grass collections for their reproductive mode (sexual versus apomixis)

* Increased knowledge of seed physiology

Activity 3. Cassava (*Manihot*) germplasm

* Consolidation of the world's largest and most comprehensive cultivated cassava germplasm collection

* About 5000 clones properly indexed and ready for exchange as pathogen-tested material

* A comprehensive wild cassava gene bank; potential traits in wild species accessions evaluated.

* Conservation of true seeds of all flowering clones in cold-room storage

* Broad knowledge on crossability of species in the gene bank

* Implementation of cryopreservation for safe and long-term conservation

* The whole collection fingerprinted by esterase isozyme; other isozymes used for additional fingerprinting and genetic diversity studies

Virology Research Unit

Goal

To support CIAT's research programs with the application of virology methods and techniques for detecting, identifying, and controlling viruses of economic or quarantine importance. Specific attention will be given to viruses affecting beans, cassava, rice, and tropical pastures, particularly forage legumes.

Strategies

Strategies comprise the detection, characterization, control, and monitoring of plant viruses.

* *Detection* involves the constant surveying of production areas for beans, cassava, rice, and tropical forage legumes in the main target areas of CIAT's research.

* *Characterization* is performed by maintaining virus isolates under glasshouse conditions and characterizing them through electron microscopy, centrifugation, spectrophotometry, electrophoresis, and molecular characterization; and by producing antisera and radioactive probes.

* *Control and monitoring* involve the identification of sources of resistance and evaluation of breeding materials under artificial (glasshouse, screenhouse, growth room) and field conditions; investigations of modes of transmission (whether mechanical or by insects or seed); implementation of suitable virus detection methods (mainly for quarantine purposes); epidemiological studies; and monitoring of pathogenic variability in key production areas.

Activities

Activity 1. Identification of viruses affecting CIAT's commodities

The VRU will concentrate research efforts on unknown viral pathogens of cassava, particularly the virus complexes found in Colombia; and of tropical forage legumes, with emphasis on species currently exchanged with collaborating national research institutions. Major viral pathogens of tropical pastures should be identified by the end of the planning period.

Activity 2. Characterization of viruses affecting CIAT's commodities (biology)

After viruses have been identified and shown to be important--that is, not opportunistic--they are characterized for pathogenicity, variability, and mode of transmission. They are then physically isolated in order to produce reliable detection methods such as antisera and probes.

A number of bean viruses, such as bean severe and cucumber mosaic viruses, must be fully characterized. The same is true for cassava viruses, found mostly in Latin America, which have only been partially characterized. This activity is expected to be completed by the end of the planning period. The identification and characterization of unknown forage legume viruses among those investigated by the Tropical Pastures Program will continue throughout the planning period. Molecular characterization of the rice "hoja blanca" virus (RHBV) should be completed within the same period.

Activity 3. Search for sources of virus resistance (plant protection components)

This activity will play a major role at the beginning of the planning period in support of CIAT's germplasm development activities. Suitable sources of genetic resistance need to be identified for the following viruses: cassava viruses in general; bean severe, bean yellow, and cucumber mosaic viruses in *P. vulgaris*; and for tropical forages, potyviruses in *Centrosema* and *Stylosanthes* species. In the case of rice, it would be advisable to broaden the crop's genetic base of resistance to RHBV.

Activity 4. Development of reliable virus detection methods for epidemiological and quarantine purposes (ecology)

This is probably the VRU's most constant and resource-demanding activity. All viruses infecting CIAT's commodities--regardless of their economic importance--must be identified for quarantine purposes to guarantee germplasm, introduced or exported by CIAT, as virus free.

The VRU will replenish and produce polyclonal and monoclonal antisera for all viruses it has characterized. The basic antisera collection will increase the unit's capacity to detect viruses that naturally infect CIAT's commodities.

The VRU also plans to expand its capacity to generate radioactive and nonradioactive specific probes for viruses not readily identifiable or detected by serology. The main thrust of this effort is to develop and utilize nucleic acid hybridization techniques for detecting whitefly-transmitted geminiviruses in legumes and viruses in general in cassava.

Activity 5. Implementation of molecular virology and genetic engineering techniques to produce transgenic plants possessing resistance to plant viruses

The recently developed technique of introducing useful foreign genes into plants by ballistic methods has allowed scientists to

regenerate many species, such as those of beans, using tissue culture techniques.

The incorporation into plants of foreign genes shown to confer virus resistance has been demonstrated for various virus-plant systems. The VRU will work on genetic transformation of bean and cassava plants by using ballistic methods to test different virus-induced plant resistance mechanisms such as coat protein, satellite, and lethal mutant-mediated plant resistance. Other vectors of genetic material, such as *Agrobacterium* spp., can also be tested with tobacco systems amenable to plant transformation. Through the use of these techniques, breakthroughs in the area of plant regeneration are anticipated.

Activity 6. Training

The VRU is expected to reach full operational capacity in 1992, when training of junior staff in molecular virology will have been completed. The unit will then be in a position to transfer information and appropriate technology to scientists in national programs, who are responsible for handling similar virus problems in their countries. Emphasis will be placed on demonstrating modern virus-detection techniques, such as cDNA probes, as practical tools for field researchers who need diagnostic capacity in the absence of adequate local virology facilities.

Other virus-detection techniques, such as immunosorbent serological methods (ELISA), will be demonstrated to promote scientists' awareness of the availability of backup centralized tests, which can greatly assist breeding for virus resistance in isolated regions.

Another major training area for national program virologists is screening for virus resistance and selection of virus-resistant germplasm.

Resource Requirements

Table 25 shows the resources allocated for the Virology Research Unit in terms of Senior Staff positions.

Table 30 describes the expected utilization of resources in the VRU for the planning period in terms of "activities" as defined by the CGIAR (see Appendix).

Visiting Scientists and Postdoctorals

Visiting scientists from institutions of developed countries are expected to be financed through non-CIAT resources. However, CIAT budgets for limited financial resources to cover, if necessary, part of the sustenance costs of such visiting scientists. CIAT also maintains a program to invite cooperating, senior scientists from national programs to conduct research at the center for periods of 6 to 12 months. On the average, CIAT can host 2 to 3 such scientists at a cost approximately equal to that of one postdoctoral fellow.

The center budgets resources for postdoctoral fellows on a yearly basis at an equivalence of 7-8 person-years. This is expected to increase to 10-11 person-years toward the end of the planning period. Postdoctoral fellows are recruited to engage in high-priority, often exploratory, research and are placed directly with the research programs or the research support units. While these young scientists make considerable contributions to the research programs, the postdoctoral program also

Table 30. Virology Research Unit. Resource utilization by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management												
3. Germplasm conservation and evaluation	1.0	2.0	6.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0	3.0	2.0
II. Crop productivity research												
3. Plant protection	3.0	6.0	23.0	4.0	6.0	8.0	10.0	7.0	8.0	9.0	10.0	8.0
5. Seed technology and production	1.0	2.0	5.0	2.0	1.0	3.0	4.0	2.0	2.0	2.0	3.0	2.0
IX. Institution building and networking												
1. Training	2.0	6.0	14.0	5.0	5.0	9.0	12.0	5.0	7.0	9.0	10.0	7.0
3. Documentation and dissemination of information	1.0	2.0	4.0	2.0	2.0	3.0	4.0	3.0	2.0	2.0	3.0	2.0
6. Networks	1.0	2.0	3.0	1.0	1.0	2.0	3.0	1.0	1.0	1.0	2.0	1.0
Total	9.0	20.0	55.0	16.0	17.0	27.0	38.0	20.0	22.0	25.0	31.0	22.0
Total Year			100.0				100.0				100.0	

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

provides them with experience in an international research setting that prepares them for careers in tropical agriculture.

Research Services

Centralization of services ensures economies of scale and reduces capital costs by providing an efficient mechanism for sharing the use of expensive advanced research equipment. Research Services at CIAT are organized to provide centralized services to all programs and units in the following areas: soil and plant analytical services, plant growth facilities (screenhouses, greenhouses, growth rooms, and growth chambers), mass spectrophotometry laboratory, and mycorrhizae laboratory. The central microscope laboratory now has updated equipment and will expand its services. The small animal colony will be transferred to Research Services. As advanced research equipment is purchased, these resources will be placed under the administration of Research Services, which, as of late 1991, will be administered by a General Administrative Services (GAS)-level staff member and supervised by a committee of users. The increase in resources for Research Services over the planning period is related to this new position.

Research Stations

CIAT maintains research stations in Colombia for experimental use by all of its programs, with commercial production only on land that is in excess of program needs.

CIAT-Palmira (404 ha of cultivable land), CIAT-Quilichao (177 ha cultivated), CIAT-Santa Rosa (29 ha cultivated), CIAT-Popayán (19 ha cultivated), and the Centro Nacional de Investigaciones, CNI-Carimagua (co-managed with ICA), are key elements in CIAT's strategy for commodity programs and for expanding needs in natural resource management research.

CIAT-Palmira. This fully irrigated station has reached maturity, but appropriate equipment replacement remains a key element in efficient management. All programs and units utilize the station, with heaviest emphasis on beans and rice research; about 20% of the cultivated area is devoted to commercial production, contributing an average of US$120,000 per year to CIAT's income.

CIAT Substations (directly managed). These stations provide a set of environments for research not available at headquarters, e.g., at Popayán (1800 m altitude), there are acid soils and a humid, cool tropical climate for beans and cassava; at Quilichao (1000 m), acid soils and a subhumid mid-altitude climate for tropical forages, cassava, beans, maize (CIMMYT), and sorghum (INTSORMIL); and at Santa Rosa (300 m), moderately acid soils with a humid lowland tropical climate for rice. The substations are managed by Station Operations as a service to all programs. The facilities are relatively modest, and, apart from the essential replacement of capital, significant capital investments are not expected in the future. On-station research by resource management programs will expand in some key areas, and this will be accommodated on existing stations with present resources.

Diagnostic work now being carried out by the resource management group will identify two further locations for on-station research over the planning period. In both cases, the research to be conducted would be in collaboration with national programs at existing stations. Modest funds have been allocated for the additional capital needed at those stations to provide appropriate office and field laboratory space for CIAT. The actual locations of these two sites should be determined by early 1993. Modest amounts of funding have been included for this purpose in the capital requests for 1993 and 1994.

In addition to the above, there will be a need to develop a mid-altitude (approximately 1500 m) screening site for the Tropical Forages Program's work on MPFTS, as well as in grasses and legumes, probably on purchased or donated land in Colombia. This site is not envisaged as a full substation. It is expected that resources for this site will be derived from normal capital allocations in 1993 or 1994.

CNI-Carimagua and Llanos-based research. On-station and on-farm research by the Rice and Tropical Forages programs in the Llanos Orientales (Eastern Plains) of Colombia has expanded greatly in recent years. The new Savannas Program will have a major set of activities in the Colombian Llanos, incorporating the existing rice-pasture activities that have a systems context. The Rice and Tropical Forages programs will continue to carry out germplasm development work (rice at Santa Rosa, and in collaboration with ICA at nearby "La Libertad," and on-farm in the area; and tropical forages at Carimagua and on-farm). In addition, the Cassava Program will

continue to develop germplasm for the acid lowland humid tropics in collaboration with ICA at "La Libertad."

All these activities will place increasing logistic demands on CIAT's Station Operations. It is expected that the administrative base now in place at Villavicencio and Santa Rosa will need to grow to provide local support for these far-flung activities. It is expected that the total resources required for the Llanos-based station operations and logistic support will be accommodated within the present budget allocated to existing activities in the region. The working budget of the new Savannas Program will help to complement the centrally funded logistic services.

Information Management Systems

To develop its information functions, CIAT has opted for decentralized resource deployment, combined with a centralized unit for support and coordination--the Information Management Systems Unit.

A series of so-called information domains have been identified within CIAT, as follows:

* Geographic Information Systems (GIS)
* Socioeconomic Information System
* Germplasm Development Information System
* Soil/Plant Information System
* Bibliographic Information System
* Financial/Administrative Information System
* Institutional Development Information System

Each domain develops information input, processing, storage, and distribution systems that support its unique information needs.

The Information Management Systems Unit assumes the following five responsibilities:

* Assists CIAT in developing centerwide standards for databases, applications, data transmission, and hardware and software specifications.

* Assumes primary responsibility for developing integrated applications that provide the user with access to all information that may be applicable in a given problem-solving context, regardless of where, in what form, and in which database the information is stored.

* Provides support to the different domains in database development, particularly those with a relatively weak infrastructure.

* Maintains the principal mainframe installation, provides centerwide microcomputer hardware and software support, and assumes direct responsibilities for administering local area networks throughout CIAT.

* Provides biometric support services to all CIAT researchers, including outposted staff (see below).

Biometric Support

As a science-based institution, CIAT relies heavily on statistical and mathematical sciences and tools for research design and analysis of results. Biometric support is provided to the center's research programs amd units in the following areas:

* Statistical/mathematical orientation in experimental design, data analysis methodology, interpretation of results

and their forecasting ability, and final presentation

* Selection of statistical summaries to store in research databases

* Collaborative methodological studies (e.g., multivariate versus univariate analysis) and data analysis projects

* Training in statistical/mathematical methods and data analysis for CIAT research associates/assistants and national program researchers, using the Microcomputer Training Laboratory facilities

The budget shown in Table 25 for this unit reflects the costs of all the above functions.

Chapter 6

MANAGEMENT, ADMINISTRATION, AND CENTRAL SERVICES

In 1991, CIAT devoted 4.2% of its core resources to management, 6.3% to administrative support, and 9.2% to central services and general operating expenses. Together, the three areas accounted for US$5,726,000, or 19.7% of the core budget. For the forthcoming operational period (1992-1996), CIAT projects general operating expenditures at approximately the same proportion. The one exception foreseen is an upward adjustment in "general expenses" in order to cover real increases in the cost of electricity in Colombia.

CIAT is aware that in the face of a more complex organization, as outlined in this operational plan, together with selected growth resulting from the addition of resource management research, there will be significantly increased demands on management, administration, and central services. However, the center's strategy of continued selective decentralization of the management and administration function, together with increased systematization of operations and cost reduction measures, should make it feasible to meet the demand of the expected ripple effect with minimal additional resources.

In terms of Senior Staff positions in the areas of management and administration, the total number will be reduced from eight in 1991 to seven in 1992. This is the result of transferring the internationally recruited position of Projects Officer to the Institutional Development Support Program, as Project Design Specialist, and creating, instead, a locally recruited position for the Projects Administration Office, within Administration.

Table 31 shows the projected Senior Staff positions and resource requirements in the areas of management, administration, and central services.

Table 31. Management and Administration. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
Senior Staff Position	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Board of Trustees	–	177	–	177	–	177	–	177	–	177	–	177
Management												
Office of Director General	2	383	2	383	2	383	2	383	2	383	2	383
Offices of Directors	3	661	3	661	3	661	3	661	3	661	3	661
Administrative support												
Office of the Controller	1	558	1	558	1	558	1	558	1	558	1	558
Office of the Executive Officer	1	426	1	426	1	426	1	426	1	426	1	426
Human resources	–	208	–	208	–	208	–	208	–	208	–	208
Supplies office	–	278	–	278	–	278	–	278	–	278	–	278
Administrative systems	–	257	–	257	–	257	–	257	–	257	–	257
Internal audit	–	109	–	109	–	109	–	109	–	109	–	109
Project administration*	1	–	–	–	–	–	–	–	–	–	–	–
General operating expenses												
Central services	–	1,159	–	1,159	–	1,159	–	1,159	–	1,159	–	1,159
Physical plant	–	557	–	557	–	557	–	557	–	557	–	557
Motor pool	–	421	–	421	–	421	–	421	–	421	–	421
General expenses (electricity, etc.)	–	532	–	582	–	582	–	582	–	582	–	582
Total	8	5,729	7	5,776	7	5,776	7	5,776	7	5,776	7	5,776

* = Paid from indirect costs recovery.

Chapter 7

CAPITAL REQUIREMENTS

The present value of CIAT's fixed assets is US$20.3 million. In order to keep its capital endowment at present levels, CIAT calculates that an annual allocation of US$1.61 million is required. With the influx of these financial resources, CIAT can guarantee the donor community that its capital infrastructure is maintained at optimal levels and that all its research, laboratory, machinery, and computer equipment will be in good operating conditions and will be replaced with state-of-the-art equipment at reasonable intervals. However, the constant pressure on CIAT to maximize its research output by availing itself of advanced research equipment requires capital resources beyond the current levels at which CIAT keeps up present fixed assets. To be in a position to replace outdated research equipment with new and enhanced equipment, and to acquire new research implements, machinery, and other equipment, CIAT projects an additional annual capital allocation of US$300,000.

Finally, as described under Research Support, CIAT projects the need to develop at least two additional research sites to accommodate the requirements of the newly established Resource Management Research Division. It is anticipated that for this purpose, CIAT will enter partnership arrangements with selected national or regional collaborating research organizations. The amounts budgeted for the development of these research sites are for upgrading and enhancing existing research sites. The first such station is projected for development in 1993, with the second in 1994. Table 32 presents projections for capital resources during 1992-1996 by type of capital items.

Table 32. Capital resources. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (constant 1991 US$'000).

	1991	1992	1993	1994	1995	1996
Asset Categories	Amount	Amount	Amount	Amount	Amount	Amount
Land, buildings, leasehold improvements	280	280	490	490	200	200
Heavy-duty equipment	280	380	430	430	320	420
Vehicles	300	330	340	340	340	340
Furniture and office equipment	50	20	20	20	20	20
Laboratory and scientific equipment	730	730	760	760	560	760
Aircraft	-	-	-	-	300	-
Computer equipment	170	170	170	170	170	170
Total	1,810	1,910	2,210	2,210	1,910	1,910

Chapter 8

SUMMARY AND ANALYSIS OF RESOURCE REQUIREMENTS

CIAT's proposed allocation of resources over the 1992-1996 period is summarized in Table 33. Information in this table is based on the classification of "activities" used by the CGIAR system (see Appendix).

A considerable shift in resource allocation to resource conservation and management reflects the fact that a large portion of this new research effort relates directly to the activities subsumed under this category. The largest increase takes place in 1992, when CIAT proposes to launch its work in resource management research. Further gradual increases will take place throughout the planning period, requiring 25% of the resources by 1996.

Crop productivity research is scheduled to diminish in relative terms in response to CIAT's increased emphasis on strategic research in germplasm development, while de-emphasizing resource-intensive work in applied crop research. Livestock research, which is mostly carried out by the Tropical Forages Program, will continue to claim approximately 9% of the center's resources.

Research on human linkages (e.g., analysis of human nutrition, sociocultural organization, understanding of gender issues) will increase slightly over time, as will CIAT's efforts in socioeconomic and policy research, planned for the area of resource management research.

It should also be noted that there is a relative decrease in the allocation of resources to institution building and networking. This is largely due to a qualitative change in the relationship envisaged between national programs and CIAT. Now that largé corps of trained specialists are available in national programs, training in production and production-related subjects can increasingly be carried out at the country level. Because international and regional networks are fully operational and largely self-sustaining, there is also less need for CIAT to invest resources in these networks. In the future, traditional institution-building activities will give way to interinstitutional cooperative endeavors, whereby each institution contributes to a common research agenda according to its specific comparative advantages.

Table 34 shows projected resource requirements for the core program during the planning period. Details on those requirements appear in the respective program or unit description. Table 35 gives the same information for complementary activities in the same period, while Table 36 presents the total resource requirements for core and complementary activities combined.

Table 37 shows the resource requirements by expense categories; Figure 2, the proposed allocation of core resources to the various expense categories for the first and last year of the planning period; Figure 3 compares actual costs of Senior Staff for 1991 with projected costs for 1992-1996; Table 38 shows total personnel requirements by program and unit for the planning period. On the basis of Table 38, Figure 4 shows a breakdown of personnel by staff categories over the planning period.

Table 33. Utilization of core resources by activities for the years 1992, 1994 and 1996 (percent share).[a]

Activities[b]	1992				1994				1996			
	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA	ASIA	SSA	LA/C	WANA
I. Resource conservation and management	1.4	1.5	16.8	0.1	1.3	1.6	18.4	0.1	1.3	2.0	21.2	0.1
2. Ecological charaterization	–	–	2.8	–	–	–	2.0	–	–	–	1.4	–
3. Germplasm conservation and evaluation	0.7	1.2	2.3	0.1	0.7	1.0	2.3	0.1	0.6	1.3	2.6	0.1
4. Natural forest ecology and management	–	–	0.4	–	–	–	0.4	–	–	–	0.4	–
6. Soils, conservation and management	0.5	0.3	5.2	–	0.4	0.6	6.5	–	0.4	0.7	7.4	–
7. Water conservation and management	0.1	–	1.1	–	0.1	–	1.0	–	0.2	–	1.1	–
8. Land use management	–	–	1.8	–	–	–	1.6	–	–	–	1.4	–
9. Development of production systems for sustainable resource management	0.1	–	3.1	–	0.1	–	4.6	–	0.1	–	6.9	–
II. Crop productivity research	2.4	5.8	17.8	0.3	2.3	6.1	15.8	0.3	2.4	6.7	14.7	0.3
1. Germplasm enhancement and breeding	1.8	3.4	7.3	0.2	1.8	3.6	6.8	0.2	1.9	4.0	6.7	0.2
2. Crop systems	0.3	0.2	1.0	–	0.2	0.1	0.7	–	0.2	–	0.6	–
3. Plant protection	0.2	1.6	5.6	0.1	0.2	1.6	4.4	0.1	0.2	1.5	4.0	0.1
4. Plant nutrition	0.1	0.6	1.9	–	0.1	0.7	2.1	–	0.1	1.0	2.1	–
5. Seed technology and production	–	–	2.0	–	–	0.2	1.8	–	–	0.2	1.3	–
III Livestock productivity research	0.5	1.4	8.8	–	0.7	1.7	7.7	–	1.0	2.1	7.3	–
2. Livestock systems	0.5	1.4	8.8	–	0.7	1.7	7.7	–	1.0	2.1	7.3	–
VI. Commodity conversion and utilization research	0.3	–	0.7	–	0.2	–	0.4	–	0.2	–	0.3	–
1. Crops	0.3	–	0.7	–	0.2	–	0.4	–	0.2	–	0.3	–
VII. Research on human linkages	0.1	–	2.0	–	–	–	3.4	–	–	–	2.9	–
1. Analysis of human nutrition	–	–	0.2	–	–	–	0.1	–	–	–	0.1	–
2. Other linkages	0.1	–	1.8	–	–	–	3.3	–	–	–	2.8	–
VIII. Socioeconomic and policy research	0.2	0.8	6.1	–	0.1	0.7	7.9	–	0.1	0.5	8.0	–
1. Economic and social analysis at micro level	–	0.4	2.1	–	–	0.4	2.4	–	–	0.2	2.6	–
2. Market analysis	0.1	0.2	1.3	–	0.1	0.2	1.8	–	0.1	0.1	1.8	–
3. Policy analysis	–	–	1.2	–	–	–	1.4	–	–	–	1.7	–
4. Research on impact	0.1	0.2	1.5	–	–	0.1	2.3	–	–	0.2	1.9	–
IX. Institution building and networking	2.2	4.8	25.9	0.1	2.1	4.2	24.9	0.1	2.4	3.4	23.0	0.1
1. Training	0.7	2.0	9.4	0.1	0.7	1.7	9.3	0.1	0.9	1.4	8.1	0.1
2. Conferences and seminars	0.4	0.2	2.4	–	0.5	0.2	2.3	–	0.4	0.2	2.2	–
3. Documentation and dissemination of information	0.3	0.7	6.6	–	0.3	0.7	6.1	–	0.3	0.6	5.8	–
5. Strengthening national research systems	0.1	0.8	4.0	–	0.2	0.7	3.8	–	0.2	0.5	3.3	–
6. Networks	0.7	1.1	3.5	–	0.4	0.9	3.4	–	0.6	0.7	3.6	–
Total	7.1	14.3	78.1	0.5	6.7	14.3	78.5	0.5	7.4	14.7	77.4	0.5
Total Year	100.0				100.0				100.0			

a. SSA = Sub-Saharan Africa; LA/C = Latin America and Caribbean; WANA = West Asia and North Africa.

b. Numbers refer to CGIAR's definitions of "activities" (see Appendix).

Table 34. Resource requirements. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Germplasm development												
Beans	22	4,898	17	3,849	17	3,849	17	3,849	16.5	3,806	16.5	3,806
Cassava	11	2,504	11	2,504	11	2,504	11	2,504	10.5	2,446	10.5	2,446
Rice	8	1,657	7.75	1,588	6.75	1,517	6.5	1,487	6.5	1,495	6.5	1,495
Tropical forages	18	4,118	13.5	3,221	13.5	3,221	13	3,095	12	2,910	12	2,910
Strategic research initiatives	–	–	–	100	–	170	–	250	–	250	–	250
Total germplasm development	59	13,177	49.25	11,262	49.25	11,261	47.5	11,185	45.5	10,907	45.5	10,907
Resource management												
Land use	–	–	6	1,357	6	1,522	7	1,752	7	1,627	7	1,542
Forest margins	–	–	2	462	2.25	612	6.25	1,515	6.75	1,640	7.75	1,809
Hillsides	–	–	2	462	2.75	653	4.75	1,159	5.25	1,284	5.25	1,309
Savannas	–	–	5.75	1,373	5.75	1,453	6.5	1,655	8.5	2,143	9.5	2,263
Strategic research initiatives	–	–	–	100	–	170	–	250	–	250	–	250
Total resource management	–	–	15.75	3,754	16.75	4,410	24.5	6,331	27.5	6,944	29.5	7,173
Institutional development support	6	3,387	8	3,582	8	3,633	8	3,658	8	3,658	8	3,628
Research support												
Genetic resources	1	558	1	570	1	570	1	600	1	600	1	600
Biotechnology research	2	399	3	654	3	654	3	654	3	654	3	654
Virology research	2	345	2	345	2	345	2	345	2	345	2	345
Research services	–	315	–	365	–	365	–	365	–	365	–	365
Research stations	1	1,282	1	1,282	1	1,282	1	1,382	1	1,482	1	1,482
Information management	1	605	1	766	1	786	1	786	1	786	1	786
Visiting scientists and postdoctorals	–	506	–	556	–	626	–	626	–	726	–	726
Agroecological studies	2	237	–	–	–	–	–	–	–	–	–	–
Research contracts	–	169	–	–	–	–	–	–	–	–	–	–
Total research support	9	4,416	8	4,538	8	4,628	8	4,758	8	4,958	8	4,958
Management and administration												
Board of Trustees	–	177	–	177	–	177	–	177	–	177	–	177
Management	5	1,044	5	1,044	5	1,044	5	1,044	5	1,044	5	1,044
Administrative support	2	1,836	2	1,836	2	1,836	2	1,836	2	1,836	2	1,836
Project administration*	1	–	–	–	–	–	–	–	–	–	–	–
General operating expenses	–	2,669	–	2,719	–	2,719	–	2,719	–	2,719	–	2,719
Total management and administration	8	5,726	7	5,776	7	5,776	7	5,776	7	5,776	7	5,776
Contingencies	–	300	–	289	–	297	–	317	–	322	–	324
Total operations	82	27,006	88	29,201	88	30,005	95	32,025	96	32,565	98	32,766
Capital												
Capital	–	1,510	–	1,610	–	1,610	–	1,610	–	1,610	–	1,610
Advanced research equipment	–	300	–	300	–	300	–	300	–	300	–	300
Research station development												
Station 1	–	–	–	–	–	300	–	–	–	–	–	–
Station 2	–	–	–	–	–	–	–	300	–	–	–	–
Total capital	–	1,810	–	1,910	–	2,210	–	2,210	–	1,910	–	1,910
Working capital adjustment	–	–	–	191	–	78	–	162	–	7	–	16
Total	82	28,816	88	31,302	88	32,291	95	34,397	96	34,482	98	34,692

* = Paid from indirect costs recovery.

Table 35. Resource requirements. Revised budget for 1991 and projected budgets for complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).*

	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Germplasm development												
Beans *	6	2,729	9	3,319	9	3,094	8	2,840	8	2,840	8	2,840
Cassava	1	1,155	4	2,110	4	2,124	4	2,117	2	1,204	2	1,078
Rice	1	558	1.25	698	2	822	2	822	2	822	2	822
Tropical forages	–	153	1.75	429	1.75	429	1.5	376	1	203	–	–
Total germplasm development	8	4,595	16	6,556	16.75	6,469	15.5	6,155	13	5,069	12	4,740
Resource management												
Land use	–	–	1	225	1	225	1	225	1	225	1	225
Forest margins	–	–	0.25	56	0.25	256	0.5	313	1	425	1	425
Hillsides	–	–	2	450	2	450	2	450	2	450	2	450
Savannas	–	–	–	–	2	670	2	670	2	670	2	670
Total resource management	–	–	3.25	731	5.25	1,601	5.5	1,658	6	1,770	6	1,770
Institutional development support	–	600	–	600	–	100	–	100	–	–	–	–
Research support												
Genetic resources	–	–	–	385	–	421	–	420	–	236	–	236
Biotechnology research	–	100	1	613	1	613	1	613	1	613	1	613
Farmer participatory research	1	279	1	279	1	279	1	279	1	279	1	279
Total research support	1	379	2	1,277	2	1,313	2	1,312	2	1,128	2	1,128
Contingencies	–	56	–	92	–	95	–	92	–	80	–	76
Total operations	9	5,630	21.25	9,256	24	9,578	23	9,317	21	8,047	20	7,714
Capital												
New capital	–	200	–	200	–	200	–	200	–	200	–	200
Equipment replacement	–	100	–	100	–	100	–	100	–	100	–	100
Total capital	–	300	–	300	–	300	–	300	–	300	–	300
Working capital adjustment	–	494	–	261	–	–	–	–	–	–	–	–
Total	9	6,424	21.25	9,817	24	9,878	23	9,617	21	8,347	20	8,014

* Not shown are the expected complementary activities, carried out in close collaboration with CIAT, by other international centers and international or regional research organizations. Many of these collaborative or joint activities will be hosted at CIAT headquarters or will be jointly based at research sites.

Table 36. Total resource requirements. Revised budget for 1991 and projected budgets for core and complementary activities for 1992–1996 (SYs = Senior Staff years; constant 1991 US$'000).

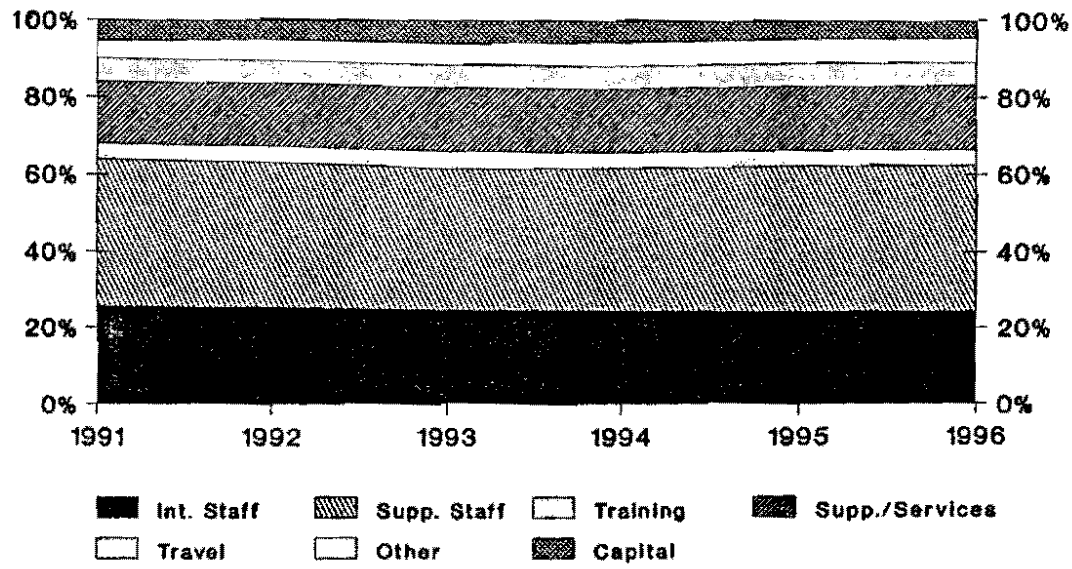
	1991		1992		1993		1994		1995		1996	
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount
Germplasm development												
Beans	28	7,627	26	7,168	26	6,943	25	6,689	24.5	6,646	24.5	6,646
Cassava	12	3,659	15	4,614	15	4,628	15	4,621	12.5	3,650	12.5	3,524
Rice	9	2,215	9	2,286	8.75	2,339	8.5	2,309	8.5	2,317	8.5	2,317
Tropical forages	18	4,271	15.25	3,650	15.25	3,650	14.5	3,471	13	3,113	12	2,910
Strategic research initiatives	–	–	–	100	–	170	–	250	–	250	–	250
Total germplasm development	67	17,772	65.25	17,818	65	17,730	63	17,340	58.5	15,976	57.5	15,647
Resource management												
Land use	–	–	7	1,582	7	1,747	8	1,977	8	1,852	8	1,767
Forest margins	–	–	2.25	518	2.5	868	6.75	1,828	7.75	2,065	8.75	2,234
Hillsides	–	–	4	912	4.75	1,103	6.75	1,609	7.25	1,734	7.25	1,759
Savannas	–	–	5.75	1,373	7.75	2,123	8.5	2,325	10.5	2,813	11.5	2,933
Strategic research initiatives	–	–	–	100	–	170	–	250	–	250	–	250
Total resource management	–	–	19	4,485	22.00	6,011	30.0	7,989	33.5	8,714	35.5	8,943
Institutional development support	6	3,987	8	4,182	8	3,733	8	3,758	8	3,658	8	3,628
Research support												
Genetic resources	1	558	1	955	1	991	1	1,020	1	836	1	836
Biotechnology research	2	499	4	1,267	4	1,267	4	1,267	4	1,267	4	1,267
Virology research	2	345	2	345	2	345	2	345	2	345	2	345
Research services	–	315	–	365	–	365	–	365	–	365	–	365
Research stations	1	1,282	1	1,282	1	1,282	1	1,382	1	1,482	1	1,482
Information management	1	605	1	766	1	786	1	786	1	786	1	786
Visiting scientists and postdoctorals	–	506	–	556	–	626	–	626	–	726	–	726
Agroecological studies	2	237	–	–	–	–	–	–	–	–	–	–
Research contracts	–	169	–	–	–	–	–	–	–	–	–	–
Farmer participatory research	1	279	1	279	1	279	1	279	1	279	1	279
Total research support	10	4,795	10	5,815	10	5,941	10	6,070	10	6,086	10	6,086
Management and administration												
Board of Trustees	–	177	–	177	–	177	–	177	–	177	–	177
Management	5	1,044	5	1,044	5	1,044	5	1,044	5	1,044	5	1,044
Administrative support	2	1,836	2	1,836	2	1,836	2	1,836	2	1,836	2	1,836
Project administration*	1	–	–	–	–	–	–	–	–	–	–	–
General operating expenses	–	2,669	–	2,719	–	2,719	–	2,719	–	2,719	–	2,719
Total management and administration	8	5,726	7	5,776	7	5,776	7	5,776	7	5,776	7	5,776
Contingencies	–	356	–	381	–	392	–	409	–	402	–	400
Total operations	91	32,636	109.25	38,457	112	39,583	118	41,342	117	40,612	118	40,480
Capital												
Capital	–	1,810	–	1,910	–	1,910	–	1,910	–	1,910	–	1,910
Advanced research equipment	–	300	–	300	–	300	–	300	–	300	–	300
Research station development												
Station 1	–	–	–	–	–	300	–	–	–	–	–	–
Station 2	–	–	–	–	–	–	–	300	–	–	–	–
Total capital	–	2,110	–	2,210	–	2,510	–	2,510	–	2,210	–	2,210
Working capital adjustment	–	494	–	452	–	76	–	162	–	7	–	16
Total	91	35,240	109.25	41,119	112	42,169	118	44,014	117	42,829	118	42,706

* = Paid from indirect costs recovery.

Table 37. Budget by categories of expenses. Revised budget for 1991 and projected budgets for core activities for 1992–1996 (constant 1991 US$'000).

Categories of Expenses	1991 Amount	1992 Amount	1993 Amount	1994 Amount	1995 Amount	1996 Amount
Personnel	18,015	19,306	19,478	20,745	21,119	21,253
Training	1,140	1,245	1,372	1,372	1,372	1,372
Supplies and services	4,539	4,959	5,231	5,561	5,641	5,661
Travel	1,702	1,807	1,852	1,987	2,032	2,077
Other expenses	1,310	1,595	1,775	2,043	2,079	2,079
Contingency	300	289	297	317	322	324
Capital	1,510	1,610	1,910	1,910	1,610	1,610
Advanced research equipment	300	300	300	300	300	300
Working capital adjustment	-	191	76	162	7	16
Total	28,816	31,302	32,291	34,397	34,482	34,692

Figure 2. Expenses by cost categories: 1991 (actual), 1992-1996 (projected).



ions for 1990 and 1991, and projected positions for 1992–1996.

			Support Staff																				Total Staff						
			Scientific and supervisory							Clerical							Other support staff													
96			90	91	92	93	94	95	96	90	91	92	93	94	95	96	90	91	92	93	94	95	96	90	91	92	93	94	95	96
		5	49	49	43	43	44	43	41	20	21	19	15	14	14	13	150	150	135	129	130	127	123	242	242	214	204	205	200.5	193.5
			24	25	25	25	25	24	24	11	10	10	10	10	10	10	97	100	100	98	94	91	90	143	146	146	144	140	135.5	134.5
			28	26	20	18	18	18	18	9	9	6	6	6	6	6	93	84	73	69	69	69	69	138	127	106.75	89.75	89.5	89.5	89.5
			15	45	34	32	31	28	27	13	14	11	11	11	10	10	163	164	121	119	110	101	96	239	241	179.5	175.5	165	151	147
			8	145	122	118	118	113	110	53	54	48	42	41	40	39	503	498	429	405	393	378	370	782	756	646.25	613.25	599.5	576.5	564.5
			–	–	15	15	16	17	17	–	–	5	5	6	6	6	–	–	54	54	58	60	60	–	–	80	80	87	90	90
			–	–	5	6	15	17	19	–	–	2	2	5	6	7	–	–	18	21	54	60	66	–	–	27	31.25	80.25	89.75	99.75
			–	–	5	7	11	13	13	–	–	2	3	4	5	5	–	–	18	26	41	45	45	–	–	27	37.75	60.75	68.25	68.25
			–	–	15	16	17	21	23	–	–	5	5	6	7	8	–	–	52	52	58	72	80	–	–	77.75	77.75	87.5	105.5	120.5
			–	–	40	43	69	68	72	–	–	14	15	21	24	26	–	–	142	152	211	237	251	–	–	211.75	226.75	315.5	356.5	378.5
		8	51	52	54	56	57	57	57	30	31	33	33	33	33	33	45	45	45	45	45	45	45	132	134	140	142	143	143	143
		1	7	8	8	8	8	8	8	2	2	2	2	2	2	2	37	45	45	45	45	45	45	47	56	56	56	56	56	56
		3	8	8	11	11	11	11	11	1	1	2	2	2	2	2	8	8	8	9	9	9	9	17	17	25	26	25	25	25
		2	6	6	6	7	7	7	7	1	1	1	1	1	1	1	7	7	7	7	7	7	7	16	16	16	17	17	17	17
		–	7	8	8	8	8	8	8	1	2	2	2	2	2	2	17	17	17	17	17	17	17	25	27	27	27	27	27	27
		1	9	9	9	9	9	9	9	8	8	8	8	8	8	8	85	86	86	86	86	86	86	103	104	104	104	104	104	104
		1	11	11	16	16	16	16	16	9	9	9	9	9	9	9	5	5	5	7	7	7	7	26	26	31	33	33	33	33
		–	3	3	–	–	–	–	–	1	2	–	–	–	–	–	5	5	–	–	–	–	–	10	12	–	–	–	–	–
	8	8	51	53	58	59	59	59	59	23	25	24	24	24	24	24	162	171	169	171	171	171	171	244	258	259	262	262	262	262
		5	4	4	4	4	4	4	4	7	7	7	7	7	7	7	2	2	2	2	2	2	2	18	18	18	18	18	18	18
		2	39	39	39	39	39	39	39	70	67	67	66	66	65	65	8	7	7	7	7	7	7	117	115	115	114	114	113	113
		–	2	2	2	2	2	2	2	1	1	2	2	2	2	2	–	–	–	–	–	–	–	4	4	4	4	4	4	4
		–	9	11	12	12	12	12	12	22	21	21	21	21	21	21	208	209	209	206	203	201	198	239	241	242	239	236	234	231
	7	7	54	56	57	57	57	57	57	100	96	97	96	96	95	95	216	218	218	215	212	210	207	370	370	372	370	365	362	359
		–	12	11	11	11	11	11	11	22	22	22	22	22	22	22	90	90	90	89	89	88	87	124	123	123	122	122	121	120
	96	96	314	317	342	344	361	365	366	228	228	236	232	237	238	239	1,016	1,022	1,093	1,077	1,121	1,129	1,131	1,640	1,649	1,759	1,741	1,814	1,828	1,834

Figure 3. Average cost per Senior Staff: 1991 (actual), 1992-1996 (projected).

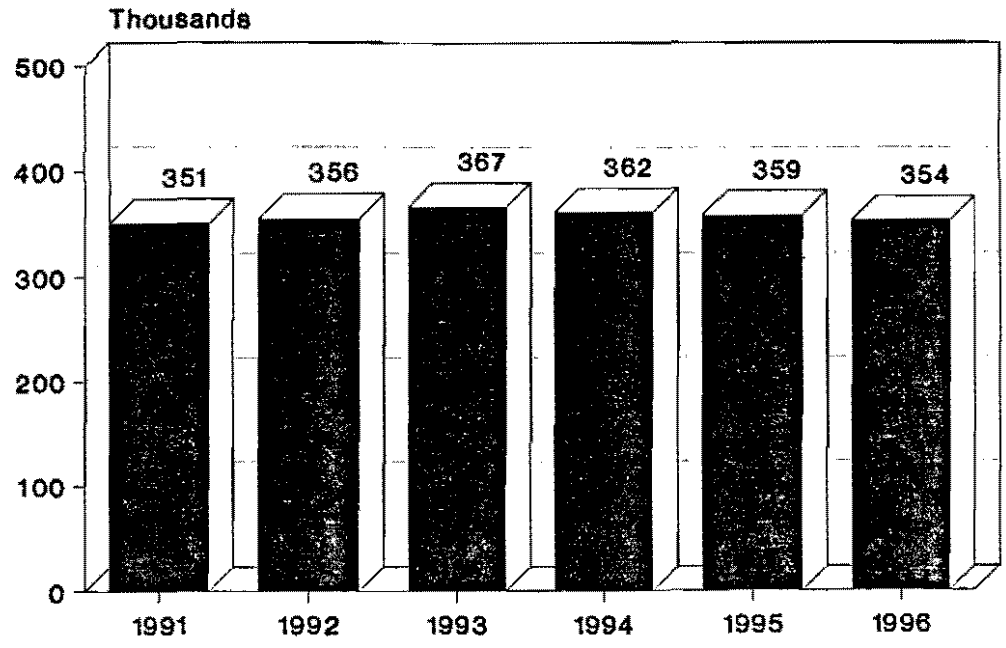
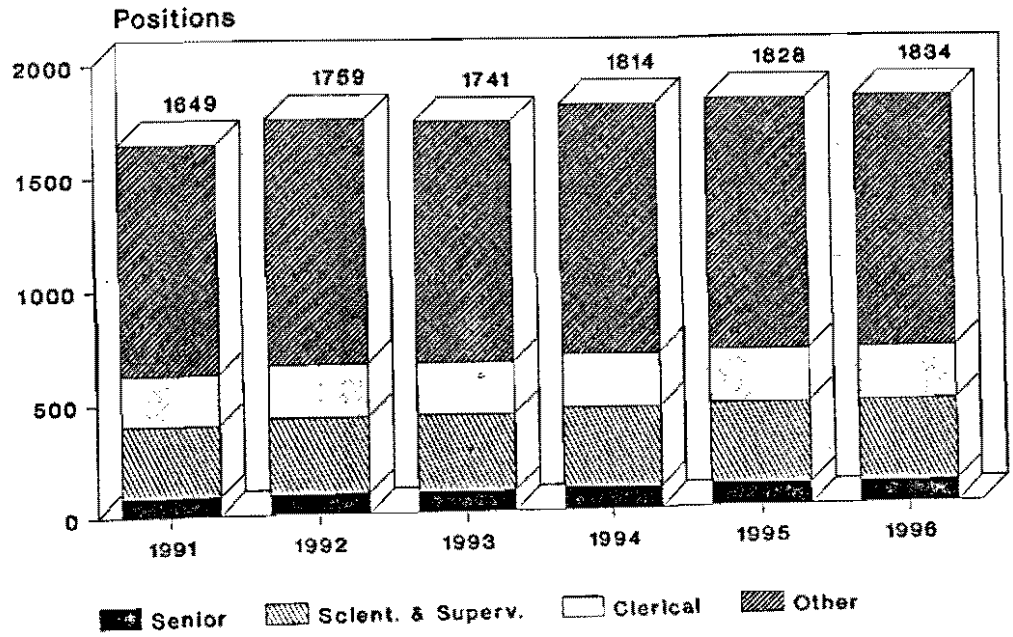


Figure 4. Composition of personnel: 1991(actual), 1992-1996 (projected).



Chapter 9

MANAGING THE IMPLEMENTATION OF THE PLAN

The five-year plan, as introduced in the foregoing chapters, is not business as usual; rather, it calls for a transformation of the center in line with the aims of the strategic plan. This transformation will coincide with a relative scarcity of resources. At the same time, very high expectations have been placed on CIAT to have a major impact in terms of sustainable agricultural production in the regions it serves. There are real problems to be solved, which will require strong and effective management of the center.

As evidenced in its strategic plan, CIAT is willing to refocus; in carrying out its mission, the center is determined to proceed with a lean, results-oriented action program. The guiding features in accomplishing the implementation of the strategic and operational plans are:

* Sharp definitions of work plans
* Choice of an appropriate modus operandi
* Design of conducive organizational structures
* Transfer of selected activities
* Maintenance of maximum flexibility
* Management of the organizational culture

Work Plans

Through its strategic plan and the present operational plan, CIAT has undertaken the basic steps to indicate clearly the directions in which the institution is headed. CIAT is committed to take the necessary additional steps to focus sharply the work of all research and administrative units so that staff throughout the organization understand the importance of their work for the institution's new mission, and the standards required for its accomplishment. Included in this endeavor of continuous planning and definition of what is expected from each program unit, or project are provisions for sharp definitions of work plans, and provisions for performance planning/monitoring, annual program reviews, and documentation of impact/results. The Director General's office will establish the necessary organizational features that ensure coordination of all activities designed to obtain systematic feedback on the results of CIAT's work in the respective environments for which this work is designed, and to obtain and analyze information on the changing environments, which may require adjustments in the technology generation process.

Modus Operandi

CIAT is involved in large and complex tasks. Clearly, no single institution will be able to accomplish these tasks on its own. Central to the CIAT strategy, that of integrated germplasm development and resource management research within the ecoregional center model adopted, is the need for an interinstitutional modus operandi. CIAT is committed to identifying innovative ways of arranging for multi-institutional linkages. These linkages should ensure sharing a common research agenda based on a common platform that provides for the free

interchange of information, technologies, and materials.

The center is committed to developing simple but effective multi-institutional linkages that provide for:

* Joint planning and effective coordination in the implementation of work plans
* Sharp definition of institutional and staff responsibilities for execution of activities
* Definition of effective oversight mechanisms for monitoring outputs and impact.

This modus operandi calls for an open organization that designs its work to be executed in a cooperative fashion; is willing to subsume recognition for work performed to the achievement of results per se; and is as concerned about the effectiveness of the contributions of others as it is concerned about the effectiveness of its own work.

Organizational Structures

While scientific progress is the result of creative, intelligent, persistent, and largely individual efforts of the scientific staff, CIAT's success in accomplishing its mission is a function of the degree to which multidisciplinary teams of scientists achieve integrated solutions. The challenge for CIAT as a research organization is to blend individual research efforts with the objectives of the programs in germplasm development and resource management research. Superimposed is the challenge to permit scientists to pursue selected research endeavors that require intradisciplinary work (e.g., plant protectionists working on plant protection models involving multiple commodities and diverse ecosystems), or that require the ad hoc formation--external to the organizational program structure--of research teams composed of various disciplinary specialists.

In the pages of this operational plan, it is evident that CIAT will continue to pursue its research work largely along multidisciplinary program structures conducting interdisciplinary research. Nevertheless, CIAT is committed to create an open internal organizational model that allows for a high degree of intercommunication among programs/units, and facilitates the creation of temporary work teams to resolve specific problems. The key mechanism to achieve this openness is a continuing process of defining medium- and short-term objectives as they arise in pursuing the center's mission, and then assembling and reallocating the resources required to achieve these dynamic objectives on a project-by-project basis. Furthermore, CIAT is committed to participatory management, whereby individual work teams/units have a major say in how they wish to organize and staff themselves in bringing about specific outcomes under their responsibility.

The chosen "program structure" implies budgeting by programs. The advantages of "project budgeting" are captured through the sharp definition of objectives, outputs, expected impact, and assumptions within each program that facilitate performance planning and monitoring. Budget provisions for inter- and intradisciplinary activities across programs are made within each one of the programs, as well as through special budget line items for strategic research in both the Germplasm Development Division and the Resource Management Research Division and in the various support units and programs. For this purpose, internal, temporary budget reallocations will be made on a project-by-project basis.

Administratively, CIAT will continue its emphasis on the principle that when it comes to processes, fewer are better. The center will work to reduce administrative procedures to the minimal amount needed for the organization to run smoothly.

Transfer of Selected Activities

The new CIAT strategy implies that the center's various programs will need to design mechanisms for others to carry out important activities presently carried out by them. These activities include production training, pre-development activities, technical assistance, and implementation and replication of pilot projects (e.g., cassava drying plants). The new Project Design Office in the Institutional Development Support Program (funded through indirect cost recovery) will assist CIAT's various programs in the development of well-designed, accountable special projects to carry out such activities and to be executed by others. If and when such projects need continued technical support from CIAT programs, the respective budgets will include provisions for such support so as not to unduly tax the center's core program.

Maximum Flexibility

CIAT cannot, and will not, invest its operational resources in more or less fixed organizational units and processes. While the center recognizes the pitfalls and limitations of continuous zero-based budgeting, it will insist that every work aspect be reviewed and justified periodically. The organization will seek to have maximum flexibility in assigning and reassigning its resources so as to be in a position to take advantage of new opportunities, embark on new initiatives, and phase out or modify processes that have outlived their usefulness or are of relatively lower priority. CIAT is aware of the fact that increased flexibility will require increased management and resource administration time; however, considering the alternative of large fixed-cost patterns and the inability to adjust to new situations expeditiously, the investment is well worth the effort.

Organizational Culture

For CIAT to excel, it not only requires sharply focused research and administrative units but it also needs a staff that is dedicated to the center's mission and values, understands its work, and is committed to do its utmost to contribute to the center's success and to observe the standards for accomplishing its work. Management is keenly aware of the importance that organizational values, attitudes, and processes--that is, organizational culture--have on the ultimate success of CIAT. It will assign great importance to the identification of factors that have positive or negative effects on CIAT's organizational culture, with the aim of reinforcing supportive traits and eliminating/de-emphasizing those that are negative.

It is clear that the implementation of the strategic and operational plans requires effective and creative management. CIAT is a strong institution that has responded very positively to strong leadership; the challenges of the future require the redoubling of the center's efforts to refocus and streamline its actions under visionary leadership and effective management at all levels of the organization.

Appendix

CGIAR'S DEFINITIONS OF "ACTIVITIES"

The CGIAR has developed a list of definitions to describe activities carried out by its chain of international agricultural research centers, to which CIAT belongs. CIAT's activities, as described in the text and tables, are listed in this appendix, together with their corresponding CGIAR definitions.

I. Resource Conservation and Management (research on selected aspects)

2. *Ecological characterization*

   Methods for ecological characterization and zoning in relation to existing farming systems and forestry, fisheries and potential land/water uses

3. *Germplasm conservation and evaluation*

4. *Natural forest ecology and management*

   Improved understanding of climatological and biological role of tropical forest ecosystems

   Development of management principles for sustained yields of wood and non-wood products and agricultural options

   Application of remote sensing methods to improve quantification of land use change with special reference to deforestation

6. *Soils conservation and management*

   Development of techniques for increased production by small farmers in Vertisol areas

   Development of appropriate tillage methods for soil, water and power conservation

   Understanding the long-term nutrient economy of tropical soils under increasing cropping intensity

   Better understanding of the chemistry and management of acid soils in the tropics

   Research on the sustainable management of cleared forests and woodlands

7. *Water conservation and management*

   Development of principles and methods for sustainable management of water resources in:
   * irrigated systems
   * rainfed systems

8. *Land use management*

   Research to understand multiple and competing land use options for:
   * watersheds
   * coastal areas
   * rangelands

9. *Development of production systems for sustainable resource management*

   Development of testing of cost-effective methods for assessing the contribution of trees and shrubs to production systems

   Development of management principles for agroforestry systems

   Multiple systems for crops/livestock/trees

II. Crop Productivity Research

1. *Germplasm enhancement and breeding* (including use of biotechnology)

Development of adaptation, tolerance and resistance to biotic and abiotic stresses for important crops

Selection for yield potential

Selection for quality:
* food
* feed

2. *Crop systems*

Sequencing, mixing, intercropping principles

Tillage, planting and harvesting systems

3. *Plant protection*

Biology and ecology of main pests

Components for pest management for main crops:
* identification and evaluation of biological control agents
* other components for pest management
* interrelationships among components

4. *Plant nutrition*

Understanding interactions between nutrients and microbiological processes for designing simple methods for improved nutrient use efficiency

5. *Seed technology and production*

Development of methods for smallholder seed production to enhance adoption of improved cultivars

III. Livestock Productivity Research

2. *Livestock systems*

Improvement of the feed resource base:
* fodder crops, pastures and shrubs
* crop residues and byproducts

Strategic feed supplementation

VI. Commodity Conversion and Utilization Research

1. *Crops*

Postharvest technology

VII. Research on Human Linkages

1. *Analysis of human nutrition*

Development of database on food consumption patterns of the rural and urban poor and on the nutritional composition of foods (including micronutrients and antinutritional factors, potentially toxic), in order to identify nutritional risks

Development of reliable, cost-effective, rapid indicators of malnutrition for agricultural program development and evaluation

Investigation of the effect of alternative production methods of technical change and alternative agricultural strategies on the nutritional quality and safety of food

2. *Other linkages*

Understanding of general gender issues

Understanding of human disease hazards from:
* irrigated agriculture
* crop, animal, water and pesticide management implications as they relate to human health

Sociocultural organization and farming systems:
* use rights
* harmonization of use of scarce resources
* risk management strategies
* mechanisms and institutions for cooperation at community level

VIII. Socioeconomic and Policy Research

1. *Economic and social analysis at micro-level*

   Development and testing of cost-effective methodology for participatory research into production systems and their nutritional consequences

   Modeling of technology and policy options for smallholder production systems

2. *Market analysis*

   Aggregate commodity supply and demand trends

   Structure and functioning of poorly understood input and product markets, e.g.:
   * livestock products
   * fertilizers
   * roots and tubers

3. *Policy analysis*

   Assessment of alternative development strategies and technology policies for poverty alleviation, including inter- and intra-sectoral relations and food security

   Particular areas identified for policy analysis are:
   * irrigation policy
   * fisheries
   * food programs
   * common property
   * labor markets
   * equity concerns
   * trade and macroeconomics policies

   Assessment of underlying causes of ongoing environmental degradation processes and identification of policy options:
   * deforestation causes and processes
   * reforestation incentives
   * chemical pollution
   * soil erosion

   Land and water use management policies (e.g., watersheds, coastal areas, rangelands, problem soils)

4. *Research on research [impact]*

   Methods for ex ante analysis of expected impact and for priority setting at the national and international level

   Ex post impact assessment studies, including development methods

IX. Institution Building and Research-Related Activities

1. *Training*

   Training of national staff on:
   * advanced research techniques
   * field experimentation for junior professionals
   * system-based on-farm research
   * research management and priority setting

2. *Conferences and seminars*

   Specialized and network-oriented events

3. *Documentation and dissemination of information*

   Specialized services

5. *Strengthening national research systems*

   Organization and management of research institutions

   Linkages among research, development policymakers and public opinion

   Research program strategies

   Building capacity

6. *Networks*

   Assist the establishment and administration of collaborative research and information networks

Part II

FUNDING REQUEST FOR 1992

OVERVIEW

At the onset of 1991, CIAT submitted to the CGIAR its long-range plan, entitled *CIAT in the 1990s and Beyond: A Strategic Plan*, together with projections of global resource needs to the year 2001. Operational details for the first five years of the strategic plan are contained in Part I of this publication, entitled *Program Plans and Resource Requirements 1992-1996.*

This second part, *Funding Request for 1992*, presents the program plans and funding requirements for the first year of the operational plan.

In its strategic plan, CIAT proposes to pursue its mission through two interdependent approaches: (1) *germplasm development*, which concentrates on strategic aspects of research to exploit the potential of gene-based mechanisms for sustainable production increases; and (2) *resource management*, which concentrates on research at the production level in selected, major, high-priority agroecosystems. This overall strategy requires both a reorientation of CIAT's existing commodity research programs and the building up of the center's capacity to engage in resource management research.

As outlined in the operational plan, CIAT proposes to begin implementing its strategic plan in 1992. Hence, the present document outlines an important shift in resource deployment as compared with past years. CIAT proposes that implementation of its strategic plan in 1992 be undertaken below the 1991 resource base approved for the center by the CGIAR:

CGIAR-approved funding for 1991:
$32,672,000
CIAT request for 1992:
$32,650,000[1]

Compared with actual funding in 1991 (i.e., $28,816,000), the 1992 funding request is 12% more than the resources available to CIAT in 1991.

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[1] Includes $1,348,000 for price increases.

FINANCIAL AND BUDGETING INFORMATION

1: 1990 FINANCIAL YEAR[2]

Core Program

The approved budget for CIAT's core program was $31,316,000. Because of a shortage of funds, however, the CGIAR asked CIAT to operate at the level of $28,916,000, or 8% below the CGIAR-approved budget request. This meant that certain reductions in planned activities had to be implemented, as shown in List 1.

Actual income from donors was $27,733,000. Self-generated income amounted to $835,000, bringing the total available funds for the 1990 core program to $28,568,000. The difference between expected and available resources (i.e., $348,000) was mainly the result of slightly slower-than-expected expenditures in the so-called "highly restricted core activities."

Tables 1 and 5 (p.142 and 146, respectively) provide details of the expenditures in 1990, both by programs and units and by categories of expenses. List 2 summarizes that information, including comparisons with the 1990 working budget as published in CIAT's *Funding Request for 1991*.

Underspending in Research Support was primarily the result of reduced operational costs of the Carimagua research station and maintaining expenditures on research contracts and visiting scientists and postdoctorals low. The underspending in Institutional Development Support was the result of fewer expenditures than expected in training activities because of the availability of increased outside funding through scholarships.

In 1989, CIAT experienced significant cash flow difficulties, caused by late payments by several large contributors; thus, the center has made every effort possible to build up its working capital. With the addition of $404,000 to the working capital fund in 1990, CIAT has now reached a working capital level equal to operating expenses for 30 days.

Figure 1 shows, in graphic form, the 1990 expenditures by area, as well as category of expenditures.

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[2] Tables 1 to 11, on pages 142 to 152, provide details for the financial years 1990 and 1991.

List 1. Reductions in the 1991 working budget for the core program; the approved budget was US$31,316,000.

Area			Reduction
1.	General downward adjustment		(1,152,000)
2.	Postponement of:		
	a.	Adjustment in working capital	(320,000)
	b.	Filling position for Agricultural Geographer in the Agroecological Studies Unit	(142,000)
	c.	Addition of Senior Staff positions originally approved for 1990:	
		i. Head, Training	(147,000)
		ii. Cassava Breeder, HQ-based	(254,000)
		iii. Cassava Quality Specialist	(254,000)
3.	Addition of other items originally approved for 1990:		
	a.	Increase in resources for research contracting	(42,000)
	b.	Construction of research services building	(189,000)
	c.	Increase in self-generated income	100,000
		Total	(2,400,000)
		Working budget 1991	28,916,000

List 2. 1990 core program: working budget versus actual outcome ('000 US$).

Areas of expenditure	Working budget	Actual outcome	Deviation (%)
Commodity research programs	13,211	13,059	(1)
Research Support	4,920	4,675	(5)
Institutional Development Support	3,000	2,748	(8)
Management and Administration	3,062	3,124	2
General operating expenses	2,613	2,688	3
Capital	1,810	1,870	3
Working capital	–	404	–
Contingencies	300	–	–
Total	28,916	28,568	(1)

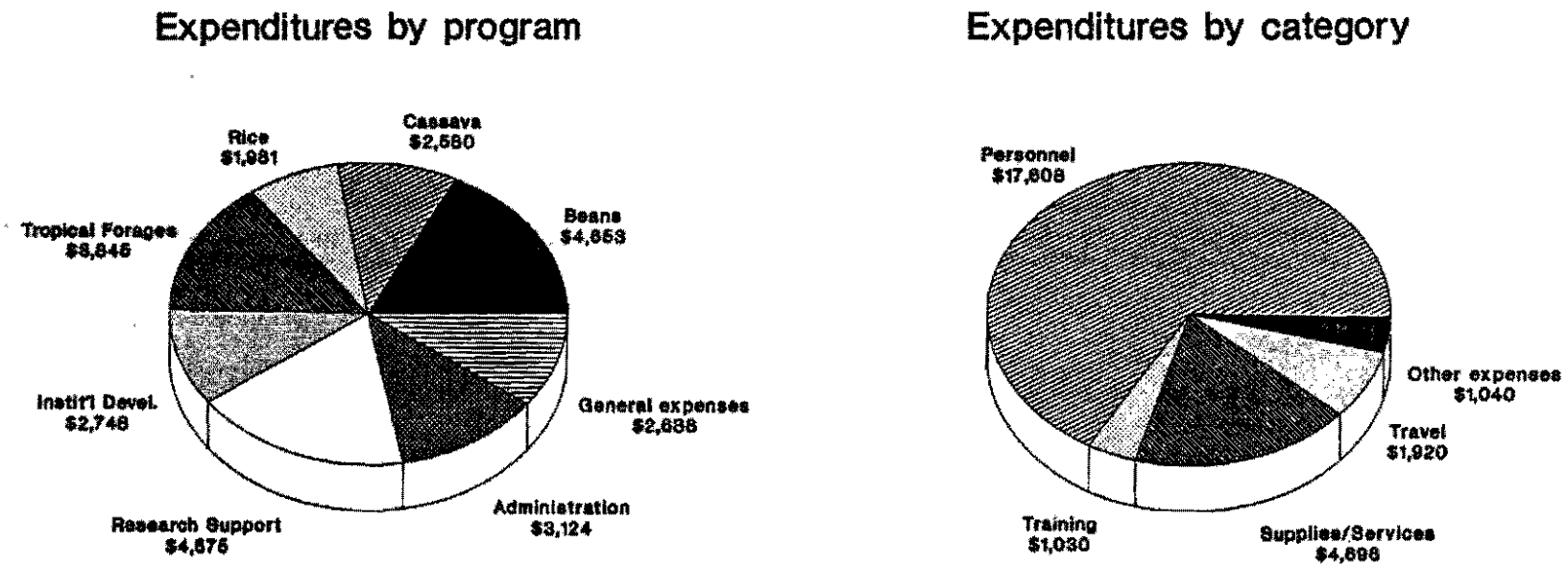

Figure 1. 1990 expenditures: amounts for core activities by program and category of expenses ('000 US$). (Total expenditures were US$26,294,000.)

Complementary Activities

In 1990, complementary activities executed by CIAT amounted to $4,641,000, involving nine Senior Staff (see Table 2, p. 143). List 3 identifies the various projects involved.

List 3. Complementary activities in 1990 ('000 US$).

Activity	Expenditures	Donor
1. *Bean Program*		
Africa: Great Lakes Region, E and S Africa	1,948	SDC, CIDA, USAID
Central America	245	SDC
Andean region	286	SDC
Research on *Phaseolus* germplasm	148	Italy
Research on *Phaseolus*	63	Belgium
Snap beans	37	Netherlands
Bean improvement	20	Iran
2. *Cassava Program*		
Development of production and processing technologies (NE Brazil)	266	W.K. Kellogg Foundation
Development of production and processing technologies (Ecuador)	77	FUNDAGRO (Ecuador)
Soil fertility and conservation	68	Germany
Development of cassava processing technologies (flour and flour products)	85	IDRC
Development of cassava processing and utilization	121	Colombia
Cassava development	34	Ford Foundation
Cassava flour utilization	22	France
3. *Rice Program*		
Caribbean Rice Improvement Network (CRIN)	205	CIDA[1]

[1] An additional amount of $306,000 is shown as core activity.

(Continued)

List 3. (Continued)

Activity	Expenditures	Donor
4. *Tropical Pastures Program*		
CIAT participation in the West African forage network	151	Japan
Research for improving native grasslands	108	Japan
Characterization and comparison of isolates of *C. gloeosporioides* causing anthracnose in *Stylosanthes*	56	Australia
Studies on socioeconomic aspects of improved pastures	25	FUNDAGRO (Ecuador)
Pastures production systems	19	GTZ
Evaluation of pasture associations in Brazil	45	IICA
5. *Research Support*		
Virology - whitefly	10	USAID
Biotech research for rice	100	Rockefeller Foundation
Research on seed production	49	Rockefeller Foundation
Farmer participatory research	183	W. K. Kellogg Foundation
6. *Training and conferences*	240	Various
7. *Capital*	30	Various
TOTAL	4,641	

FINANCIAL AND BUDGETING INFORMATION

2: 1991 FINANCIAL YEAR

Core Program

Against an approved budget of $32,672,000, a total amount of $28,816,000 was expected to be available. This funding shortfall, which in real terms was $1.4 million below the resources available in 1990, implied a number of reductions, as shown in List 4.

The resulting working budget for 1991 is shown in Table 1, p.142.

List 4. Reductions in 1991 working budget resulting from funding shortfall.

Budget requirements		
	1990 budget base	28,916,000
	+ inflation adjustment (4.09%)	1,183,000
	1991 cost of 1990 set of activities	30,099,000
Area		**Reduction**
a.	Reductions as projected in the mid-term plan for 1991:	
	i. Bean Agronomist (Central America)	(122,000)
	ii. Support for African cassava study	(75,000)
	iii. Regional rice project in Caribbean (CRIN)	(300,000)
	iv. Transfer of Seed Unit to Institutional Development Support Program	(438,000)
b.	Selective reductions in the operations budget	(786,000)
c.	Additions	
	i. Transfer of Seed Unit from Research Support to Institutional Development Support Program	438,000
	1991 Working budget	28,816,000

Complementary Activities

In 1991, CIAT expects to spend $6,424,000 in the form of complementary activities as shown in List 5.

List 5. 1991 complementary activities ('000 US$).

Activity	Budget	Donor
1. *Bean Program*		
Africa: Great Lakes Region, E. and S. Africa	1,800	SDC, CIDA, USAID
Central America	562	SDC
Andean region	150	SDC
Research on *Phaseolus* germplasm	217	Italy
2. *Cassava Program*		
Soil fertility and conservation	98	Germany
Development of production and processing technologies (NE Brazil)	276	W.K. Kellogg Foundation
Green spider mite	120	UNDP
Biotechnology network	190	Netherlands[1]
Genetic improvement in Brazil	187	IFAD
Development of production and processing technologies (Ecuador)	92	FUNDAGRO (Ecuador)
Development of cassava processing technologies (flour and flour products)	45	IDRC
Integrated projects in tropical America	147	Colombia, France
3. *Rice Program*		
Caribbean Rice Improvement Network (CRIN)	532	CIDA[2]
Joint study of upland-rice root physiology and architecture	26	France

[1] Not yet confirmed.
[2] An additional amount of $90,000 is shown as core activity.

(Continued)

List 5. (Continued)

Activity	Budget	Donor
4. *Tropical Pastures Program*		
CIAT participation in the West African forage network	16	Japan
Research for improving native grasslands	65	Japan
Characterization and comparison of isolates of *C. gloeosporioides* causing anthracnose in *Stylosanthes*	72	Australia
5. *Institutional Development Support Program*		
Training trainers	600	IDB[1]
6. *Research Support*		
Biotechnology research DNA fingerprinting	100	Rockefeller Foundation
Farmer participatory research	279	W.K. Kellogg Foundation
7. *Contingencies*	56	Not yet funded
8. *Capital*	300	CIDA, USAID, SDC, W.K.Kellogg, Japan
9. *Working capital*	494	Not yet funded
Total	6,424	

FINANCIAL AND BUDGETING INFORMATION

TABLES

Table 1. Budget request by programs and units: amounts for core activities in 1989, 1990, 1991 and 1992 (SYs = Senior Staff years; thousands of current US dollars).

	Actual 1989		Actual 1990		1991 Budget				1992 Budget request		Changes over 1991 estimate	
					Approved		Estimate					
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	$'000	%
1. Operational programs					***		***		***			
Germplasm development												
Beans	21	4,412	21	4,663	22	5,007	22	4,898	17	3,849	(1,049)	(21)
Cassava	11	2,381	11	2,580	14	3,416	11	2,504	11	2,504	–	–
Rice	8	1,897	8	1,981	8	1,867	8	1,657	7.75	1,588	(69)	(4)
Tropical forages	17	3,943	17	3,845	19	4,412	18	4,118	13.5	3,221	(897)	(22)
Strategic research initiatives	–	–	–	–	–	–	–	–	–	100	100	–
Total germplasm development	57	12,633	57	13,059	63	14,702	59	13,177	49.25	11,262	(1,915)	(15)
Resource management												
Land use	–	–	–	–	–	–	–	–	6	1,357	1,357	–
Forest margins	–	–	–	–	–	–	–	–	2	462	462	–
Hillsides	–	–	–	–	–	–	–	–	2	462	462	–
Savannas	–	–	–	–	–	–	–	–	5.75	1,373	1,373	–
Strategic research initiatives	–	–	–	–	–	–	–	–	–	100	100	–
Total resource management	–	–	–	–	–	–	–	–	15.75	3,754	3,754	–
Institutional development support	4	3,224	3	2,748	7	3,823	6	3,387	8	3,582	195	6
Research support												
Genetic resources	1	421	1	495	1	523	1	558	1	570	12	2
Biotechnology research	1	356	2	421	3	709	2	399	3	654	255	64
Virology research	2	355	2	339	2	365	2	345	2	345	–	–
Research services	–	330	–	276	–	344	–	315	–	365	50	16
Research stations	1	941	1	817	1	1,349	1	1,282	1	1,282	–	–
Carimagua station	–	567	–	434	–	–	–	–	–	–	–	–
Information management	–	524	–	510	1	629	1	605	1	786	181	27
Visiting scientists and postdoctorals	–	526	–	450	–	706	–	506	–	556	50	10
Agroecological studies	1	199	1	209	2	372	2	237	–	–	(237)	(100)
Seeds	2	487	1	438	–	–	–	–	–	–	–	–
Research contracts	–	–	–	26	–	196	–	169	–	–	(169)	(100)
Animal herd	–	185	–	260	–	–	–	–	–	–	–	–
Total research support	8	4,891	8	4,875	10	5,193	9	4,416	8	4,538	122	3
Management and administration												
Board of Trustees	–	140	–	229	–	185	–	177	–	177	–	–
Management	5	1,245	5	1,146	5	1,159	5	1,044	5	1,044	–	–
Administrative support *	2	1,855	2	1,749	2	1,858	2	1,836	2	1,836	–	–
Projects administration **	1	–	1	–	1	–	1	–	–	–	–	–
General operating expenses	–	2,633	–	2,686	–	2,772	–	2,669	–	2,719	50	2
Total management and administration	8	5,873	8	5,812	8	5,968	8	5,726	7	5,776	50	1
Contingencies	–	–	–	–	–	314	–	300	–	289	(11)	(4)
Total operations	77	26,621	76	26,294	88	30,000	82	27,006	88	29,201	2,195	8
2. Capital												
Capital	–	2,607	–	1,870	–	2,098	–	1,510	–	1,610	100	7
Advanced research equipment	–	–	–	–	–	–	–	300	–	300	–	–
Total capital	–	2,607	–	1,870	–	2,098	–	1,810	–	1,910	100	6
3. Working capital adjustment	–	33	–	404	–	574	–	–	–	191	191	–
4. Price increase	–	–	–	–	–	–	–	–	–	1,348	1,348	–
Total requirements	77	29,261	76	28,568	88	32,672	82	28,816	88	32,650	3,834	13

* Includes US$300,000 for EPR/EMR in 1989.

** Paid from indirect cost recovery.

*** Positions are shown for the full year although for budgetary purposes a till ratio of 96 percent is assumed.

Table 2. Budget request by programs and units: amounts for complementary activities in 1989, 1990, 1991 and 1992 (SYs = Senior Staff years; thousands of current US dollars).

	Actual 1989		Actual 1990		1991 Budget				1992 Budget request		Changes over 1991 estimate	
					Approved		Estimate					
	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	SYs	Amount	$'000	%
1. Operational programs												
Germplasm development												
Beans	6	2,108	6	2,696	9	2,350	6	2,729	9	3,319	590	22
Cassava	2	258	2	890	4	462	1	1,155	4	2,110	955	83
Rice	–	159	–	204	2	706	1	558	1.25	698	140	25
Tropical forages	–	201	–	321	2	583	–	153	1.75	429	276	180
Total germplasm development	8	2,726	8	3,710	17	4,101	8	4,595	16	6,556	1,961	43
Resource management												
Land use	–	–	–	–	–	–	–	–	1	225	225	–
Forest margins	–	–	–	–	–	–	–	–	0.25	56	56	–
Hillsides	–	–	–	–	–	–	–	–	2	450	450	–
Total resource management	–	–	–	–	–	–	–	–	3.25	731	731	–
Institutional development support	–	321	–	215	–	–	–	600	–	600	–	–
Research support												
Genetic resources	–	127	–	–	–	–	–	–	–	385	–	–
Biotechnology research	–	183	–	66	–	100	–	100	1	613	513	513
Virology research	–	19	–	10	–	–	–	–	–	–	–	–
Seeds	–	41	–	49	–	–	–	–	–	–	–	–
Farmer participatory research	1	175	1	183	1	192	1	279	1	279	–	–
Total research support	1	545	1	308	1	292	1	379	2	1,277	898	237
Contingencies	–	–	–	–	–	44	–	56	–	92	36	64
Total operations	9	3,592	9	4,233	18	4,437	9	5,630	21.25	9,256	3,626	64
2. Capital												
New capital	–	513	–	263	–	571	–	200	–	200	–	–
Equipment replacement	–	189	–	145	–	285	–	100	–	100	–	–
Total capital	–	702	–	408	–	856	–	300	–	300	–	–
3. Working capital adjustment	–	–	–	–	–	1	–	494	–	261	(233)	(47)
4. Price increase	–	–	–	–	–	–	–	–	–	382	382	–
Total requirements	9	4,294	9	4,641	18	5,294	9	6,424	21.25	10,199	3,775	59

Table 3. Budget request for CIAT-hosted activities of other institutions [a]: amounts for activities of hosted institutions in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

Institution	Actual		Budget Estimates	
	1989	1990	1991	1992
Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)	240	211	230	230
Instituto Colombiano Agropecuario (ICA)	-	191	50	50
International Board for Plant Genetic Resources (IBPGR)	235	195	128	130
International Institute of Tropical Agriculture (IITA)	210	101	-	-
International Fertilizer Development Center (IFDC)	35	64	94	100
International Rice Research Institute (IRRI)	267	236	200	200
Mississippi State University (for INTSORMIL) [b]	30	26	30	40
Total	1,017	1,024	732	750

[a] Activities shown are those carried out in close collaboration with CIAT, by other international centers, and international or regional research organizations. These collaborative or joint activities will be hosted at CIAT's headquarters or will be jointly based at research sites.

[b] INTSORMIL = International Sorghum and Millet Program.

able 4. Budget request by activities: amounts for core activities in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

ctivities as Defined by CGIAR *	Actual 1989	Actual 1990	1991 Budget			1992 Budget request		Changes over 1991 estimate	
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Resource conservation and management	3,195	3,103	3,900	3,511	13.0	5,782	19.8	2,271	65
Crop productivity research	7,853	7,599	9,210	8,291	30.7	7,681	26.3	(610)	(7)
. Livestock productivity research	4,206	4,154	4,500	4,051	15.0	3,125	10.7	(926)	(23)
I. Commodity conversion and utilization research	160	210	300	270	1.0	292	1.0	22	8
II. Research on human linkages	186	184	210	189	0.7	613	2.1	424	224
III. Socioeconomic and policy research	1,438	1,578	1,680	1,511	5.6	2,073	7.1	562	37
. Institution building and networking	9,583	9,466	10,200	9,183	34.0	9,635	33.0	452	5
Subtotal	26,621	26,294	30,000	27,006	100.0	29,201	100.0	2,195	8
Price increase	-	-	-	-		1,168	-	1,168	-
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

See Appendix of "Program Plans and Resource Requirements 1992-1996" for fuller definitions of activities.

Table 5. Budget request by categories of expenses: amounts for core, complementary and hosted activities in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

Expenses by categories	Actual 1989	Actual 1990	1991 Budget Approved	1991 Budget Estimate	1992 Budget request	Changes over 1991 estimate $	Changes over 1991 estimate %
Core							
Personnel	16,946	17,608	19,667	18,015	19,306	1,291	7
Training	1,641	1,030	1,356	1,140	1,245	105	9
Supplies and services	4,847	4,696	5,273	4,539	4,959	420	9
Travel	2,237	1,920	2,265	1,702	1,807	105	6
Other expenses	950	1,040	1,105	1,310	1,595	285	22
Subtotal	26,621	26,294	29,666	26,706	28,912	2,206	8
Contingency	-	-	314	300	289	(11)	(4)
Price increase	-	-	-	-	1,168	1,168	-
Total core	26,621	26,294	30,000	27,006	30,369	3,363	12
Complementary							
Personnel	1,056	1,312	1,517	1,728	2,936	1,208	70
Training	334	593	807	781	1,230	449	57
Supplies and services	589	762	509	1,003	1,656	653	65
Travel	909	720	432	948	1,520	572	60
Other expenses	704	846	1,128	1,114	1,822	708	64
Subtotal	3,592	4,233	4,393	5,574	9,164	3,590	64
Contingency	-	-	44	56	92	36	64
Price increase	-	-	-	-	370	370	-
Total complementary	3,592	4,233	4,437	5,630	9,626	3,996	71
Hosted activities							
Personnel	371	358	405	263	269	6	2
Training	187	89	162	65	67	2	3
Supplies and services	215	332	235	244	250	6	2
Travel	169	123	172	90	92	2	2
Other expenses	44	96	50	70	72	2	3
Subtotal	986	998	1,024	732	750	18	2
Contingency	-	-	-	-	-	-	-
Price increase	-	-	-	-	-	-	-
Total hosted activities	986	998	1,024	732	750	18	2
Total							
Personnel	18,373	19,278	21,589	20,006	22,511	2,505	13
Training	2,162	1,712	2,325	1,986	2,542	556	28
Supplies and services	5,651	5,790	6,017	5,786	6,865	1,079	19
Travel	3,315	2,763	2,869	2,740	3,419	679	25
Other expenses	1,698	1,982	2,283	2,494	3,489	995	40
Subtotal	31,199	31,525	35,103	33,012	38,826	5,814	18
Contingency	-	-	358	356	381	25	7
Price increase	-	-	-	-	1,538	1,538	-
Grand total	31,199	31,525	35,461	33,368	40,745	7,377	22

Table 6. Staffing pattern: approved positions for 1989, 1990 and 1991 and proposed core positions for 1992.

	Actual 1989	Actual 1990	1991 Budget		1992 Budget request	Changes over 1991 estimate	
			Approved	Estimate		No.	%
1. International staff positions			**	**	**		
Germplasm development							
Beans	21	21	22	22	17	(5)	(23)
Cassava	11	11	14	11	11	-	-
Rice	8	8	8	8	7.75	(0.25)	(3)
Tropical forages	17	17	19	18	13.5	(4.5)	(25)
Total germplasm development	57	57	63	59	49.25	(10)	(17)
Resource management							
Land use	-	-	-	-	6	6	-
Forest margins	-	-	-	-	2	2	-
Hillsides	-	-	-	-	2	2	-
Savannas	-	-	-	-	5.75	6	-
Total resource management	-	-	-	-	15.75	16	-
Institutional development support	4	3	7	6	8	2	33
Research support							
Genetic resources	1	1	1	1	1	-	-
Biotechnology research	1	2	3	2	3	1	50
Virology research	2	2	2	2	2	-	-
Research stations	1	1	1	1	1	-	-
Information management	-	-	1	1	1	-	-
Agroecological studies	1	1	2	2	-	(2)	(100)
Seeds	2	1	-	-	-	-	-
Total research support	8	8	10	9	8	(1)	(11)
Management and administration							
Management	5	5	5	5	5	-	-
Administrative support	2	2	2	2	2	-	-
Projects administration *	1	1	1	1	-	-	-
Total management and administration	8	8	8	8	7	(1)	(13)
Total international staff	77	76	88	82	88	6	7
2. Supervisory positions	303	314	311	317	343	26	8
3. Support positions	1,209	1,244	1,241	1,251	1,346	95	8
Total core	1,589	1,634	1,640	1,650	1,777	127	8

* Paid from indirect cost recovery.

** Positions are shown for the full year although for budgetary purposes a fill ratio of 96 percent is assumed.

Table 7. Staffing pattern: approved positions for 1989, 1990 and 1991 and proposed complementary positions for 1992.

	Actual 1989	Actual 1990	1991 Budget		1992 Budget request	Changes over 1991 estimate	
			Approved	Estimate		No.	%
1. International staff positions							
Germplasm development							
Beans	6	6	9	6	9	3	50
Cassava	2	2	4	1	4	3	300
Rice	-	-	2	1	1.25	0.25	25
Tropical forages	-	-	2	-	1.75	1.75	-
Total germplasm development	8	8	17	8	16	8	100
Resource management							
Land use	-	-	-	-	1	1	-
Forest margins	-	-	-	-	0.25	0.25	-
Hillsides	-	-	-	-	2	2	-
Total resource management	-	-	-	-	3.25	3.25	-
Research support							
Biotechnology research	-	-	-	-	1	1	-
Farmer participation research	1	1	1	1	1	-	-
Total research support	1	1	1	1	2	1	100
Total international staff	9	9	18	9	21.25	12.25	136
2. Supervisory positions	14	23	20	23	56	33	143
3. Support positions	25	51	32	51	129	78	153
Total positions	48	83	70	83	206.25	123.25	148

Table 8. Budget request for capital expenditures and assets: amounts for core and complementary activities in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

	Actual 1989	Actual 1990	1991 Budget		1992 Budget request	Changes over 1991 estimate	
			Approved	Estimate		$'000	%
Expenditures							
New							
Laboratory and scientific equipment	151	582	849	420	489	69	16
Heavy duty equipment	23	252	309	60	52	(8)	(13)
Furniture and office equipment	368	452	186	30	10	(20)	(67)
Vehicles	244	-	80	20	21	1	5
Aircraft	-	-	-	-	-	-	-
Land, buildings, leasehold improvement	941	839	300	200	208	8	4
Computer equipment	-	-	-	45	47	2	4
Subtotal	1,727	2,125	1,724	775	827	52	7
Replacement							
Laboratory and scientific equipment	231	202	325	430	447	17	4
Heavy duty equipment	174	324	71	280	343	63	23
Furniture and office equipment	-	250	80	20	21	1	5
Vehicles	387	802	300	360	408	46	13
Aircraft	-	-	-	-	-	-	-
Land, buildings, leasehold improvement	-	-	-	110	114	4	4
Computer equipment	-	-	-	135	140	5	4
Subtotal	792	1,578	776	1,335	1,471	136	10
Total expenditures	2,519	3,703	2,500	2,110	2,298	188	9
Capital stock							
Fixed assets (beginning of year)	26,663	29,182	31,943	20,257	20,757	500	2
Additional assets							
New	1,727	2,125	1,724	775	827	52	7
Replacement	792	1,578	776	1,335	1,471	136	10
Subtotal	29,182	32,885	34,443	22,367	23,055	688	3
Accrued depreciation	-	(12,628)	-	(1,610)	(1,610)	-	-
Year-end fixed assets	29,182	20,257	34,443	20,757	21,445	688	3

Table 9. Budget request for price assumptions: amounts for core activities (%).

Expenses by categories	1990/ 1991	1992	Currency denomination			
	Net change	Budget amount ($'000)		Devaluation (%)	Inflation rate	Net price adjustment
Personnel						
	4.50	7,745	US$	-	5.0	5.0
	0.50	11,561	Col$	22.0	24.0	1.6
Training						
	5.00	1,000	US$	-	5.0	5.0
	5.00	245	Col$	22.0	28.0	4.9
Supplies and services						
	11.47	1,736	US$	-	10.0	10.0
	12.69	3,223	Col$	22.0	32.0	8.2
Travel						
	4.55	1,245	US$	-	5.0	5.0
	-6.36	562	Col$	22.0	22.0	-
Other						
	4.53	678	US$	-	4.5	4.5
	-4.75	1,206	Col$	22.0	22.0	-
Total	4.09	29,201	-	-	-	4.0

Table 10. Budget request: sources and application of funds. Amounts for core, complementary and hosted activities in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

	Actual 1989	Actual 1990	1991 Budget		1992 Budget request	Changes over 1991 estimate	
			Approved	Estimate		$000	%
Sources of funds							
1. Grants							
For core programs	28,421	27,733	31,956	28,100	31,910	3,810	14
For complementary programs	4,169	4,641	5,294	6,424	10,199	3,775	59
For hosted activities	1,017	1,024	1,023	732	750	18	2
2. Other income							
For core programs	840	835	716	716	740	24	3
For complementary programs	125	-	-	-	-	-	-
Total sources	34,572	34,233	38,989	35,972	43,599	7,627	21
Application of funds							
1. Operational programs							
Core	26,821	26,294	30,000	27,006	30,369	3,363	12
Complementary	3,592	4,233	4,437	5,630	9,626	3,996	71
Hosted	986	998	1,023	732	750	18	2
2. Capital							
Core	2,607	1,870	2,098	1,810	1,986	176	10
Complementary	702	408	856	300	312	12	4
Hosted	31	26	-	-	-	-	-
3. Working capital and reserves							
Core	33	404	574	-	295	295	-
Complementary	-	-	1	494	261	(233)	(47)
Total applications							
Core	29,261	28,568	32,672	28,816	32,650	3,834	13
Complementary	4,294	4,641	5,294	6,424	10,199	3,775	59
Hosted	1,017	1,024	1,023	732	750	18	2
Total applications	34,572	34,233	38,989	35,972	43,599	7,627	21
Memo item							
Working capital at year end	1,525	2,429	2,157	2,923	3,479	556	19

Table 11. Budget request: balance sheet. Amounts for core, complementary and hosted activities in 1989, 1990, 1991 and 1992 (thousands of current US dollars).

	Actual		Estimate	Projection
	1989	1990	1991	for 1992
Assets				
Cash and short-term deposits	3,594	6,687	4,600	3,400
Accounts receivable	10,387	10,416	10,941	10,778
Inventories	1,459	1,061	936	886
Other assets	973	433	330	310
Property, plant and equipment	29,182	20,257	20,757	21,445
Total assets	45,595	38,854	37,564	36,819
Liabilities and fund balances				
Liabilities				
Bank overdrafts and loans	3,395	5,400	4,200	3,000
Accounts payable	4,501	7,233	5,049	4,127
Payments in advance from donors	2,240	285	935	900
Accrued salaries and benefits	1,363	1,240	1,350	1,300
Long-term liabilities - Staff reserves	1,279	1,610	1,850	2,000
Total liabilities	12,778	15,768	13,384	11,327
Fund balances				
Capital fund	29,182	20,257	20,757	21,445
Working capital fund	1,525	2,429	2,923	3,447
Infrastructure fund	50	50	100	150
Capital development fund	300	350	400	450
Commitments for capital acquisitions	1,760	-	-	-
Total fund balances	32,817	23,086	24,180	25,492
Total liabilities and fund balances	45,595	38,854	37,564	36,819

FUNDING REQUEST FOR 1992

CIAT's funding request for 1992 is equivalent to the budget proposed for 1992 in the operational plan for 1992-1996 described in Part I, *Program Plans and Resource Requirements* 1992-1996.

Core Program

The budget request for the 1992 core program amounts to $32,650,000. Included in this budget request are monies for the setting up of the proposed new effort in resource management research. As shown in the operational plan, CIAT proposes to finance the initiative in resource management research through a combination of reallocating existing resources and using additional resources. A large part of the additional resources required to finance resource management research in the 1990s is proposed to be added in 1992 itself. It should be noted that the total amount requested by CIAT for its core program in 1992 is, in fact, slightly below the original, CGIAR-approved budget for 1992 (i.e., the CGIAR-approved budget under the earlier mid-term plan presented by CIAT in 1988 for the period 1989-1993).

List 6 shows the principal changes in the proposed 1992 budget vis-à-vis the 1991 working budget. Details and justification for items in the list are provided in the *Program Plans and Resource Requirements* 1992-1996.

Self-generated income

Earned income in the 1992 financial year is projected to be at $740,000, including estimated income from farm production, overhead on special projects, and financial transactions (mostly interest).

Donor funding

Against the budget request for $32,650,000 and in light of a projected self-generated income of $740,000, CIAT's request for funding from the CGIAR amounts to $31,910,000.

List 6. Principal changes ('000 US$) in the proposed 1992 budget.

Area			Amount[1]
1991 Budget base			28,816
Germplasm Development Division			
1.	Bean Program		
	a.	Deletion of position for Cropping Systems Specialist	(150)
	b.	Deletion from the core program of three African-based positions	(645)
	c.	Deletion of regional coordination position in the Andean region	(254)
2.	Rice Program		
	a.	Phasing out of core the coordination position for the Caribbean regional program	(90)
	b.	Net of other adjustments	21
3.	Tropical Forages Program		
	a.	Addition of positions for:	
		i. Germplasm Specialist	230
		ii. Agronomist for germplasm screening (West Africa)	190
	b.	Deletion of positions for:	
		i. Agronomist for germplasm screening (Llanos)	(230)
		ii. Livestock Systems Specialist	(234)
		iii. Agricultural Economist	(177)
		iv. Specialist for integration of systems	(199)
		v. Nutrient Recycling Specialist (humid tropics)	(107)
		vi. Pasture Reclamation Specialist (Cerrados)	(183)

[1] Numbers in parentheses signify amounts reduced.

(Continued)

List 6. (Continued)

Area			Amount[1]
	c.	Net of other adjustments	(187)
4.	Strategic research initiatives in germplasm development		100
Resource Management Division			
1.	Land Use Program		
	a.	Positions for:	
		i. Program Leader	160
		ii. Agricultural Land Use Specialist	217
		iii. Environmental Geographer	225
		iv. Environmental Impact Assessment Specialist	225
		v. Information Management Specialist	100
		vi. Resource Economist	200
		vii. Economic Policy Analyst	200
	b.	Support for Sociologist	30
2.	Forest Margins Program		
	a.	Positions (1/2 each) for:	
		i. Agricultural Economist	113
		ii. Cropping Systems Specialist	128
		iii. Livestock Systems Specialist	108
		iv. Anthropologist	113
3.	Hillsides Program		
	a.	Positions (1/2 each) for:	
		i. Agricultural Economist	113
		ii. Cropping Systems Specialist	128
		iii. Livestock Systems Specialist	108
		iv. Anthropologist	113

[1] Numbers in parentheses signify amounts reduced.

(Continued)

List 6. (Continued)

Area			Amount[1]
4.	Savannas		
	a.	Positions for:	
		i. Program Leader	160
		ii. Cropping Systems Specialist	255
		iii. Nutrient Cycling Specialist	255
		iv. Livestock Systems Specialist	255
		v. Crop/Pastures Systems Specialist	200
	b.	Positions (1/4 each) for:	
		i. Economist	120
		ii. Nitrogen Cycling Specialist	51
		iii. Ecophysiologist	57
5.	Research station support in Llanos		20
6.	Strategic research initiatives in resource management research		100
Institutional Development Support Program			
1.	Addition of Head of Training		135
2.	Transfer of Project Design Specialist from Management and Administration (paid from indirect cost recovery)		0
3.	Addition to conferences budget		60
Research Support			
1.	Closing of Agroecological Studies Unit (now incorporated in Land Use Program)		(237)
2.	Elimination of line item for research contracts (now incorporated into strategic research initiatives)		(169)

[1] Numbers in parentheses signify amounts reduced.

(Continued)

List 6. (Continued)

Area		Amount[1]
3.	Addition of position for Molecular Cytogeneticist in Biotechnology Research Unit	255
4.	Addition to Visiting Scientist/Postdoctoral Fellow budget	50
5.	Addition to Information Management Systems	161
6.	Net of other modifications	62
General Operating Expenses		
1.	Addition to electricity budget	50
2.	Transfer of Project Design Specialist from Management and Administration to Institutional Development Support Program (paid from indirect cost recovery)	(0)
Contingencies		(11)
Capital		100
	Subtotal	31,111
Cost increases (inflation)		1,348
Working capital adjustment		191
	TOTAL 1992 REQUEST	32,650

[1] Numbers in parentheses signify amounts reduced.

Complementary Activities

As indicated in the operational plan (see Part I), CIAT proposes complementary activities in 1992, the cost of which will amount to $10,199,000, involving a total of 21 Senior Staff positions. List 7 below summarizes the projected complementary activities and shows the funding status of the respective projects.

List 7. 1992 Proposed complementary activities ('000 US$).

Activity	Budget	Donor
Germplasm Development Division		
1. Bean Program		
Africa: Great Lakes Region, E and S Africa	2,645	SDC, CIDA, USAID
Andean region	254	SDC
Biotechnology network	300	Not yet funded
Research on *Phaseolus* germplasm	120	Italy
2. Cassava Program		
Soil fertility and conservation	98	Germany
Development of production and processing technology (NE Brazil)	276	W.K. Kellogg Foundation
Green spider mite	180	UNDP
Biotechnology network	323	Netherlands
Propagation from true seed	130	Not yet funded
Genetic improvement in Brazil	224	IFAD
Germplasm development in E and S Africa	255	Not yet funded
Socioeconomic research, utilization and marketing in Asia	340	Not yet funded
Integrated projects in tropical America	284	Colombia, France, IDRC
3. Rice Program		
Caribbean improvement network	622	CIDA
Joint study on upland-rice root physiology and architecture	76	France

(Continued)

List 7. (Continued)

Activity	Budget	Donor
4. Tropical Forages Program		
Ecology (Savannas)	161	Not yet funded
Screening in SE Asia	203	Not yet funded
Research for improving native grasslands	65	Japan
Resource Management Division		
Tree specialist (Hillsides)	225	Not yet funded
Silviculture (Hillsides)	25	Not yet funded
Forest ecosystems (Forest Margins)	56	Not yet funded
Forest policy (Land Use)	225	Not yet funded
Institutional Development Support Program		
Training trainers	600	IDB
Research Support		
Microbial genetics	215	Not yet funded
Biotechnology research DNA fingerprinting	100	Rockefeller Foundation
Bean genetic improvement	298	Belgium
Farmer participatory research	279	W.K. Kellogg Foundation
Sorghum and soybean germplasm	80	Not yet funded
Forage germplasm biology	91	Not yet funded
Forage in vitro management	134	Not yet funded
Phaseolus bean germplasm	80	Not yet funded
Contingencies	92	Not yet funded
Capital	300	CIDA, USAID, SDC, Japan, W.K. Kellogg Foundation
Working capital adjustment	261	Not yet funded
Cost increases (inflation)	382	
Total	10,199	

ACRONYMS

Acronym	Name
AFRNET	Pan-African Livestock Feed Resources Network, Ethiopia
BCMV	bean common mosaic virus
BGMV	bean golden mosaic virus
BNF	biological nitrogen fixation
BRU	Biotechnology Research Unit, CIAT
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CBN	Cassava Biotechnology Network
CD-ROM	compact disc-read only memory
CEEMAT	Centre d'Etudes et d'Experimentation du Machinisme Agricole Tropical, France
CENARGEN	Centro Nacional de Recursos Genéticos, Brazil
CGIAR	Consultative Group on International Agricultural Research, USA
CGM	cassava green spider mite
CIDA	Canadian International Development Agency, Canada
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico
CIP	Centro Internacional de la Papa, Peru
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France
CLAIS	Comisión Latinoamericana de Investigación en Sorgo
CNI	Centro Nacional de Investigaciones, Colombia
CNPMF	Centro Nacional de Pesquisa de Mandioca e Fruticultura, Brazil

CRIN	Caribbean Rice Improvement Network, Dominican Republic
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
ELISA	enzyme-linked immunosorbent assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brazil
EMPASC	Empresa de Pesquisa Agropecuária de Santa Catarina, Brazil
EPR/EMR	External Program Review/External Management Review, CIAT
FAO	Food and Agriculture Organization of the United Nations, Italy
FUNDAGRO	Fundación para el Desarrollo Agropecuario, Ecuador
GAS	General Administrative Services, CIAT
GDP	Germplasm Development Programs, CIAT
GIS	geographic information systems
GRU	Germplasm Resources Unit, CIAT
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit [German Agency for Technical Cooperation], Federal Republic of Germany
HCN	hydrogen cyanide
IBPGR	International Board for Plant Genetic Resources, Italy
ICA	Instituto Colombiano Agropecuario, Colombia
ICM	integrated crop management
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
IDRC	International Development Research Centre, Canada
IDSP	Institutional Development Support Program, CIAT

IEMVT	Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux, France
IFAD	International Fund for Agricultural Development, Italy
IFDC	International Fertilizer Development Center, USA
IFPRI	International Food Policy Research Institute, USA
IICA	Instituto Interamericano de Cooperación para la Agricultura, 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
IPM	integrated pest management
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières, France
IRRI	International Rice Research Institute, Philippines
MPFTS	multipurpose forage trees and shrubs
NFTA	Nitrogen Fixing Tree Association, USA
NRI	National Resources Institute, England
R & D	research and development
RFLP	restriction fragment length polymorphism
RHBV	rice "hoja blanca" virus
RIEPT	Red Internacional de Evaluación de Pastos Tropicales
RMRP	Resource Management Research Programs, CIAT
SDC	Swiss Development Cooperation, Switzerland
UNDP	United Nations Development Programme, USA

USAID	United States Agency for International Development, USA
VAM	vesicular-arbuscular mycorrhizae
VRU	Virology Research Unit, CIAT
WARDA	West Africa Rice Development Association, Ivory Coast

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