REPORT OF THE

INTERNALLY COMMISSIONED EXTERNAL REVIEW

ON

RESOURCE MANAGEMENT RESEARCH

OF THE

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL

(CIAT)

Panel

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Dr. Robert Havener
Director General
CIAT
Palmira, Colombia

Dear Dr. Havener

I have the pleasure of transmitting to you the Report of the First Internally Commissioned External Review on Resource Management Research of the Centro Internacional de Agricultura Tropical (CIAT). The Panel charged with this Review has closely examined the activities relating to Resource Management Research at the Centro's headquarters in Cali and has heard from a large number of senior staff members and has met with the leaders of all the Programs, SRG's and Research Units. Members of the Panel also had the opportunity to visit the field sites in the Cauca Valley and Carimagua in Colombia and in Brasilia, Uberlandia and Acre in Brazil. We also had at our disposal the results of prior reviews, the Annual Reports of the different programs, all publications from the programs and a specially prepared outline of the NRM.

As you will see from our report, in spite of the problems faced lately by CIAT, it is our opinion that the Center has put together a very credible program in Resource Management Research. What CIAT is doing is at the cutting edge of an entirely new but absolutely essential research area and is truly path breaking. In such circumstances researchers have to develop their own methods and standards, which is always a risky enterprise. We feel that the staff is performing excellently and the quality of the research is uniformly high.

The Panel wishes to thank the staff for its patience in attending to our queries and intrusions into their daily activities, and especially Dr. Douglas Pachico who arranged for the convening of the panel and saw to it that all our needs were attended to.

We trust that the report will be of help in the planning of the future activities at the Center.

Your sincerely,

Otto T. Solbrig
Chair, ICER Panel

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FOREWORD

This is the Report of the First Internally Commissioned External Panel appointed to review the research of CIAT in the area of Natural Resources Management The membership of the panel and their backgrounds are listed in Annex 1

This review was commissioned by CIAT in December of 1994 The full terms of reference for the Review are detailed in Annex II The Panel visited CIAT and the research sites in Colombia and Brazil between June 12 and June 30 1995 It included visits to Acre Brazil by Drs Nelson and Solbrig and to the Brasilia and Uberlandia research sites in Brazil by Dr Duxbury The full panel spent a day in Carimagua Colombia and another in the Rio Cabuyal site The staff prepared a detailed document on the work on Natural Resources Management at CIAT and made oral presentations to the panel on June 19 The panel also met singly with the leaders of all NRM Programs and Units and also had an opportunity to speak to the leaders of the commodity programs and Research Units It was given access to the Annual Reports of all projects and all publications both those in the open literature as well as unpublished manuscripts

The Panel feels that it has obtained a good overview of the NMR program Evidently in a program as vast and diverse as this it is not possible to comprehend every detail Yet we are confident that we have a reasonably accurate view of this program It is the Panel s hope that this report be useful to the researchers at CIAT to CIAT s management and to the Board

CHAPTER 1 INTRODUCTION

Exponential population growth and consumption characterize the 20th century These two phenomena have their roots in the agrarian revolution of the 17th century and the industrial revolution of the 18th and 19th centuries in Europe with their twin beliefs in the unbounded plenty of nature and the power of human ingenuity expressed through science and technology to reveal and make available the power of nature From Bacon to Saint Simeon western writers and thinkers expressed their confidence in a bright future free of want

Two world wars and the specter of atomic wars have reduced considerably the enthusiasm of the world for science and technology as the principal instruments to resolve social problems Furthermore increased consumption and population growth have revealed a world with definite limits In their optimism the 19th century failed to grasp the implications of the thermodynamic laws namely that every human activity increases entropy or in other words is degrading in some form The significance of the thermodynamic laws became visible when after the second war poverty inequality and the threat of famine increased together with exponential population growth and consumption

Humans (and all other organisms) need a continuous supply of energy (food) to function Concern arose in the 1950 s that with then existing technologies massive famines would arise unless food supplies could be increased dramatically This was how the CGIAR system came into being and was the impetus in the development of a package of technologies that have been called the green revolution They were built around improved germplasm together with high inputs of fertilizers and energy There is no question that the timely intervention of the International Agricultural Research Centers (IARC) in collaboration with national agricultural organizations prevented extensive famines in spite of increased growth in consumption and population

The expansion of agropastoral activities throughout the world in the last 40 years has brought to the fore a problem that has plagued agriculture since Babylonian times the degradation of the natural resource base on which it depends As long as land was plentiful this was not of particular concern since degraded and unproductive land could always be replaced by new land But as the most fertile land was used up and agricultural expansion incorporated increasingly more marginal areas degradation of the natural resource base accelerated and became a distressing problem

Furthermore the advance of the agricultural frontier resulted in massive deforestation and transformation of natural landscapes This increased the value to certain sectors of society of unspoiled nature and powerful environmental movements appeared especially in the developed world that tried to reduce or eliminate landscape

transformation For the first time in the west the feeling arose that there were limits to the exploitation of nature and the meaning of entropy started to be appreciated Not everybody shared these new views that have been grouped into what is called environmentalism and the transformation of nature has continued almost unabated but in an increasingly more confrontational context

That agriculture is a degrading activity is undeniable There is no way to grow plants or raise animals for human consumption without affecting biodiversity and soil and water resources and increasing erosion Whenever humans appropriate part of the sun s energy they are denying that energy to some other organism Even hunter gatherers impacted their environment The more an individual consumes the greater its effect on nature the greater the population on this planet the greater the collective impact Both consumption and population have increased tremendously and unless both consumption patterns and population growth stabilize natural resources will continue to be degraded Ultimately sustainability requires stabilization of consumption patterns and of population growth However it will take at least a century for this to occur

In the meantime it is imperative that technologies be developed to reduce the human impact on nature It is clear that the efficiency of energy transfers in agriculture and other human activities is very low and that if increased it leads to less degradation of nature Consequently any effort to improve agricultural efficiency and reduce loss of natural resources should be strongly encouraged

1 1 Sustainable use and sustainable development

The belief that human ingenuity in the form of technology could overcome limitations imposed by nature was bolstered in the last century by the enormous progress that Europe made in overcoming the initial misery and poverty that was the result of the dislocations created by the agrarian and industrial revolutions In the America s belief in progress through technology became almost a religion as thousands of poor streamed over the Atlantic in search of personal improvement Yet the improvement of the living standards of the European and North American populations was made possible in part because of their ability to exploit new sources of energy and materials It was the unused lands of Canada the United States Argentina and Australia as much as technological advancements that made economic growth possible before WWII Yet out of European success in increasing the living standards of their populations arose a strong belief in the power of technology This

faith in development through technology led the industrial nations of Europe and North America to export their model of economic development to the rest of the world Their belief on the power of development was shared by many leaders of third world countries

As the best lands became used up the expansion of agriculture increasingly involved more marginal lands that is lands with some kind of limitation be it soils with poor physical or nutrient characteristics areas with water limitations or mountainous regions on steep slopes These soils are easily degraded

Consequently as large colonization schemes were encouraged by both governments and international development institutions environmental disasters of varying proportions followed

The necessity on one hand to keep expanding agriculture so as to attend to the food needs of the world and the necessity to reduce or eliminate the negative effects of agricultural development led to the concept of sustainable development If by development we understand the expansion of economic activities depending on natural resources that are in part non renewable development never can be sustainable unless there is substitution among various forms of capital natural physical human and institutional A related concept is that of sustainable use that implies the judicious use of renewable resources in such a way that they don t become exhausted Contrary to sustainable development sustainable use is a more readily attainable objective Agriculture is the prototype activity to test the concept of sustainable use In the context of agriculture sustainable use is the application of technologies that maintain and enhance the resource base on which domestic plants and animals depend soil water and an environment reasonably free of competitors pests and diseases

Over the centuries and across the world a large number of reasonably sustainable agricultural systems have evolved from slash and burn agriculture in tropical regions to crop rotation in Europe These systems however break down when they are forced to become more productive beyond a certain threshold be it shorter rotations in slash and burn agriculture shifts to monocroping in rotation systems The so called green revolution was an attempt to increase the productivity of traditional agricultural systems based on crop rotations by encouraging continuous cropping through the introduction of high yielding varieties combined with chemical fertilization and the use of agro chemicals It was very successful in its effort to increase production but it is clear that it is not a sustainable system What is now needed is to

find ways to make it sustainable Reversion to less productive systems as is sometimes advocated is not the answer as the demand for food is still increasing On the contrary agriculture will have to become even more productive since the demand for agricultural products can no longer be supplied solely by increases in the arable area farmed

1 2 Role of CIAT

CIAT can play a major role in this new environment It has developed an international reputation for its work on the improvement of tropical crops and pastures If it can complement this with a program to develop ways to increase productivity while conserving natural resources it will have completed the requirements for producing a truly sustainable agriculture The task will not be easy since sustainability is not simply a question of managing natural resources such as reducing soil loss or improving water quality Sustainability involves also social and economic dimensions

Sustainability does not mean simply to manage resources so as to maintain a certain level of production forever Sustainability must allow for the improvement of the well being of the inhabitants of a region and it must also be economical Three major objectives are implied by sustainability Environmental integrity Economic efficiency and Equity

By environmental integrity is meant the necessity of any sustainable system to maintain the productive capacity of the basic resources such as soil water light and biodiversity Environmental integrity permits modification of the environment provided that these modifications maintain the basic ecological services of the ecosystem So for example tropical savannas can be transformed for use in cattle raising without compromising environmental integrity provided that due consideration is taken for the necessity to maintain gallery forests and of managing the soil so as to avoid erosion etc However when slash and burn farmers in Brazil keep trees of Brazil nuts (*Bertholetia excelsa*) standing in their fields but fail to maintain an environment in which the pollinators of this tree can coexist with it they are not conserving the species even though the trees are kept alive Environmental integrity is maintained in the first case but not in the second

Economic efficiency should aim at obtaining the maximum economic benefit subject to maintaining environmental integrity as a condition Economic efficiency does not mean mining a resource in the most efficient way because environmental

integrity must be maintained A well managed improved pasture allows the rancher to increase the efficiency with which he harvests solar energy and transforms it into beef for human consumption without creating soil erosion or decreasing the quality of the water

Equity implies that the benefits from the economic activity should be distributed impartially among all the social actors Equity does not imply equality in income but equality in opportunities Equitable distribution of income and resources usually increases economic efficiency and environmental integrity

The debate about sustainability that has been taking place is in essence a discussion about the relative importance of each of these three components Research in natural resources likewise involves the development of techniques that address these three aspects Research involving environmental integrity revolves around the well known issues of soil plant water pests etc and involves primarily natural and agricultural scientists from plant breeders to agronomists This type of research has been conducted at CIAT for a long time in conjunction with crop improvement programs and its extension to natural resources presents no special problems Research on economic efficiency is likewise an extension of research already being conducted at CIAT It involves primarily economists and social scientists It represents however a greater departure from what has been done in the past since it goes beyond market analysis to looks at other dimensions such as the role of policy and institutions in economic behavior the importance of changes in land value and the economic importance of natural goods such as biodiversity

CIAT has always been deeply concerned with rural poverty and equity issues It has been the one International Center that has conducted research on crops that are targeted to subsistence farming Yet research on equity issues probably represents the biggest departure for CIAT from the manner in which research has been conducted in the past So far it has operated under the belief that if it conducted well its mission of increasing food supplies and food security it would automatically help alleviate poverty and increase equity What is now suggested is that CIAT go beyond that point and document in what ways lack of equity is a hindrance to sustainability and to suggest policies and scenarios that can increase sustainability by improvements of social and economic equity Equity issues also require expertise not traditionally found at CIAT

As we move from issues of environmental integrity through economic efficiency to equity considerations the scales of analysis necessarily increase Environmental

integrity involves many site specific issues at the plot and field levels and up to the farm level while economic efficiency involves scales that go from the farm to the region and beyond Equity issues involve mostly regional and national concerns These different levels of inquiry can be integrated and their interconnections understood through the application of systems analysis

The ultimate objective is to produce a sustainable highly productive agriculture for the tropics This requires the input of all the programs working in a coordinated and collaborative fashion The contribution of the plant breeder in this effort is as important as that of the systems analyst Only in this fashion can the formidable challenge of producing sustainable agricultural systems for the 21st century be met

1 3 The Natural Resource Management Approach

As the previous discussion shows it is our view that all research activities at CIAT have the responsibility of contributing to the development of sustainable agricultural systems in tropical America and beyond Such a mandate implies that all approaches must work towards enhancing productivity environmental integrity economic efficiency and equity Not all specific programs will contribute equally to all these goals Some are more focused and have more expertise in issues of productivity while others are in a better situation to analyze and identify economic constraints some programs have worldwide commitments to a certain crop while others are focused on a particular ecosystem in tropical America Yet by working together and by coordinating their knowledge they can contribute substantially to CIAT s research agenda Rather than thinking of two research approaches one on commodities and one on natural resources CIAT needs to see itself as having one research policy contributing to commodity development a sustainable fashion and developing sustainable agriculture within a commodity strategy In our conversations we have found a degree of agreement with this outlook in both staff and management and are confident that it can be implemented Clearly commodity development in a non sustainable environment is eventually self defeating Likewise no program of sustainable agriculture will succeed if it does not contribute to increased food supplies and food security

The mechanism to achieve better integration between programs and collaboration between scientists is to have researchers from different programs collaborating in Program projects whenever possible and called for So for example we envision those programs whose primary concern is in commodity development

ollaborating with the Land Management Program in trying to produce sustainable esource management techniques for particular crops Likewise we expect Programs with an agroecosystem approach to involve commodity researchers in projects involving the development of prototype farming systems

We now discuss the relation between Programs Units and Scientific Research Groups (SRG s) in more detail

1 3 1 Organization

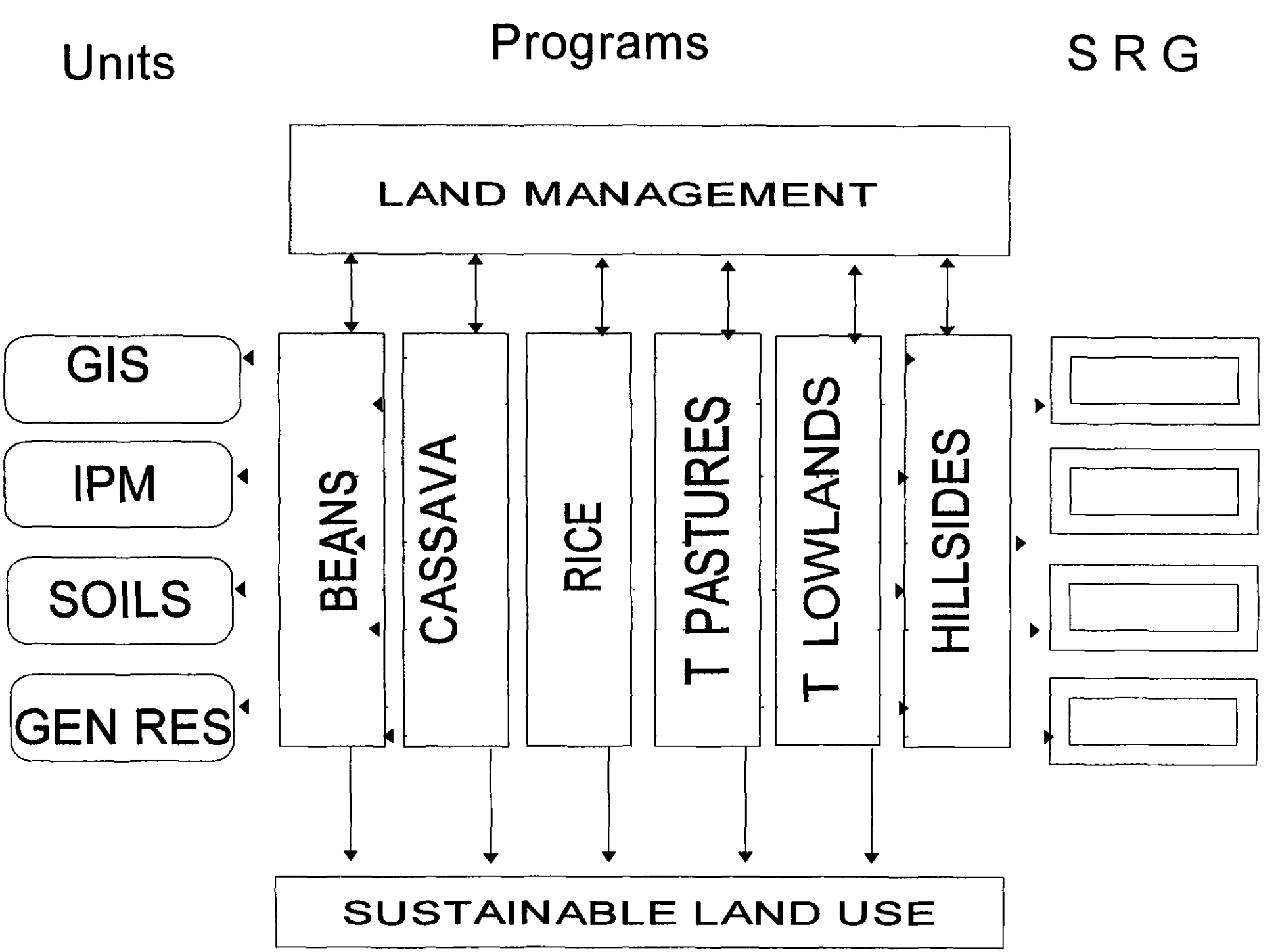
Since the objective of CIAT is to increase human welfare through increased agricultural production in a sustainable manner we strongly recommend that the separation of the programs into commodity research and natural resources management research (NRM) approaches be dropped and that instead CIAT have a single research effort to increase productivity in a sustainable manner under a single Deputy Director General for Research We further envision three types of research units Programs Units and Scientific Research Groups (see Figure 1)

1 3 1 1 Programs are the basic research units of CIAT Programs have their own budget and execute projects We envision seven programs Land Management Beans Cassava Rice Tropical Forages Tropical Lowlands and Hillsides We recommend that the land management SRG be made into a program which it is at present in everything but name

The Land Management Program was described by the recent external review as an umbrella program to understand policy effects on land use systems at an aggregate level We agree that this description is conce- ually accurate and should be kept organizationally the Land Management Program should be seen on the same footing as the other programs

We are also recommending that the research in the Forest Margins carried out in the Tropical Lowlands Program s Prototype Cropping Systems project be discontinued as discussed further on

1 3 1 2 Research Units also have their own budgets and their own projects Research Units develop around some technology that is of common interest such as Geographical Information Systems (GIS) or Biotechnology Research Units provide logistic support to the programs in the form of common projects or in the execution of specific projects that address issues of interest to the programs We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T LOWLANDS
HILLSIDES
SUSTAINABLE LAND USE

envision four Research Units Geographical Information Systems Unit an Integrated Pest Management Unit a Soils and plant analysis Unit and a Genetic Resources Unit

CIAT uses **GIS** in virtually every area of its research It has developed an impressive capability in this area both in terms of hardware and software and in the training of specialized personnel The system is using the ARC INFO software for map data preparation and ERDAS software for remote sensing analysis and has a number of Sun workstations printers and plotters for the analysis and production of maps The unit has a rich base of digitized maps of different regions of Latin America as well as maintaining the CIAT Climate Database for the Tropical World

We see the GIS lab as a prototype Research Unit GIS is a very sophisticated new technology for the analysis of georeferenced complex systems GIS is much more than a technology to produce accurate maps although it also can do that As the various projects that have been undertaken by the GIS lab show the technique can be applied across all programs and with various levels of sophistication

Currently the GIS lab is loosely connected with the Land Management Program (presently an SRG) However a great deal of interest in use of GIS was expressed by the other programs and therefore we feel that GIS should be a separate Unit Since the Land Management Program is the principal user of GIS we feel it appropriate that there be a close interaction and consultation between these two entities

On account of its high level of expertise the GIS Research Unit may be called to undertake projects that do not fall within the mandate of CIAT but are interesting from a disciplinary point of view and are fully funded such as the recently completed Cenicaña project It is our opinion that the GIS Research Unit should concentrate on CIAT related work as much as possible

Integrated pest management is at present a SRG with an attached Virology Research Unit We propose that these functions be merged into an Integrated Pest Management (IPM) Unit The integrated Pest Management SRG and the Virology Unit are presently seen as supporting the commodity programs This function they should continue to perform but pest management is so central for Natural Resource Management that we would like to encourage Programs to have IPM projects in conjunction with the IPM unit

Likewise we feel that characterization of soils and measurement of soil properties and function are central to all Programs and that the various activities in this

area should be merged into a Soils Unit as recommended by the External Program Review (EPMR) However in contrast to the EPMR we recommend that the focus of the soils unit be on the supply of information and analytical services and should not include activities such as nutrient cycling and organic matter dynamics which more properly belong in research Programs Services provided by the unit should include maintenance of soil data bases and routine and specialized analyses (e g stable isotope analyses) The unit could assist in methods development and application and should engage in collaborative research with programs as appropriate A current example of the latter would be the development of soil quality indicators The SoilS Unit would bring the scientific issues relating to soil into a better focus and could result in the elimination of duplication of facilities A Soils Unit together with the IPM Unit would help focus on these two very crucial natural resources

Finally we would like to suggest that the **Genetic Resources Unit and the Biotechnology Research Unit** be combined into a single unit Such a unit would have its principal interactions with the programs involved in commodity development but could also be of extreme importance to the Tropical Lowlands and the Hillsides Programmes Such arrangement is favored by the leaders of both the existing units

1 3 1 3 Scientific Research Groups (SRG) were originally envisioned as interprogram groups coalescing around a common disciplinary theme As originally planned SRG s would have their own budget and would originate their own projects This was later overruled by the CIAT Board of Trustees We concur with this decision yet see great usefulness in the concept of the SRG We feel however that SRG s should not be permanent organizational units (such as Programs or research Units) but should be flexible arrangements that could be formed when members of different programs feel the need to explore a particular scientific issue with the view of initiating an interprogram project They should be disbanded when their objectives have been met Because of their interproject and disciplinary nature the formation of SRG s should be encouraged by the Deputy Director General Research in response to Management or staff perception of research issues

We now present a more detailed discussion and make specific recommendation in relation to three Programs Tropical Lowlands Hillsides Land Management and the GIS unit

CHAPTER 2 THE NATURAL RESOURCE MANAGEMENT RESEARCH APPROACH

2 1 Tropical Lowlands Program

The stated overall goal of the program is 'to develop and test a diverse set of sustainable land use forms for the acid soil savannas and forest margins of tropical America (CIAT 1995 ICER paper) The program strategy to achieve this goal has three major elements

- understanding land use dynamics
- understanding the biophysical and socioeconomic processes that affect natural resource management
- development and testing of prototype systems

2 1 1 Savannas Sub Program

The Savannas Sub Program is the most developed and has the clearest and most attainable goals within CIAT s NRM approach This is due in part to its evolution from the tropical forages germplasm program which effectively gives it a longer history than the other programs The major efforts in the Savannas are (i) to develop a mechanistic understanding of the processes relevant to enhanced productivity increased efficiency and environmental quality (ii) the development and evaluation of prototype sustainable land use systems especially agropastoral systems and (iii) understanding land use dynamics

Overall the research program is ambitious but well conceived It is producing high quality results that are relevant to it s objectives and is well balanced between strategic and applied research

The EPMR recommended that the Sub Program be reduced to one site however differences (detailed below) between the sites argue against this However without additional resources the scope of the Sub Program and the balance of activities between the two sites should be carefully considered and more limited than at present Currently the bulk of the activities are in Colombia where ten principal staff are stationed and only one principal staff person is stationed in Brazil (a second principal staff person is associated with the tropical forages program) Given the

limited although effective inputs from EMBRAPA into the program it is unrealistic to expect that one scientist can run the program that has been planned for the cerrados We recognize the barriers created by Brazilian institutions to greater involvement of CIAT in the cerrados but support continuance of efforts to expand the program in Brazil Taking a pragmatic view results of the quality required cannot be obtained in the allotted time with the current level of effort

The Savannas Sub Program should strive to ensure complementarity with related work in other ecosystems Process level understanding and evaluation of potential soil quality indicators apply across ecosystems and programs should communicate and collaborate in these areas As a minimum Programs should use similar methodologies

2 1 2 Research Sites

Research is carried out in the Meta region of the Colombian llanos on level well drained oxisols and at *Planaltina near* Brasilia and in the Uberlandia region of Brazil on gently sloping topographies and oxisols that vary in texture but are also generally well drained The llanos is smaller in area and much less developed than the Cerrados Principal differences between the regions include rainfall and soil P fixing capacity Rainfall and length of dry season are 2500mm and 3 months respectively in Colombia compared to 1200 1500mm and a 6 to 7 months respectively in Brazil The soils at the Brazilian sites are known to be more strongly P fixing those at the Colombian sites

In 1992 a long term experiment was established in collaboration with EMBRAPA at their Cerrados center (CPAC) at Planaltina near Brasilia Collaboration with the Land Management SRG and EMBRAPA led to identification of the Uberlandia region as an appropriate place for detailed studies This region is at the Southern end of the cerrados and includes several major categories identified by GIS based factor analysis The interpretation of the factor analysis is not clear to us since the *methodology is unique* It is clear however that the Uberlandia region represents the most advanced stage of development of cerrados agriculture and *infrastructure* Land use in 1992 was 60% pasture 15% annual crops (soybeans maize and rice) and 8% reforestation (pine and eucalyptus) Only 7% of the land was still native cerrados Since 1992 cropland has increased somewhat mostly at the expense of forest Poultry and swine feeder and cattle finishing industries are established in the region and maize is presently imported from the north Other value added industries such as oil processing are also present About 25% of the land is currently rented which is

atypical of the cerrados Soils of the region are predominantly oxisols (60%)and Ultisols (23%) and both clay and sand textures are abundant

The principal advantage of the Uberlandia region to CIAT is that it provides a good setting for the evaluation of agropastoral systems Collaboration with the Geography and Animal Science departments at the Federal University of Uberlandia appears to be well established and provide expertise and local knowledge that EMBRAPA cannot The main disadvantage of the site is that it is a 5 hour drive from Brasilia (and Planaltina) where the EMBRAPA and CIAT savannas program is based This creates management difficulties increases the transaction costs of collaboration and may limit the scope of activities However it will provide a good test of technology adoption without heavy involvement of CIAT or EMBRAPA

Mechanistic understanding of the processes relevant to enhanced productivity increased efficiency and environmental quality is being investigated in two long term experiments and a suite of projects characterized as strategic research on key processes

2 1 3 Long Term Experiments

Two long term experiments at Carimagua (Cultlcore)in the Llanos and CPAC Planaltina in the cerrados have been established with collaboration of CORPOICA in Colombia and EMBRAPA in Brazil It is evident that in both cases the collaboration is real Both experiments were established from native savanna so they address the effect of different systems and practices on productivity and soil degradation rather than rejuvenation of degraded soils The experimental objective is addressed through a combination of process level studies and modeling

2 1 3 1 **Design** The experiments include the cropping systems and practices common to the respective regions and include native savanna controls Large plot sizes allow management equivalent to a farm and the possibility of splitting plots to introduce new treatments Both experiments include two levels of lime addition a low fertilizer rate and a higher rate designed to raise soil pH and reduce Al saturation However there are some differences in design between the two experiments that may limit comparisons between them These differences are

	Carimagua	Planaltina
Replications	4	2
Pasture Stocking Rates	1	2
Pastures	Grass legume	Grass legume and grass only
Tillage	Conventional and No tillage	Conventional and Flexible tillage
Green Manures	Crop green manure rotation	No crop green manure rotation

The choice of limiting the Planaltina experiment to two replications makes this a marginal field experiment Presumably the desire to include two stocking rates and the need to keep the experiment to a manageable size are the reasons for this choice The omission of an improved grass only pasture at Carimagua is surprising since this option rather than the grass legume pasture is most widely adopted by farmers EMBRAPA TropSoils CRSP research has demonstrated the feasibility of growing a green manure following crops at Planaltina and this could be done to complement the Carimagua experiment The choice of tillage treatments at Planaltina should be reconsidered since no tillage is beginning to be adopted by farmers in the cerrados and will probably become the principal tillage practice in the future

2 1 3 2 Measurements The strategy of making a common suite of measurements in both experiments coupled with supplemental studies on additional factors or processes is appropriate and takes advantage of collaboration with advanced institutions It is important that the same basic set of measurements be made in both experiments using identical methodologies and similar frequencies of measurement This is only being partially achieved at present Measurements common to both sites are standard agronomic assessments (crop and animal performance nutrient removal root growth and weed pressure) and soil chemical assays (soil nutrient levels pH and Al saturation) Timely completion of analyses appears to be a problem especially in Brazil

Soil physical measurements are more comprehensive at Carimagua (bulk density infiltration rate aggregate stability and penetration resistance) than at Planaltina (penetration resistance is only data reported) Infiltration rate is most meaningfully made *in situ* rather than by the *in vitro* method being used at Carimagua Differences in soil megapore (worm channels) and macropore (related to soil aggregation) content as a function of systems and management practices make it

especially important to study water flow pathways and the effects of flow pathways on solute (nutrient and pesticide) leaching Routine soil moisture relationships perhaps using time domain reflectrometry (TDR) should also be considered

Soil biological measurements are the least comprehensive and most different between the two sites Residue decomposition and earthworm population and dynamics are studied at Carimagua while mycorrhiza population and activity are studied at Planaltina Initial results of the population studies show large system effects and on going or planned work to link activities and population dynamics to nutrient availability and cycling is important Soil biology is the least developed of the traditional soil science areas and the work of CIAT and partners in the long term experiments is at the cutting edge of research Greater effort in this area is encouraged

The studies on residue decomposition and nitrogen release at Carimagua provide valuable information about the dynamics of nutrient supply and demand in the systems included in the experiment The complementary strategic research with a variety of herbaceous and shrubby legume forages at Carimagua is important to selecting legume components of agropastoral system that synchronize as far as is possible nutrient release from organic sources with crop demand in order to maximize nutrient efficiency and minimize leaching losses

Other research being carried out on the long term experiment at Planaltina in collaboration with advanced country institutes namely organic matter dynamics with Bayreuth Univ and greenhouse gas fluxes with Cornell Univ is opportunistic The linkage with universities both national and international is encouraged because the long term experiments provide an excellent setting for thesis research at the process level thus fulfilling well the interests of CIAT and universities Collaborative studies of this type should be carried out or extended to both sites as much as possible since they should always be relevant to the basic goals of the experiments

2 1 4 Satellite Experiments

Not all questions or processes can be studied in the long term experiments and it is appropriate for strategic research on key processes to also be carried out through satellite experiments A wide range of valuable experiments concerned with C N and P transformations and dynamics litter decomposition processes earthworm dynamics soil physical conditions and crop nutritional requirements are being carried out at Carimagua but none are being carried out at Planaltina Instead additional

experiments in Brazil are on farm and at the University of Uberlandia It is however important to evaluate in Brazil key processes that would be affected by the differences in climate and soils between the Carimagua and Planaltina

Land degradation is an important factor that is not included as a variable in the long term experiments and is uncertain in satellite experiments Studies that begin with degraded lands (pastures?) are warranted since this is a common starting point in Brazil and CIAT is promoting pasture renovation technologies and agropastoral systems as rejuvenation methodologies Tillage practice provides a good example of an area that should be studied in this way No tillage is being studied at Carimagua beginning with savanna and is being rapidly adopted by farmers in Brazil beginning with degraded soils

On farm research at Uberlandia is concentrated on use of legume grass pastures and agropastoral systems It is a mixture of system development evaluation and demonstration This simultaneous combination of activities is unusual and difficult Whether it is justified by the rapid rate of change in agriculture in the region remains to be seen Problems at the system level are familiar namely establishment and persistence of legumes Land use history is variable between and sometimes within experiments which complicates interpretation and extrapolation Farmers were extremely enthusiastic about interactions with CIAT and were highly cooperative

The experiment at the University of Uberlandia research farm (in collaboration with the animal science department) was designed to compare milk production from legume grass and grass pastures bringing a dimension not being studied in the llanos Legume establishment in this experiment was very good Technology transfer activities also underway included propagation of *Arachis pintoi* and *Stylosanthes mineirao* seed for use by university researchers and farmers The initiatives that the university scientists appear willing to take in both technology development and transfer should greatly help the program

Planned collaborative research with the Univ of Gottingen to quantitatively characterize pasture degradation will help with baseline definition as well as interpretation of the impact of systems and/or practices on soil quality

2 1 5 Prototype Cropping Systems

Prototype cropping systems have been studied in the llanos and the cerrados Studies in the llanos demonstrated that monocrop rice yields drop over time but the reasons for this are not fully understood From a processes viewpoint it is important that the reasons for degradation be better characterized in order to establish that this is really occurring i e that yield declines cannot easily be overcome by more appropriate agronomic management Rice pasture systems with periodic rejuvenation appear to be more sustainable than monocrop rice and measures of soil physical properties and biological activity indicate better soil quality Economic comparisons of the two systems are needed

Studies on weed ecology that are being made in systems with rice have application to design of cropping systems that minimize weed pressure and therefore the need to use herbicides Such studies are long term and have some degree of system and environmental specificity but potentially can have an important impact on both productivity and resource management

A socio economic study on adoption of ley farming systems in the llanos revealed that many factors were involved in farmer decision making The identification of these factors and farmer needs and requirements for cropping systems and practices are valuable inputs to the design of prototype systems and additional studies of this type are strongly recommended

Because native savannas are not prototype systems studies on their ecology are not evaluated here Prototype cropping system studies in the Cerrados have been previously discussed in the section on satellite experiments

2 1 6 Other Issues

2 1 6 1 Socio Economic Analyses Socio economic analyses at the system or farm level are lacking for the various experimental systems being evaluated and also for the prototype cropping systems being developed Farm budgets and risk assessments should be utilized in both design and evaluation phases

2 1 6 2 Modeling The intent of the program is to integrate mechanistic knowledge into models to facilitate extrapolation This approach is logical and also has the advantage of allowing scenario testing It is suggested that CIAT utilize existing process models and model frameworks that allow integration of models and environmental variables e g ALES and GAPS (both Cornell Univ frameworks)

Use of models requires that they be validated for the environments being investigated The program is well aware of this situation having discovered that the P sub model of the CENTURY grasslands model is inappropriate for oxisols This illustrates that models can also be used to test our understanding of processes and can help to identify research needs and/or critical parameters or processes

2 1 6 3 Scope of Study The natural resources that CIAT programs address include soil water air and biological resources Much of the effort of the CIAT NRM program is directed to the soil resource which is appropriate because of the strong link between this and sustainable agricultural production Less attention is given to water resources either at the field or watershed scale and effort in this area could be increased beginning with the field scale Biological resources are being evaluated through documentation of plant biodiversity in native savanna and studies of the effects of agricultural systems on various biological communities These are valuable scientific contributions and continued investigations in these areas are encouraged The effects of agriculture on the atmosphere are being studied within the context of the greenhouse effect and climate change Studies on soil carbon levels (carbon sequestration) and dynamics and on greenhouse gas fluxes could be expanded as agricultural use of savannas has many effects that are potentially significant at a global scale

2 1 6 4 Scale of Study The panel was asked to address the question of moving from plot/field scale to watershed scale Watershed scale studies imply that the effects of land use/management on streamwater quantity and quality (sediment load and chemical quality) will be investigated This scale of study requires considerable investment in monitoring and analysis which is long term and extremely expensive even with small watersheds of several hectares Current research in the U S on run off from land surfaces is concentrating on so called critical zones or areas within a watershed since the bulk of surface run off generally comes from a small proportion of the landscape This research begins with hydrologic models and extends to validation and management of critical areas to reduce or eliminate surface run off and associated pollutants It is possible to consider this approach without

getting involved in demanding and expensive monitoring and without directly demonstrating impact

A second issue is groundwater quality which is generally investigated by measuring the concentration of pollutants in wells Models of leaching of pollutants to groundwater are widely use in the U S to investigate various management scenarios but these are difficult to validate and often are confounded by macropore flow The strategy of measuring pollutant concentrations in soil profiles or soil water coupled with knowledge of effective rooting depth of crops provides some assessment of pollutant leaching

Ideally different land uses or managements are compared in paired small watershed studies but this is usually applied to a limited number of systems because of the large costs involved Nevertheless this approach may be feasible for CIAT Although the Hillsides Sub Program uses the term watershed freely measurements are not being carried out at a watershed scale Rather the watershed is used as a geographic unit within which various activities occur The ability of this program to evaluate water quantity and quality issues will at best be done through models which without validation activities could lead to questionable results

2 1 6 5 Indicators of Soil Quality Sensitive indicators of soil quality are needed to measure changes resulting from cropping system pattern and/or soil management Ideally indicators should be relevant to both soil productivity and agricultural sustainability goals Separate indicators are needed to describe the soil biological chemical and physical environment and perhaps some aggregate of these can be used to describe overall soil health Considerable attention is being given to this subject by developed country institutions following the politicization of the term soil health The issue is obviously complex and far from being resolved

CIAT is taking the correct approach in investigating changes in active soil organic matter and nutrient pools soil physical properties such as aggregation and compaction and soil chemical properties such as Al saturation It is recommended that this activity continue with inter Program collaboration and involvement of the proposed soil unit It would be a logical topic for an SRG

2 2 Forest Margins Sub Program

The goal of the forest margin component of the Tropical Lowlands Program is

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

Two research strategies are envisioned to attain this goal The first that is being carried out by the Land Management Program is to help effect changes in macroeconomic policies to discourage deforestation and conversion to pastures by large enterprises The second strategy is to develop technologies to intensify and stabilize agriculture and make it economically feasible for small to medium sized farmers to settle and thereby reduce deforestation This last objective was the responsability of the Forest Margins Subproject of the Lowlands Program

Two research sites were chosen one in the State of Rondonia (Theobroma) the other in the state of Acre (Pedro Peixoto) both in Brazil

Pedro Peixoto about 80 km from Rio Branco the capital of the state of Acre is an old colonization project with more than 20 years of existence Nevertheless the average settler has lived in the area only eight years and only about a third of the settlers arrived prior to 1975 two thirds arrived in the 1980 s or later Farmers practice small scale agriculture on land that they clear keep some cattle and extract products from the forest Mean annual rainfall is approximately 2000 mm and the soils are mostly oxisols (Latosolo Amarelo Vermelho Distroficos according to the Brazilian soil classification)

Theobroma is 300 Km south south east of Porto Velho the capital of Rondonia It is a slightly older settlement than Pedro Peixoto yet the average settler has been here only six years Most settlers arrived in the 1970 s (36%) or 1980 s (58%) Roughly half of the area (46%) has been deforested by now Cocoa used to be the main crop but now the area is used for pastures (26%) annual crops (7%) perennial crops (5%) and fallow (8%) Annual mean rainfall is approximately 2000 mm and the soils are oxisols (Latisolos) Alfisols (Terra Roxa) and Ultisols (Podzolicos)

The two research sites are economically and socially highly dynamic areas as can be inferred from the settlement patterns

CIAT has entered into a consortium arrangement with ICRAF CIAT EMBRAPA CATIE ESALQ AND IICA to collaborate on land use system improvement called the Alternative to Slash and Burn (ASB) Project Several projects are being carried out as part of this consortium The first called Prototype sustainable cropping systems for forest margins involves a CIAT cropping system specialist based in Rio Branco Acre and an ICRAF scientist based in Porto Velho Rondonia Both collaborate with the EMBRAPA agroforesty experiment stations in Acre and Rondonia

In Acre a number of experiments both at the EMBRAPA station and in farmers fields are being executed as follows

1 Bean regional trials for the Carioca and Pink seed type
2 Introduction of leading bean cultivars from southern Brazil
3 National Web Blight nursery
4 Adaptation trial of interracial crosses of beans
5 Cultural practices for reducing web blight incidence and Phosphorous fertilization

In addition trials are being conducted to test the conditions under which *Arachis pintoi Pueraria phaseoloides* and other legumes can be introduced as cover crops and forage and the effect of different legumes in suppressing *Imperata brasiliensis* Also CIAT collaborates with TSBF in conducting experiments on the effect of different kinds of litter on farm output EMBRAPA conducts a number of trials at its station to test the suitability of various trees as living fences and is also testing the suitability of various perennial crops for the region

The Land Management Program is conducting a project entitled A diagnostic study of agricultural land use in the southeast Brazilian Amazon This study that is being conducted at both Pedro Peixoto and Theobroma and is based on a program of interviews and a time series analysis of remote sensing imagery overlain with cadastral information From this analysis it is very clear that farmers in this area are not practicing slash/and burn agriculture in the classical sense of the word i e where abandoned land is allowed to revert to bush and forest and is farmed again after a long period of fallow and where the burning of the woody vegetation is seen as a soil improvement process Instead farmers clear approximately 1 2 Ha every other year farm it for two years and repeat the process Abandoned agricultural land is converted to pasture and not left in bush fallow Economic analysis shows that it is in this process of land conversion from forest to pasture where the real economic gains are realized with increases in land values that averaged 93% a year in Pedro Peixoto

and 97% in Theobroma Farmers are therefore more motivated to improve their land by the addition of ponds fences corrals and improved access rather than in increasing yields from crops that account for less than half the average cash income (the other half coming from sales of labor) At both sites local ranchers and city based speculators have purchased continuous blocks of colonists parcels to form new ranches or expand existing ones Payments for cleared land are significantly higher than for forested land

2 2 1 The viability of the Forest Margin program in Acre and Rondonia

How likely is it that the present Forest Margin Sub Program of the Tropical Lowlands Program will fulfill its objective of reducing deforestation by developing ecologically and economically sound production systems for already cleared land? From the brief analysis of the situation in Acre Rondonia it appears to us that the socio economic forces that are at work in this area will determine that the very well intentioned efforts of the Forest Margins Sub Program will have at best a minimal effect

The analysis indicates that conversion of forest to pasture and land speculation is the most profitable economic activity Under present circumstances of land availability settlers can profit much more from this activity than they can from a more settled pattern of growing crops It is indicative that although these colonies were established over 20 years ago that most settlers have been here only for seven to eight years or less This situation is not surprising It is common in areas of agricultural frontier for the expansion to be driven by speculation Access to market through roads is a much more important factor in deforestation in these regions than is access to improved agricultural methodology The study also confirms previous studies by Hecht Fernside and others Furthermore as already indicated since farmers do not practice slash and burn according to the generally accepted definition of this term this research cannot be said to be a contribution to the improvement of slash and burn methods We therefore recommend that research on Prototype sustainable Cropping Systems for Forest Margins be dropped but that the Diagnostic Study of Agricultural Land Use in the Southwestern Amazon be continued and completed as programmed

2 2 2 Alternative models of research

Mitigation of deforestation in the wet tropical lowlands is still a very worthwhile objective The question is how best to attain this objective We suggest two alternative models which involve a change in research site and will involve a much greater commitment of resources

The first alternative is to concentrate in the development of prototype sustainable cropping systems for Slash and Burn to be executed in an area where true slash and burn is practiced as for example in some areas of Central America Such a project will require consultation with partners in the alternatives to slash and burn project It would require some relocation of personnel and the designing of specific experiments but would not involve any changes in the applicable paradigm

The second approach is to study the lowland forests of the entire Amazonian Basin concentrating not only on the forest margins but on the entire unforested basin as well in order to develop strategies for sustainable use of the Amazon forest These strategies will have to meet the interests of the multiple stakeholders in the Amazonian Forest national and private interests in developing the area for forest products agriculture agro pastoral activities and mining interests of indigenous people in maintaining the forest to continue their traditional use of the forest rubber tappers Brazil nut collectors hunters and other persons interested in maintaining the forest as a source of non traditional forest products environmentalists and other interested in maintaining biodiversity etc Such a study would require a substantial involvement by the Land Management Program and the GIS Unit and would require the formation of a Consortium with at least the principal Institutions involved in Research in the Amazon basin along the lines of the SSALLSSA consortium for investigation of the Tropical Savannas As this approach evolved there would be a change in paradigm necessitating modification in name to something like Humid Tropical Lowlands Sub Program There would be need to involve CIFOR ICRAF and IFPRI and establish a broad alliance with interests concerned with the development and preservation of humid tropical forests for whom Amazonia is the number one priority worldwide And much greater resources would be required than those currently allocated to the Forest Margins Sub Program

2 3 The Hillsides Program

Under CIAT s Strategic Plan (April 1991) all three agroecosystem programs had a common set of four objectives

(i) Characterize farm types and their influence on land use which requires

- understanding farmer decision making
- developing agroecosystem specific models of uses of farm land
- establishing research priorities

(ii) Development of strategic research on mechanistic models of nutrient cycling water use and vegetation dynamics with a view to broad extrapolation of results through techniques such as systems modelling and GIS

(iii) Develop and test technology related to

- production and soil and water conservation components
- sustainable land use systems
- estimating externalities
- resource management skills required

(iv) Enhance national research systems through training pilot projects networks and documentation

In the implementation of these objectives the Hillsides Program evolved a sharp focus on the rural poverty subsector as a consequence and cause of resource degradation The proportion of rural population in this sub sector ranges from 40% in Venezuela to 80% in Guatemala and have access to 10 20% of the farm lands in hillside areas In adjusting to this modified focus the Program placed emphasis on participatory research by small farmers and decision support systems which incorporate the values of the more impoverished stakeholders into community efforts to orient land and water use beyond the farm level The output of these two program components is seen as a validated methodology for putting in place sustainable institutional arrangements for participatory research and community management of

aspects of land and water use either inter farm or off site which will be replicable in the wide diversity of physical cultural and socio economic situations which characterize the Andean and Central American hillsides This effort is complement by two interrelated components mechanistic models of soil degradation nutrient cycling etc and development of prototype systems for sustainable land use and at the same time is seen as a critical input to the Decision Support component

2 3 1 Overview and Assessment

2 3 1 1 Participatory Research In many respects this may be seen as an integral part of the Decision Support component It is identified separately partly because CIAT has been engaged in this activity for the past nine years and has had and continues to have significant external funding specifically targeted to the topic

The unit of account of this activity is the CIAL Approximately 100 CIALs are currently at some stage of consolidation in Colombia Bolivia Brazil Ecuador Peru and Honduras based on initial experience from five formed in 1990 In Colombia each CIAL on average serves 200 farm families

There has been careful monitoring and evaluation (M&E) of the inputs into creating consolidating and maintaining the CIALs The inputs have been provided by host institutions NGOs government agencies or farmer coops as well as CIAT M&E has identified a number of innovative and successful multipliers from the CIALs upstream into input purchase and downstream into storage processing and marketing What have not been tested or validated yet are

- options for streamlining the creation and consolidation process
- procedure to facilitate multipliers
- the expected time before a CIAL may become independent of the host institution
- the preconditions for separation from the host institution which give acceptable expectation of self sustaining activities to exploit opportunities from research on production conservation marketing or a diversification of rural employment or to address constraints arising from the highly dynamic nature of hillside agriculture
- the change in welfare (indicators?) of the CIAL beneficiaries relative change experienced by non beneficiaries
- the sustainability of agriculture (indicators) in the CIALs relative the before and without situations

At the present time there is no typology of hillside situations based on the expectation that the methodology may have to be adapted on the basis of pre determined site characteristics The approach has been to exploit opportunities as they arise in the various hillside countries and develop typologies as appropriate through M&E

The tactical questions which arise for CIAT are

- staff time required for training to enlarge the sample of CIALs and how far to enlarge the sample?
- staff time for M&E of individual CIALs and analysis of results to refine methodology and evaluate performance along the lines suggested in paragraph 5 above?
- the elapsed time before M&E and associated analysis can be expected to yield a credible methodology with validated performance over an established time?
- the nature of intermediate outputs which may be reported to donors?

These questions need to be addressed through scenarios to establish what CIAT considers the minimum time horizon and critical mass of funding required to deliver a methodology which can be applied and adapted on a large scale by national entities private or public At this stage the Program should be in a position to specify

- whether a typology is needed for instance do remote minifundio situations such as the Guatemalan hillsides require a modified model? can the model be adapted to drier mid altitude or altiplano situations?
- the nature of the risks associated with the whole enterprise for example the vested interests and potential discontinuity of host institutions and changes in dynamics of macro policy
- the GIS on the biophysical characteristics of potential CIAL sites required for large scale application of the methodologies developed
- the expected costs and benefits of expanding the GIS to cover socio economic and institutional aspects such as size of farms land tenure income distribution education levels health indicators rural population growth institutional structure etc

The research goals of this component are clear and highly relevant to natural resource management (NRM) and poverty alleviation in the hillsides agroecosystem With regard to feasibility the goals must be seen as high risk with a long term and

potentially high payoff The research strategy is appropriate but requires more careful specification of the time horizon and a critical mass of inputs from CIAT and host institutions and the nature and extent of potential risks In many respects this may be regarded as an exclusively strategic research activity since it is concerned with the development of a tested methodology for creating sustainable CIALs which facilitate sustainable land use The product is the methodology not the CIALs

CIAT s comparative advantage in this research area lies first in the fact that it has pioneered the approach to participatory research by groups with a two way flow of information between farmers and researchers concerned with commodities and farm or land use systems And second CIAT brings to bear the whole range of CG research on commodities prototype systems mechanistic models and land use management as they apply to NRM in hillsides

CIAT has been extremely effective in Colombia generating viable collaboration with a wide diversity of research partners many of whom have been in conflict or duplicating the efforts of others in the past This very success must be viewed as a matter of concern in scenario where CIALs are to be formed without CIAT involvement CIAT s prestige as an objective high quality scientific research institution without vested interests has perhaps been the major factor in facilitating agreement on a common agenda with CIALs If this is the case the issue needs to be addressed by research

The achievements to date are encouraging However it is essential to define when and by what criteria performance will be measured There should be on evaluation of all CIALs in the experiment every two or three years using criteria such as those outlined in above An interim analysis of the methodology should be undertaken by 1998 It will take at least 10 years to validate the robustness and wide applicability of the methodology The commitment of the CGIAR and donors to this approach is a matter of some concern

2 3 2 Decision Support Systems

At the present time this research effort is being carried out exclusively in the 3200 ha Rio Cabuyal sub catchment in Rio Cauca of Colombia It aims to draw on experience from the participatory research mechanistic models and prototype systems projects (with inputs from the GIS Unit and Land Management Program in the area of systems modelling) in evolving both the institutional structure and the information

needed by this structure to undertake NRM addressing inter farm and upstream/ downstream issues at the watershed level

As in the case of the CIALs CIAT has used its prestige and analytical capability to catalyze the formation of what may be termed a watershed management agency CIPASALA It is planned to use a series of heirachical and interactive models to generate dialogue among the stakeholders on the issues establish the basis for conflict resolution and implementation of NRM decisions In addition of the mechanistic models developed from on farm experiments within the sub catchment the approach is expected to draw on models such as RUSLE EPIC SWRRB CERES CROPGRO AEGIS+ TOPOG IRM WEPP and DTM

This is an ambitious experiment based on a process approach with a need to test the relevance of modelling complex biophysical socio economic and institutional interrelationship in arriving at NRM decisions at the watershed level The simplest part of the experiment is to view the NRM entity CIPASALA initially as an enlarged CIAL with a much wider mandate Questions related to the durability effectiveness and process of consolidation of the entity are essentially the same as those related to the CIALs Beyond this level of analysis it is not clear how the project expects to validate and link the range of applicable models what the nature of the feedback process is from the stakeholders to model specification what the stakeholders see as the criteria for evaluating their NRM performance and how the modelling contributes both to the formulation of performance indicators and implementation of investments incentives and regulatory mechanisms by the entity

As with the CIALs the product of this project is a validated methodology for establishing sustainable watershed management entities with an evolving information system to support NRM decision making However the challenge is an order of magnitude greater Since the product of the project is methodology the steps in development and validation and assessment of performance are similar but vastly more complex There is a question of typology Because of the intersectorial nature of the project the context is likely to be more site specific and more dynamic making it more difficult to quantify cause effect relationships NRM indicators of inter farm or upstream/downstream effects will be more difficult to quantify and should be developed for the before and after and with and 'without establishment of watershed management entities The resources required from CIAT and its partners will be higher and the time frame to prove one or a set of viable methodologies will be much longer Because of these factors the risks are significantly higher A threat which must be weighed is that due to the difficulty of providing intermediate products

from the project funding may be discontinued before the threshold has been reached where credible results are in place

The problem being addressed is very real The complexity of NRM in the hillsides is not a reason to back off The process approach leans towards iterative and successive approximation on both ends and means which may be seen as a cause of uneasiness both to management and donors As a basis for reducing the scope of the project and focusing on key elements in the decision making process it is suggested consideration be given to an overall modelling exercise for the Cabuyal sub catchment by the Land Management Program This might include adaptive interactive workshops which have been applied to complex systems elsewhere The purpose would be to simplify the approach and identify a few viable points of entry into the system which offer promise of evaluation with two or three years as a basis for decision on further work In line with this aim it is our opinion that model components designed to measure down stream impacts below the Cabuyal sub catchment should be dropped The watershed focus of the exercise should be on micro watersheds within the sub catchment to address tradeoffs and conflicts associated with such aspects as drinking water or mini irrigation

2 3 3 Prototype Cropping Systems

The prototype cropping systems currently being evaluated are based on CIAT mandate crops with the addition of components and practices to reduce soil erosion However farms that we visited combined high value vegetable and fruit crops coffee and the CIAT crops Some of the fruit crop production was stimulated by the CIALs that CIAT helped establish Hillside farms will probably always have complex and dynamic cropping patterns that respond to changing economic conditions and market opportunities Given this scenario CIAT prototype cropping systems should include the range of crops that hillsides farmers are likely to use At the least they should be as advanced as the best farmer systems Furthermore it is important to develop farming systems and practices based on the constrains of hillsides and the needs of hillside farmers Collaborations with the relevant CG centers such as AVRDC and CIMMYT should be developed as appropriate Research on agroforestry systems in collaboration with ICRAF is also encouraged A twofold strategy that is consistent with the plan presented by the Sub Program is recommended

(i) improvement/modification of systems that currently exist and are likely to persist at least in part and
(ii) development of new systems e g agroforestry

We believe that control of soil erosion should be given a higher priority than soil chemical quality It is not clear whether soil erosion will be experimentally evaluated but we recommend this Prototype systems should utilize results of the soil erosion studies at Quilichao Measurements of soil processes and soil quality should be consistent with similar studies in the tropical lowlands Program

2 3 4 Soil Quality Studies

This project is difficult to evaluate due to it s relatively short existence and incomplete results It s goal is to develop methods to quantify soil quality changes resulting from various land uses and management practices and to evaluate the costs of soil quality changes to farmers and society

The research approach being used in two of the four sub projects is to investigate spatial relationships of various soil properties related to soil quality in a matrix where land use is also a variable This approach has the potential to separate natural soil variability factors from land use factors in addition to determining whether spatial patterns of soil quality exist However the spatial distribution of soil properties is potentially *confounded* by other variables and the spatial analysis methods are complex and sometimes controversial The value of the complex approach being taken cannot be assessed at the present stage of the project

Preliminary results show that contrary to expectations soil properties relevant to nutrient retention are more favorable in cropped soils than forest Maximum yield trials for beans and maize substantiated this pattern when the highest yields were obtained following intensive cassava and the lowest yields were obtained following forest The simplicity of the preliminary results of these projects contrasts with the complexity of the project descriptions and proposed analytical methodologies

The third sub project addresses the effect of fertilization practices on soil acidification but no results are available yet However this is a topic that has been thoroughly investigated in temperate climates and the results of the various practices should be easily predictable

The final sub project concerned with soil macrofaunal diversity follows TSBF protocols and complements a similar study in the savannas Preliminary results show large land use effects on species diversity and biomass and different trends than those found for soil nutrient retention

Overall the project has a worthwhile objective and early results suggest that the approach being followed will provide useful results It is suggested however that an effort be made to keep the approach and analytical methodologies as simple as possible on the premise that the simplest model that fits the data is the best model until proven otherwise

2 4 The Land Management Program

Under the 1991 Strategic Plan the Land Use Program was aimed at improvement of management of land resources in tropical America It was expected to work in partnership with the agroecosystem and commodity programs as well as with other CG centers and national entities This is still and should continue to be the mandate

The EPMR in its report of February 1995 recommended that the existing Land Management SRG be transformed either to a Program or a Unit depending on the orientation that CIAT considers more appropriate to its future plans In view of the NMR context presented in Section I we are convinced the role of the Land Management SRG should go beyond that of servicing CIAT programs which is generally associated with a Unit It is currently functioning as a Program and should continue to do so

2 4 1 Projects

2 4 1 1 Changes in Tropical Land Use Patterns at a Latin American Regional Scale Over the past six years the GIS Unit has developed a series of regional scale digitized maps covering almost 50 environmental social and economic variables Recently digital coverage of legally protected areas native reserves and national parks was published Work has recently been initiated on a new updatable digital map of land use and land degradation for use with other overlays as an instrument in planning for NRM aimed at sustainable agr cultural development and poverty alleviation CIAT itself has been a major client for these products The fundamental challenge in this on going project is to assess the cost precision and desirable frequency of updating and extending the data base and its application by national or international entities concerned with NRM in tropical America It should be the role of the Land Management Program to develop performance indicators of how and where data is used in natural resource planning and management decisions and

to guide the GIS Unit on precision scope and frequency of updating and analyzing data which would be relevant to the users

2 4 1 2 Diagnosis of Agricultural Land Use in the SW Brazilian Amazon

This project addresses the socio economic policy and institutional forces which underlie the dynamics of forest conversion to pasture (via a 2 3 year crop rotation) in Acre and Rondonia Regardless of whether or not the Forest Margin Sub Program is carried forward in its present form it is our opinion that this project is a critical building block in understanding NRM issues in the humid tropical lowlands agro forest ecosystem It should therefore be completed as soon as is feasible with a view to using the results to explore options for design of a multi country multi partner initiative (project) Strategies for NRM in the humid tropical lowlands of the Amazon basin modelled after the SSALLSSA project which addresses NRM strategy in the savannas

The research goals are clear feasible and highly relevant to CIAT s mandate to take the lead on the lowland tropical ecosystems in Latin America within the CG s Ecoregional Approach to Research The Center s comparative advantage in this area is widely recognized and the quality of work completed is testimony To date there has been little need for collaboration with research partners EMPRABA IFPRI and ICRAF but effort should be made to increase their involvement in completing the project Its impact should be judged by the contribution to the on going national and international debate on NRM in the Brazilian Amazon and to the design of future biophysical and social science research to address NRM issues in the humid tropical lowlands of South America

2 4 1 3 Strategies for Sustainable Agricultural Land Use in Lowland Savannas of South America (SSALLSSA) This is a very significant initiative $3 5 million over 5 years involving NARs universities ministries of agriculture NGOs and private sector interests from four countries plus the University of Wageningen If funded it should be carefully assessed as a potential model for systematically focusing CIAT s NRM efforts in the hillsides ecosystem and particularly in the humid tropical lowlands which comprises a critical component of CIATs mandate under the CG s Ecoregional Approach to Research as discussed in paragraph 4

Should this project eventuate it provides a significant challenge and opportunity for CIAT to demonstrate it can bring its inter disciplinary breadth and depth to bear on broad NRM issues which demonstrate the multi level linkages among resource user decisions inter user questions (e g watersheds) and institutional and policy forces

which may operate at the local regional or national levels It goes without saying that the project will be policy relevant The real question is the perception of the degree of relevance by decision makers in each of the levels It would appear important to build from country specific analysis to comparative analyses and then to ecosystem wide analysis in devising insights on NRM issues These insights will be particularly valuable to CIAT for possible mid course correction to the Savanna Sub Program But the primary criterion by which the project should be evaluated is how the results are viewed and acted upon by those decision makers in the four countries whose decisions impinge on NRM in the savannas The project is large enough and long enough to generate expectations of a breakthrough in multi level NRM decision making Aside from the stated outputs (training GIS policy guidelines public awareness and criteria to assess international proposals for cooperation in NRM projects in the savanna) it will be important that CIAT from the outset take the initiative of what expectations are reasonable and how their achievement will be measured

2 4 1 4 Indicators of Sustainable Land Use The Land Management Program has taken the initiative in generating CIAT wide discussions on land quality indicators (LQI) and has participated in an international working group on the subject It is to be expected that most of the further work on LQIs will be carried by the various CIAT Programs and Units and the Land Management Program will be a user by incorporating them into its broader systems models

A recently initiated project undertaken in association with UNEP will examine environmental and sustainability indicators for Latin America and the Caribbean The aim is to develop a network (national regional and international entities) which will enhance capacity to generate and exchange data within a standardized framework and publish a bi annual report on change in sustainability indicators The project will also carry out research into new indicators defined from use of systems analysis Although this project goes beyond the normal mandate of CIAT in agriculture it is relevant to the broader context within which the Centre must operate as it evolves its NRM work Given UNEP s interest the research is basically strategic This type of enterprise must be viewed as giving CIAT broad regional and international "visibility in areas beyond its normal sphere of influence Judiciously selected such activities can be extremely valuable to furthering CIAT s agenda However it is our opinion that as a general rule the Land Management Program should concentrate its work as much as possible on indicators and NRM issues related to CIAT s mandate in tropical America

2 4 2 Evaluation

The Land Management Program plays an important role in addressing policy oriented research involving biophysical and socioeconomic issues It uses System Analysis to research complex questions of resource use in Latin America The principal tools are databases related to biophysical aspects such as climate soil land use and socio economic measures It is the principal user of Geographical Information Systems (GIS)

The Program will be reduced by one senior Scientist is the GIS lab is made into an independent research Unit Because the Land Management Program is the principal user of GIS mechanism to make this transition a smooth one such as retaining part of the GIS SS time should be explored

The Land Management Program is in need of the services of an ecologist which we justify more fully under general recommendations

Another disciplinary field is less clear As covered under general recommendations we see a need for greater attention to economics in most if not all Programs to facilitate the NRM approach The question of where additional economists might be located has been left open The Land Management Program is certainly one potential location a possible Economic Unit is another The type of economist(s) and their number which might be considered for incorporation in the Program will depend in part on how it sees its role in interacting with the other five Programs

We understand a macro economist has been recruited who will be directly associated with the modelling exercises and policy studies related to the work of the Hillsides and Tropical Lowlands Programs Thus the question outstanding is whether or not one or two socio-economists (or production economists) would usefully contribute to the thrust of the Program and at the same time provide services to other Programs which would help in both ex ante design and ex post evaluation of crop experiments and prototype farming systems for NRM The rationale for this latter activity being based within the Program rests on the expectation of enhanced exchange of information which would be mutually beneficial to the NRM Approach of CIAT

The implication from Figure 1 is that we see an important role for the Land Management Program in providing an NRM focus to and eliciting information relevant

to broader NRM issues from the other Programs The focus is NRM in general in Tropical America and the two ecosystems hillsides and tropical lowlands in particular We would expect scenario modelling e g use of GOAL type models to be applied sparingly to policy analysis with primary emphasis of the Program placed on systems analysis which addresses CIAT s mandate in sustainable Land Use in Tropical America for landscapes at progressive levels of aggregation from prototype system micro watershed watersheds local regional and national levels

CHAPTER 3 THE ROLE OF THE COMMODITY APPROACH IN NATURAL RESOURCE RESEARCH

Within the CGIAR system CIAT presently has the global mandate for research on beans and cassava and forages and for rice in Latin America and the Caribbean This is an important function and it clearly should be continued The four Programs have however different emphases and different responsabilities in executing their mandate

3 1 1 **Beans** are a very important food crop in developing countries of Africa and the Americas particularly Brazil Mexico and southern Africa Beans are important as cheap sources of calories proteins and minerals in the diet and complement the proteins of cereals such as rice or corn According to the report of the fourth external program and management review (EPMR) the [Bean] Programme has recognized that technology *per se* will not close the gap between experimental station and farmer yield It requires an understanding of the socioeconomic and anthropological dimensions of the change process in rural communities It is here that stronger collaboration and interaction with programmes with a primarily natural resources approach (Tropical Lawlands) and Hillsides could be mutually beneficial

The Bean Program is collaborating with the Tropical Lowlands Program in forest margins research in Acre but as explained above we do not feel that this research has much chance of success at that site Another area for collaboration between the Bean Program and The Tropical Lowland and Hillsides Programmes is in the projects on tolerance of beans to low soil phosphorous levels Collaboration with the Soil Unit is especially recommended Research on cultural practices to increase soil fertility and reduce soil erosion that the Bean Program is developing in its African networks is another potential area of collaboration some of that research results can be transferred to the Americas

3 1 2 **Cassava** both fresh and in processed form is a very important source of food and a source of income and employment for rural people in many countries of the Latin America Africa and Asia It is very important in marginal areas because of its tolerance to low soil fertility and drought and its capacity to recover after pest and disease damage Cassava is also blamed for soil degradation and soil erosion especially in tropical mountain regions

Cassava figures prominently in the prototype farming systems that the Hillsides Program is developing and the Cassava and the Hillsides Programs should be encouraged to develop common projects The Cassava Program is deeply involved in integrated pest management We also would like to see joint projects between the Cassava and Hillsides Programmes and the IPM Unit The Cassava Program is also seriously investigating small scale processing of cassava in areas where the crop is changing from that of a rural staple to a source of multipurpose carbohydrate Here we would like to see a greater involvement of the Land Management Program in identifying macroeconomic constraints and performing market analyses and the model appears to have promise for extension to other Programmes notably Hillsides

3 1 3 **Rice** is the second most important cereal in the world (after wheat) and more people depend on rice as their principal starch source than on any other cereal Within the CGIAR system IRRI has global responsability for rice while CIAT has regional responsability for Latin America and the Caribbean Originally CIAT core funded research in both irrigated and upland rice and had some great successes in introducing irrigated rice varieties At the end of 1993 CIAT decided not to core fund irrigated rice and instead encouraged the creation of a consortium of Latin American NARS This consortium called FLAR (Latin American Irrigated Rice Fund) administered by CIAT is responsible for research in irrigated rice breeding

CIAT s upland rice research strategy is to develop germplasm as an agroecosystem management component Upland rice is an important element in the prototype agro pastoral systems being developed by the Tropical Lowland Program and collaboration between the Rice Program and Tropical Lowlands Program is an obvious one The Rice Program is concerned in elucidating the genetic and physiological mechanisms of rice tolerance/ resistance to biotic and abiotic stresses under acid soil conditions objective which is shared with the Soil Unit and the Tropical Forages Program Another area where upland rice is making a contribution to Natural Resources Research is in their efforts to educate farmers on rational insecticide and fungicide use

Finally the Rice Program work on resistance to rice blast diversified resistance to *Tagosedes*/RHBV and their research on weed control are a natural area of interaction between the Rice Program and the IPM unit

3 1 4 *Tropical Forages* The Tropical Forages Program evolved from the former Tropical Pastures Program and became operationally in 1992 Because the Tropical Savanna Sub Program of the Tropical Lowlands Program had a similar origin relations between these two Programmes have been a model of cooperation between a commodity centered and NRM centered Program

The mandate of the Tropical Forages Program is the development of improved forage germplasm for agroecosystems with acid soils in the humid and sub humid tropics worldwide

In summary we see the four Programs with a primarily commodity approach playing an important role in Natural Resources Management Research The principal encumbrances are two (1) the global mandate of the Bean Cassava and Tropical Forage Programs requires that substantial time and effort be invested outside of Latin America and the Caribbean and (2) the obvious resource limitations under which these three programs are operating Greater collaboration with other programs and with researchers in other institutions could be a source of expertise and of resources to undertake some of these projects

CHAPTER 4 INTERINSTITUTIONAL COLLABORATION

CIAT maintains a number of relations with national and international agricultural research organizations Universities and NGO s We have had only limited opportunities to explore these relations At Carimagua we observed the interactions between CIAT and CORPOICA scientists which we found to be cordial and fairly interactive In Brazil we had the opportunity to observe the interactions between CIAT s programmes being hoste by EMBRAPA We found the relations between both institutions to be cordial Interactions between CIAT scientists and EMBRAPA scientists were more limited in Brazil than CORPOICA CIAT in Colombia as far as we could observe

CIAT has entered into a number of cooperative arrangements with many institutions The more explicit introduction of NRM into the CIAT's operations have brought complexities which have forced greater attention to partnerships and consortia This trend has been reinforced by two factors

- directives from the TAC and CG Secretariat
- given the severe budget constraints a need was seen to pursue consortia as a means of obtaining financial rather than substantive inputs

Frequently this has led to high transaction costs in negotiation interim revues and reporting to donors on short term results The matter was extensively reviewed by the EPMR We like to cite from that document (pp 66 paragraph 1) the following paragraph that captures fully our own concerns in this matter

The trend towards greater cooperation among organizations is clearly a good thing Nevertheless there are limitations in how far such a trend can go Every joint endeavor has transaction costs and the time spent by scientists on liaison and consultation reduces the time they can devote to their own research At some stage the Center will have to consider trade offs and may find it advisable to put a brake on involvement in additional multipartner exercises

CHAPTER 5 SUMMARY AND RECOMMENDATIONS

Natural Resources Management Research is a new area of research and the paradigms are still being developed By its nature research in managing natural resources is long term and more risky than commodity type research Yet it is of the greatest urgency that this kind of research be pursued since the greatest priority in agriculture today is the problem of degradation of natural resources It is the panel s feeling that the four major thrusts pursued by CIAT in this area trying to understand social and economic macro constraints through the use of systems analysis and GIS research on the bio physical aspects of natural resources development of sustainable prototype farming systems and research on the social constraints to sustainable use of resources in poor and marginal areas are sound and encouraging of positive results

Natural Resources Management Research at CIAT is of high quality and is starting to have an impact on resource management especially in those areas were research has been going on longest Examples are the rice pasture prototype cropping system in the acid soil savannas and the organization of CIAL s in the hillsides

The Natural Resources Management Approach has labored under a severe resource limitation The evolution of the Approach has been complicated by the need for greater integration across center Program the requirement of a critical mass of resources with expectation of a long term commitment and recognition of the inherent risks associated with the enterprise Aside from these characteristics the complexity of NRM will require heavy emphasis on systems analysis and GIS and has forced the consortia and partnership model for substantive reasons It has also forced this model for financial reasons often with high transaction costs in negotiation interim reviews and reporting on short term results The measurement of NRM performance from Programs becomes particularly difficult when CIAT is expected to deliver International Public Goods Contrary to the case of research with commodities CIAT (or any other institutions) cannot ever acquire in house the necessary expertise to cover all areas of research Inevitably it will have to work with partners both within the CGIAR system National Agricultural Research Organizations experts in Universities and Non Governmental Organizations It should however pick its partners carefully and solely with the objective of increasing the breadth of expertise needed to research rigorously a given problem

In order to enable the various Programs better to coalesce around NRM issues the panel feels that the Center needs strengthening in certain areas of ecology and economics In economics the commodity Programs will be in a better position to integrate with the ecosystems Programs and place demands on the Land Management Program if they can undertake or have access to ex ante and ex post analysis of financial (and economic) returns as well as socio economic assessment of adoption crops and prototype farming systems These will be relevant to research design and performance evaluation At the same time there is need for economic analysis at the sectoral and macro policy level We also don t have a strong view of where this expertise should be located i e either in a Unit or distributed among some of the Programs

In order to manage natural resources it is necessary to understand the behavior of ecosystems before they are impacted by agriculture which is the domain of ecology Particularly important is to evaluate the anthropogenic impact on natural biodiversity All the NMR Programs are in need of ecological input The Savanna Sub Program of the Tropical Lowlands Program has procured the services of an ecologist through a collaboration with CIRAD EMVT but there is no in house ecological expertise to help the other two programs This item we feel should have high priority

The Panel concurs with the Fourth External Programme and Management Review that CIAT s initiative in natural resource management is important to the Centre and to the CGIAR Expansion should continue We also concur with the EPMR that expansion should not be at the expense of the commodity programs It is the opinion of the Panel that the commodity programs should be seen as a central part of the overall strategy of CIAT to increase agricultural production in a sustainable way

The Panel has made a number of specific recommendations which are justified in the body of the report A brief summary follows

RECOMMENDATIONS

The Panel recommends

A Organizational

1 In order to focus the Centers work on sustainable land use and in line with the EPMR s recommendation (EPMR Report page 80) the separation of Programs into commodities and NMR should be dropped All Programs should answer to the Deputy Director General for Research (page 7)

2 In order to allow the Units to play a trans Programs role in providing services and managing projects which facilitate the NRM dimension they should be consolida ed disassociated from SRGs and focussed primarily on services to the Programs (page 7)

- The GIS lab which currently is within the Land Management SRG should be established as a Unit with Center wide responsibilities (page 8)
- The BRU and GRU should be merged (page 9)
- In line with the recommendation of the EPMR a Soils Unit should be established but with specific terms of reference to supply information and analytical services (page 8)
- The functions of VRU and the IPM SRG should be merged into an IPM Unit with a mandate to promote inter Program activities in this area which are seen as critical to NRM (page 8)

3 The Land Management SRG should be established as a Program as on equal footing with the other six Programs (page 7 30)

4 Ways should be found to strengthen ecology and economics in all Programs in order to facilitate the NMR Approach of the Center (page 33)

5 In partial variance from the recommendation of EPMR the SRGs should be seen as flexible problem specific groups with a budget allocation and a finite life They would be created to develop projects which would be implemented by two or more Programs or Units Many of such projects are seen to be relevant to NRM (page 9)

6 Within the Tropical Lowlands Program the Forest Margins Sub Program should be reformulated (page 21)

- On the assumption that CIAT will continue its association with the ASB project in Acre and Rondonia the objective should be changed and the design modified to be consistent with the revised objectives
- In view of CIAT s mandate from the CG to take the lead on NRM in the Lowland Tropics of America the Program should actively explore two options to address management of the humid tropical lowlands ecosystem in the Latin America and Caribbean Region which is a critical focus of world attention

  (i) Research on ASB in typical bush fallow rotations
  (ii) Inter center and multi partner research on NRM for the Amazon basin

B Programs

7 The Hillsides Program should (page 24)

- focus on referring monitoring and evaluating the participatory on farm research to establish clear performance criteria for the CIAL methodology
- standardize and simplify work on mechanistic models and prototype cropping systems to be consistent with similar CIAT research in other ecosystems
- take active steps to simplify and focus the modelling work proposed for the Decision Support Project

8 The Land Management Program should (page 33)

- place emphasis on interactions with the other six Programs in order to help the NRM orientation of research in crops prototype farming systems watersheds and other levels of landscape management and to obtain information relevant to its multi level models of NRM
- as far as possible restrict its focus to the hillside and lowland ecoregions of tropical America
- complete the Diagnosis of Agricultural Land Use in the SW Brazilian Amazon with a view to exploring options together with the Tropical Lowlands Project for launching a CIAT initiative for the Amazon Basin (see points 6 (ii) above)

9 The Savannas Sub Program should (page 10)

- keep the two study regions in Colombia and Brazil because of significant climate and soil differences between them
- reconsider the balance of activities between the two sites Greater activity in Brazil would be preferable although we recognize the barriers raised by Brazilian institutions If the staffing level in Brazil cannot be increased the scope of the program should be consistent with quality research
- modify the long term experiments at Carimagua and Planaltina to overcome differences in design that limit the potential for comparison between the two sites
- ensure that a suite of priority measurements using the same methodologies are consistently made in both long term experiments Additional attention should be given to soil physical and biological parameters
- make greater use of socio economic information in both design and evaluation phases of research experiments and prototype cropping systems
- achieve greater complementarity in process level studies and measurement of soil parameters between the Hillsides and Tropical Lowlands Programs including use of the same methodologies This is critical in the assessment of soil quality and it is recommended that this become a topic of a SRG

6 ACKNOWLEDGEMENTS

The panel wishes to acknowledge the cordial welcome received from CIAT management and staff during its visit to the Institution and in the field visits and the time expended in answering the queries of the panel We are most grateful

Dr Douglas Pachico organized our visit and saw to it that all details were attended to He also made available to us all necessary information Thanks to him our work was made considerably more efficient and pleasant We are very grateful but not surprised that an economist would shine in trying to increase the efficiency of the panel

Dr Raul Vera arranged for our visits to Acre and Carimagua and accompanied us into the field giving us an opportunity to learn much more about CIAT s work than would otherwise have been possible His good will deep knowledge of the program and southern cone charm greatly added value to our work

Dr Michael Thung was our host in Acre and he and Dr Sam Fujisaka showed us around in the field We appreciated their time and their insights Dr Thung s sense of humor and enormous ability to interact with farmers and researchers helped us in obtaining a better understanding of the area and its inhabitants

Dr Miguel Ayarza coordinated the program in Brasilia and together with Mr Lourival Vilela organized the field program at Uberlanadia Their charm and professionalism made the visit both informative and enjoyable Socializing with the farmers illustrated the close collaborations that they have established

Dr Ron Knapp arranged for our visit to the Hillsides research site and made it possible to obtain a very good understanding of the local situations His enthusiasm and exuberance was contagious and we all came back totally infused with the problems and accomplishments of the program he so ably directs

Ms Gloria Posada helped put together this final report Her graciousness in dealing with the demands put on her by short deadlines and her incredible ability in deciphering our handwriting was of tremendous help

Many other persons to numerous to name made our stay at CIAT most pleasant and profitable To all of them we are extremely grateful We do not wish to

close without mentioning Ms Maria Eugenia Cobo who took care of our travel arrangements

ANNEX I PANEL COMPOSITION AND BIOGRAPHICAL INFORMATION

Name **Otto T Solbrig (Argentina)**

Position Bussey Professor of Biology Harvard University U S A

Education B S (1954) University of La Plata Argentina
Ph D (1959) University of California Berkeley

Expertise Population ecology Biodiversity National Resources in Latin America

Experience 1960-66 Associate Curator Grey Herbarium Harvard University
1966-69 Professor University of Michigan
1969 Present Professor Harvard University
1983 84 Visiting Professor Universidad de los Andes Merida Venezuela
Member Advisory Committee International Congress of Systematical and Evolutionary Biology 1979 present
Member U S Advisory panel to the Interciencia Bioresources Program 1982 present
Chairman Decade of the Tropics Program 1982 94
Member Coordinating Committee of IUBS/SCOPE/UNESCO Program in Biodiversity 1991 93
Advisor Man and the Biosphere Program UNESCO 1990 91
Member Expert Committee on Biodiversity UNCED 1990 92
President International Union of Biological Sciences 1985 88
Editorial Boards Biology International (1980 present Topics in Evolutionary Biology 1982 present Environmental Reviews 1992 present Journal of Biography 1988 present

Name **John M Duxbury (U S A)**

Position Professor Department of Soil Crop and Atmospheric Sciences Cornell University Ithaca N Y U S A

Education B S (1963) and Ph D (1966) University of Birmingham England

Expertise Soil Science Natural Resource Management Environmental Chemistry

Experience 1966-67 Chester Beatty Cancer Research Institute London
1968 70 Research Associate Cornell University
1970 present Assistant Professor Associate Professor and Professor Cornell University
1977 Visiting Professor Univ of Florida
1991 present Director Agricultural Ecosystems Program Cornell University
Chairman Amer Soc Agron Working Group on Climate Change 1993 present
Panel member OTA U S Congress Agriculture Trade and the Environment 1993 95
Panel member External Reviews of USDA ARS Hydroecosystems Unit Fort Collins CO 1989 Natural Resources Research Center Fort Collins CO 1995
Division Chairman Soil Biology and Biochemistry Soil Sci Soc America 1989 90
Editorial Board Soil Sci Soc Amer J 1982-88
Consultant to US Justice Department Exxon Corp and FAO

Name **Michael Nelson (New Zealand)**

Position Consultant

Education B S Agriculture University of New Zealand 1951
M S Agricultural Economics University of New Zealand 1953
Ph D Agricultural Economics Oregon Staten University 1956

Experience 1957-62 Economist Stanford Research Institute
1962-63 Economics Advisor to Government of Argentina
1964-66 Chief Economist Maule Basin Project Chile
1967 72 Research Associate Resources for the future Chile
1972 75 Agricultural Advisor Food Foundation Mexico
1975 80 Senior Economics Officer UN Commission for Latin America Chile
1980 82 Senior Economist and Deputy Chief Agricultural Economics and Policy Division World Bank

1982-88 Chief Division of Natural Resources UN Commission for Latin America
1988 present Consultant for World Bank FAO IFAD IDRC

ANNEX II TERMS OF REFERENCE

TERMS OF REFERENCES INTERNALLY COMMISSIONED EXTERNAL REVIEW OF NATURAL RESOURCES MANAGEMENT RESEARCH

Dr John Duxbury

While contributing to an overall understanding and appraisal of natural resource management research at CIAT give particular attention to research related to soil plant interactions especially in the tropical lowlands projects A mechanistic understanding and models of soil chemical physical and biological processes in agropastoral and sequential crop production systems and prototype sustainable cropping systems and the hillsides projects effects of soil degradation and of practices for soil conservation or regeneration on potential productivity and prototype systems

With respect to these research areas assess and evaluate the following issues

- Relevance clarity and feasibility of research goals
- Appropriateness of research strategy for attaining specified goals
- Balance between strategic and applied research
- CIAT s comparative advantage in this research
- Effectiveness of collaboration with research partners
- Staff and resource needs in context of critical mass needed to attain research goals
- Quality and achievement to date
- Expected future outputs
- Future direction and evaluation of research
- How progress/impact can be assessed

TERMS OF REFERENCES INTERNALLY COMMISSIONED EXTERNAL REVIEW OF NATURAL RESOURCES MANAGEMENT RESEARCH

Dr Michael Nelson

While contributing to an overall understanding and appraisal of natural resource management research at CIAT give particular attention of social science related research especially the projects of the land management resource group the tropical lowlands project dynamics of land use in the tropical lowlands and the hillsides projects decision support systems for land use planning and technology design and participatory research

With respect to these research areas assess and evaluate the following issues

- Relevance clarity and feasibility of research goals
- Appropriateness of research strategy for attaining specified goals
- Balance between strategic and applied research
- CIAT s comparative advantage in this research
- Effectiveness of collaboration with research partners
- Staff and resource needs in context of critical mass needed to attain research goals
- Quality and achievement to date
- Expected future outputs
- Future direction and evaluation of research
- How progress/impact can be assessed

TERMS OF REFERENCES INTERNALLY COMMISSIONED EXTERNAL REVIEW OF NATURAL RESOURCES MANAGEMENT RESEARCH

Dr Otto Solbrig

To provide overall coordination and leadership of review panel to achieve consensus around a consistent set of comments and recommendations contained in a concise and clear report

To provide guidance to individual panel members in their response to their terms of reference

To insure that the panel assesses and provides guidance on the following broad issues

- The relevance soundness clarity and feasibility of the goals strategy objectives and priorities of hillsides tropical lowlands and land management research
- The effectiveness of the management structure and organization of NRMR in programs projects units and scientific resource groups
- Interaction of NRMR with national systems advanced research other international centers and other organizational units within CIAT in terms of CIAT's comparative advantage transaction costs and quality of relations with national systems
- Relation between resources both current and potential and goals and activities including site selection in agroecologies

REPORT OF INTERNALLY COMMISSIONED EXTERNAL REVIEW

INTERNATIONAL CENTER FOR TROPICAL AGRICULTURE (CIAT, CALI-COLOMBIA)

NOVEMBER 17 – 21 1997

CONTENTS

Introduction

The ICER (Internally Commissioned External Review) panel met at CIAT Cali Colombia from November 16 21 1997 Previous to the Cali visit the Panel had been provided with documents pertaining to the review The first half of the review consisted of reading documents meeting with the Director of the Genetic Resources phone conversations with our liaison to the Board of Trustees visits to the laboratories greenhouses and fields of CIAT and numerous discussions with the research staff The latter half of our meeting involved deliberation and writing of our final report On the last day we discussed with the Director General and the Director of Genetic Resources our findings

We found many strengths in the Genetic Resources Directorship The staff is deeply committed to the mission of CIAT is actively engaged in numerous important research areas and is highly interactive The objectives of the SB 01 and SB 02 units have recently changed there is less emphasis on the development of cultivars for direct use by farmers and an increased emphasis on pre breeding activities The organization of the Directorship has also changed from a program based structure to one based on projects At the same time the percent of total funding committed to specific donor funded projects has increased These factors have lead to challenges for CIAT in redefining its role in tropical agriculture and for the staff in defining research direction CIAT has great potential for carving out a new unique role The utilization of native genetic variation via new quantitative methods will allow CIAT to incorporate the variation found in its germplasm banks quickly into prebreeding populations Likewise the utilization of molecular techniques and genetic transformation will speed the incorporation of new genetic variants into tropical corps The Directorship has identified several new directions including the establishment of a Biodiversity Assessment Regional Laboratory that will respond to new opportunities in research and funding

First we present a series of comments which identify the significant findings of our committee Next we give our recommendations and then discuss the issues raised in the Terms of Reference for SB 01 and SB 02

Comments

1 The panel was impressed with the hard work and dedication of the scientists in the Directorate of Genetic Resources The individuals we met had a deep commitment to the mission of CIAT to tropical agriculture and to the people it serves The research staff in the DGR has done a commendable job of keeping abreast of the latest scientific issues of incorporating recent scientific developments into the work of CIAT and of networking with other institutions The strong connections that staff has forged between the project groups and various other institutions worldwide keeps the work at CIAT current and in step with the continuously changing directions of science The quality and dedication of the research staff from the program leaders to the technicians in the labs and fields is a major strength of CIAT

2 CIAT and DGR have several assets that make it nearly unique on an international scale and will allow CIAT to maintain a strong international position The extensive germplasm collection the vast field and greenhouse space and the staff to support these facilities offers the opportunity to study and incorporate germplasm from wild species and landraces into pre breeding stock Recent studies have indicated that such transfer of native germplasm into pre breeding stock can be done relatively rapidly (the QTL approach of Tanksley) thus making the germplasm resource of CIAT directly accessible to development and assuring CIAT a singular niche in tropical agriculture

3 The research objectives of the DGR have recently broadened and include areas such as *in situ* conservation socio economic considerations and native biodiversity that were not traditionally a major focus or strength of CIAT At the same time the change from program to project format has resulted in scientific objectives that are short term and often tied to specific funding opportunities Finally budget cuts have resulted in a decrease in staff All of these issues together are beginning to blur the focus of the research activities The staff is very earnestly trying to accomplish these multiple objectives and is simply spread too thin both in human resources and in expertise

It is imperative for the maintenance of CIAT s central position in international agriculture that this situation be remedied CIAT s reputation is based on past accomplishments in the development and distribution of new varieties Breeding activities are now being turned over to NARS with the exception of some region in Africa CIAT needs to very carefully define its new role in international agriculture so that it remains a conspicuous player and so that it retains the attention of its donors In this light the objectives of DGR need to be very carefully defined and managed so that the existing research staff can produce outstanding research that will not only stand up to international standards but also maintain the central role of CIAT in international agriculture Such research

already exists at CIAT the QTL work on rice is a good example and such an approach could be extended to other crops

4 Changes in the nature of funding appear to have an effect well beyond just the reduction in support The tight linkage of funding to specific objectives and donor support has both broadened the range of research and narrowed the flexibility and discretion of work within the units Moreover the commitment for support is necessarily shortened reducing the likelihood of long term projects that may well have the greatest ultimate benefit for CIAT Many aspects of SB 01 and SB 02 do not fit well within the project format The clearest example is the germplasm conservation activities which are a basic mandated function of CIAT independent of projects However the panel agrees with the rationale behind the change from programs to projects The project format does not necessarily preclude adequate support and flexibility Portions of the core budget could be set aside for support of the germplasm conservation and for support of core SB 02 activities thus providing security and flexibility while maintaining accountability

A final aspect of funding is significant Because of the increased need to identify outside funds a natural tendency exists to expand the range and nature of research at CIAT CIAT must necessarily respond to its donors However if funding opportunities are not carefully evaluated in the context of CIAT s objectives and current work the units will become diffuse and it will be difficult to identify major accomplishments with CIAT The panel already detects a tendency towards producing small studies in a wide range of areas

5 CIAT is by definition an international facility Yet CIAT is increasingly identified with Colombia It is appropriate that Colombia s interest is acknowledged as host country Colombia s changing agricultural basis and its desire to emphasize tropical fruits are all reasonable concerns for CIAT However with the proposed establishment of the Biodiversity Assessment Regional Laboratory and the current discussions with the Von Humboldt Institute CIAT will need to monitor its international representation

The proposed Biodiversity Assessment Regional Laboratory presents a window of opportunity for CIAT Because of the change in emphasis in CIAT from development of new varieties to agrobiodiversity the establishment of such a facility will provide both scientific and funding flexibility The DGR has a clear set of guidelines to determine which species and avenues of research will be pursued

6 Important information and tools (processes and gene sequences) related to modern biotechnology are now protected by intellectual property rights (IPR) Private multinationals or national public organizations are usually not eager to provide high cost research products or processes to CIAT because such products would

have to be released free of charge to third parties thus reducing their own potential royalty return As a result increasingly more private and public institutions in DCs and LDCs request assurance that their IPR will be honored and that results of any jointly developed research will also be protected

According with the DRAFT VERSION 5 presented to ICER for comments CIAT is currently revising its IPR policies The main objectives are under the prevailing IP environment to permit exchange of genetic materials and techniques and to ensure that the results of projects reach the intended beneficiaries in developing countries

CIAT should choose to exercise legal protection if such action is needed for developing critical strategic research alliances or to prevent appropriation of products intended to reach partners in developing countries The draft document presents four protocols to be used in each particular case depending on what material or process is being exchanged However it needs to clarify to end users and partners what is meant by material derivatives as stated in Protocol I It is clear that as a CG Unit, CIAT must assure that germplasm is freely available to all countries But by requiring that recipient countries can not seek IP protection for new cultivars (see UPOV definition) eventually derived from germplasm received from CIAT may create some concern to breeders working in public or private national programs

When discussing a new project which includes the use of proprietary genetic material (e g 35 S promoter) or proprietary processes (use of Bt genes for plant protection) CIAT should take into consideration as part of a general policy the possible effects of the IPR in the deployment of the potential outcomes of that project CIAT could become liable for distributing material that it knows to be of proprietary nature Intellectual Property Laws usually allow for the freedom of use for research purposes However as all countries in Latin America, for instance are part of the Trade Related Intellectual Property (TRIPs) Agreement and follow the rules of the World Trade Organization (WTO) NARSs may not be able to use the genes or processes deployed by CIAT to produce varieties for commercial purposes Furthermore CIAT should consider along with other CG Centers the strategic need to research for new molecular assets that would be protected by the CG System to be licensed to partners in developing countries

7 Biosafety One of the most widely discussed subjects inthe Biotechnolgy world is the biosafety of transgenic plants The UNCED Conference held in Rio de Janeiro in 1992 set the background scenario for many years to come when member countries of the Convention of Biolog cal Diversity discussed the transbourdary movement of living modified organisms CIAT is an International Research Center and therefore should be leading research in the area of risk assessment of traits which will be introduced in its mandate crops Of major importance are the studies involving plants which have their Center of Origin in Latin America and are likely to benefit from transgenic traits e g cassava and common beans The Panel sees a project in this area as an excellent opportunity

for networking and collaboration with NARS in individual developing countries and with private and public Institutions from the North

The Panel recognizes that CIAT has already prepared its Biosafety Guidelines in 1991 (BOT approved) and has formed its institutional Biosafety Committee (IBC) with the participation of an interdisciplinary group that includes representation from the Colombian National Agricultural Institute The IBC has recommended that the Center s DG make the decisions on permission for field testing Genetically Modified Organisms(GMO)

The Panel also understands that the Colombian regulatory framework is currently under review and a final re_ulation will be issued by Government in early 1998 With this legal instrument in place CIAT will be able to apply for field tests in Colombia All transgenic research has so far been carried out in containment (laboratory and greenhouse) using techniques for handling GMOs CIAT s biosafety guidelines have been designed according to the experience of DCs e g OECD and USDA and its IBC monitors technological and legislative developments worldwide for updating CIAT s guidelines

8 Network and Capacity Building CIAT is recognized world wide for its capacity to coordinate and implement the Cassava Biotechnology Network (CBN) CBN s impact includes the incorporation dissemination and updating of farmers perspectives into biotechnology priorities transfer of new biotechnology tools for cassava to national programs and the development of participatory projects that increase the relevance of R&D targets The CBN has provided an entire new opportunity to laboratories and scientists in developing countries by distributing 40 small grants and organizing three international scientific meetings on three continents CIAT also coordinates the Beans Advanced Research Network (BARN) which was organized in 1990 and has provided the opportunity for two scientific meetings and participates in the Rockfeller Foundation Rice Biotechnology Network The Panel recognizes that all CBN s effort should not come to a loss because of lack of funds and urges the scientific and donor community to support its continuation based on the excellent outcome provided so far

CIAT is also beginning to be highly praised in the Latin American region for the training courses and in service training it has provided since 94 Through these mechanisms CIAT has made available to partners a range of genetic materials culture lines molecular maps probes vector strains genomic and cDNA libraries and state of the art methodologies This effort has to be continued because it gives to scientists and laboratories in the region the comparative advantage of learning in their own language with less expensive travel and housing costs

9 External Reviews We would like to compliment CIAT for the excellent documents presented to the Panel and for the presentations prepared by members of the Team Their willingness to present their project results made our analyses much easier to prepare However we would like to comment on the length of the review With the amount of information that a Panel has to analyze it would be useful to add two extra days to the Panel work That would certainly allow for a more profound review of the scientific aspects of every line of research and to allow the panel to reflect on its findings Receiving the documents via e mail would allow more time for reading and would also speed up the process on arrival It may be a good idea to invite at least one of the members of this Panel to the next review giving this person the very good opportunity to review the progress and the implementation of our recommendations

Recommendations

- Establish a position assigned to SB 01 for computer/data base support This position was eliminated during budget cuts but is essential for the implementation of the recommendations from the 1995 CGIAR genebank review panel

- Provide additional expertise in the area of population genetics and evolutionary biology either by collaborative arrangements or by future staff positions

- Stabilize a molecular biology position assigned to SB 02 project

- Establish firm and formal links with IARCs to draw from state of the art research

- Publish the conservation methodologies developed at CIAT in international journals so that these technologies become widely disseminated Include these and other methodologies on CIAT s Internet Home Page when possible

- Continue rigorous peer review to promote research of international standards

- Establish a computer based monitoring system for germplasm conservation operations

- Provide core budget support for the germplasm activities of SB 01 so that budget stability is achieved and that the Upgrading plan can be achieved

- Provide more flexible core budget for the strategic gap filling approach in the biotechnology very fast moving field

- Provide appropriate fields to maximize environmental variation and gene x environment interactions for germplasm collections at Palmira

- Characterize the cassava germplasm collection before it is placed in in vitro storage The decision to place the cassava collection into in vitro culture should be carefully deliberated

- Establish a pilot program for field collections of essential germplasm

- Develop a friendly user GIS system to allow for methodology to be transferred to partners and NARSs

- Establish the Biodiversity Assessment Regional Laboratory and implement the guidelines that have already been written (Genome Research in Agrobiodiversity at CIAT)

- Consider a cassava breeding program which incorporates wild germplasm similar to the current program in rice and bean QTL s

- Contribute in a limited manner to in situ conservation efforts by providing guidelines and genetic information to other agencies such as Ministries of the Environment or conservation agencies

- Establish with urgency an agreement on biosafetv with Colombia, taking into full account internationally established procedures such as OECD guidelines

- Review formal interactions with NARS based on the broader mission of CIAT

- Combine when possible external reviews to reduce the burden on the staff

SB 01 Integrated Conservation of Neotropical Genetic Resources

The direction and hence title of the SB 01 unit is a result of the Internally Commissioned External Review on Gene Bank Operations by CGIAR in August 1995 and the new project framework introduced at CIAT in mid 1996 Activities carried out by the former Genetic Resources Unit and other projects related to conservation are grouped into a single conservation project Integrated Conservation of Neotropical Genetic Resources ICNGR

The general objectives of ICNGR include 1) the assembling of germplasm collections that are fully available to users that meet international standards and that are fully relevant to the purpose of conservation 2) to contribute through training to building the capacity in conservation sciences and techniques within the region and 3) to develop *in situ* conservation methodologies for farmer landraces and wild relatives

I Project Goals

The specific objectives of SB 01 are given as

- To make FAO collections fully meet international standards
- To make FAO collections and their pertinent information fully available
- To make FAO collections genetically and socially relevant
- To contribute to the formation of human resources in conservation methodologies in the region
- To provide scientific input in *in situ* conservation of farmers landraces and wild relatives

Related objectives identified by the SB 01 include

- To improve or develop conservation techniques integrating conventional and modern biological technologies and focusing on *ex situ* collections of mandate germplasm with linkages to *in situ* conservation on farm or in protected areas

- To assess and characterize the structure and diversity of genetic resources of wild and cultivated mandate species selected non mandate species and associated organisms through the use of analytical genomic technologies and agroecological information

- To make genetic resources databases and genetic stocks and pertinent information available to users at CIAT and in partner institutions

The following outputs have been used by the panel to measure progress towards the research goals

- CIAT mandate germplasm collections maintained with state of the art conservation techniques and made globally available Germplasm samples tested for freedom from major pests and pathogens
- Distributed Neotropical genetic resources better characterized at the species and genetic levels
- Improved germplasm conservation methods using seed and field techniques
- Improved germplasm conservation methods using *in vitro* and cryopreservation techniques
- Genetic structure characterized within and between gene pools of *Phaseolus* and *Manihot* using molecular markers
- Agroecological information integrated with genetic diversity using GIS and molecular makers (beans cassava and tropical forages)
- Genetic material distributed to partners
- Databases maps probes strains assembled and made available to partners
- Capacity building activities in conservation technologies and processes organized with national partners
- Strengthened links with other CIAT projects through common biological approaches

Below we address each of the questions posed in the TOR in turn

1 Are the research goals and priorities clearly identified and is the process to measure this adequate?

The research goals and priorities are clearly set by the unit and it adequately measures its progress towards these objectives The first priority of the unit is to conserve its germplasm collection according to international FAO standards Table 1 indicates the conservation goals for seed and other categories of the SB 01 Records of number of accessions placed into storage measure progress towards this goal Quality of conservation technologies is measured by monitoring of viability of stored material Figure 1 is an example of the unit s conservation strategy showing the management of germplasm for *Phaseolus* and tropical forages Table 2 is an example of the type of monitoring SB 01 undertakes for the quality of stored germplasm This example shows the percent of germination for stored *Phaseolus* and forages over the last 4 years The second area of work for SB 01 distribution of germplasm resources is also well documented by records Records of publica ons and tallying of hands on training activities courses conferences and posters monitor the third and fourth aspects of the unit s work research and human resources

Table 1 Proposed amounts of seed and categories for conservation

Weight gr / 100 sem	FORAGE						*PHASEOLUS*					
	5 C		20 C			TOTAL	5 C		20 C			TOTAL
	Distrib	Monitoring	Base	Repatriation	Duplicates		Distrib	Monitoring	Base	Repatriation	Duplicates	
< 1	9 000	6 000	6 000	6 000	6 000	33 000						
1 - 10	7 000	2 000	2 000	2 000	2 000	15 000						
10 - 30	3 000	1 000	1 000	1 000	1 000	7 000						
> 30	1 000	1 000	600	300	600	3 500	1 000	1 000	600	300	600	3 500
									600	300	600	1 500 *

* Alternate option if not enough seed is produced

Fig 1 Flow Chart for Germplasm Management of *Phaseolus* and Tropical Forages

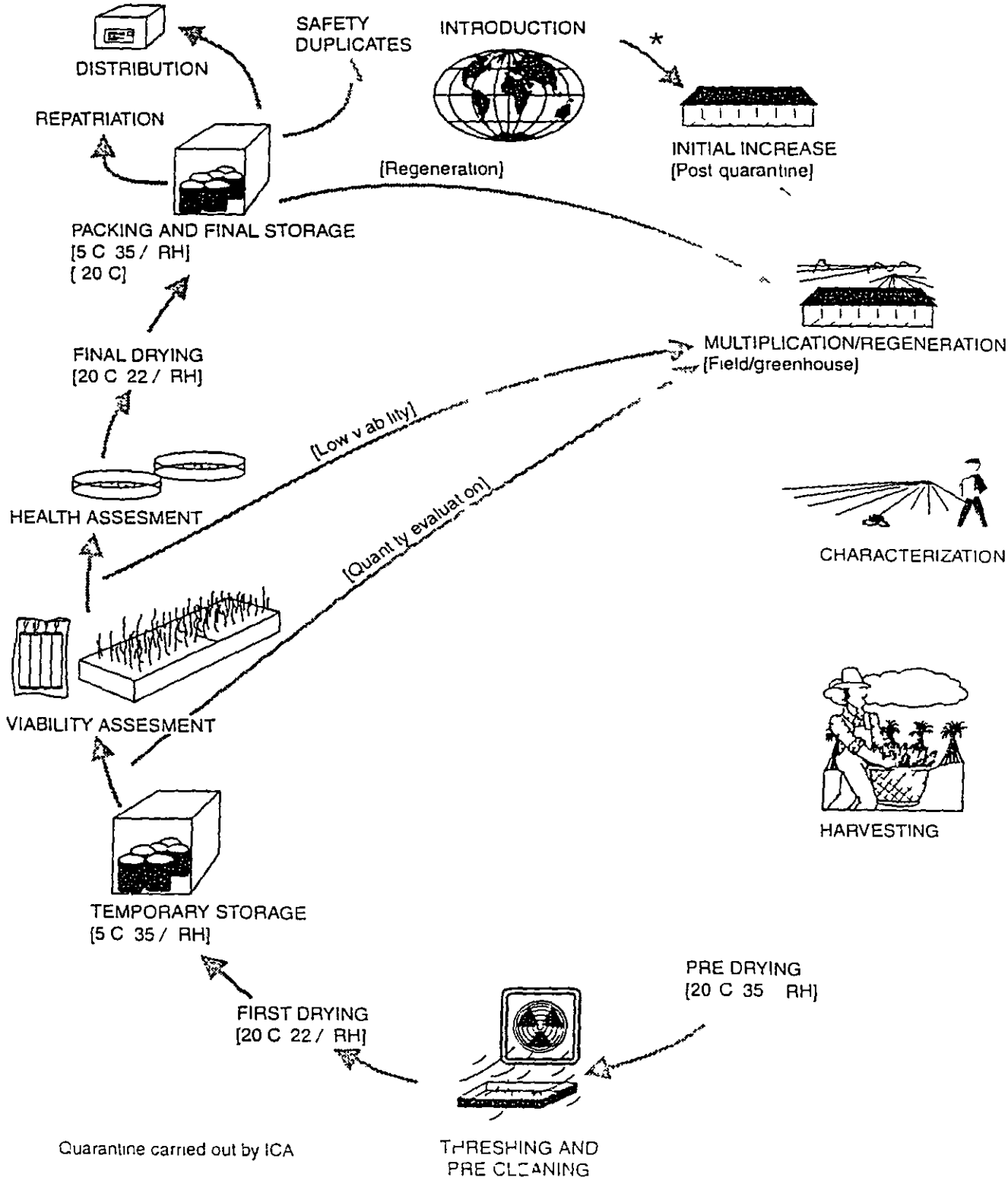

Table 2 Germination tests for *Phaseolus* and forages during the last 4 years

	Phaseolus Germination (/)					Forages Germination (/)				
	0	1 50	51 84	85 100	TOTAL	0	1 50	51 84	85 100	TOTAL
1994						1	5	101	91	198
1995						0	14	53	259	286
1996	96	404	756	571	1 827	0	0	0	0	0
1997	2	89	401	1 416	1 908	0	0	7	189	196

2 Does the research respond to the stakeholders needs?

CIAT holds in trust for the peoples of the world an essential and irreplaceable germplasm collection ICNGR is striving to reach and maintain FAO international standards in its curatorship of the germplasm collection The unit is responsive to requests for germplasm and its provides carefully monitored material to other organizations The research work of the unit is essential in developing techniques and strategies for conservation that can be applied towards other species and can be transferred to NARS We conclude that the work of the SB01 unit is highly responsive to the stakeholders needs

3 Are milestones well indicated and can their achievement be monitored?

Milestones for acquisition and maintenance of the germplasm collections are clear and the record keeping can monitor their achievement as discussed above

4 Are the research objectives feasible within the indicated time frames?

Based on the accumulated knowledge and experience of CIAT the proposed research objectives of the unit are ambitious and feasible within the indicated time frames only if adequate resources are provided Essential concerns such as eliminating the backlog of material to be placed in storage GIS documentation computerization upgrading and accessibility of records are all feasible within the projected time frames with adequate resources The goal of the unit is to provide secured stability in germplasm conservation services (short term conservation long term conservation viability monitoring safety duplication and repatriation) for twenty years by establishing appropriate facilities and staffing Such a goal is feasible with appropriate resource commitments (discussed separately below)

5 Is research attention to *in situ* conservation adequate?

The role of CIAT *in situ* conservation of ag obiodiversity is discussed in the context of several research projects The nature of such work is not specified Our understanding is that SB 01 in collaboration with SB 02 view their roll as identifying geographical areas

of concern and interest (e g molecular marker studies indicate that a specific geographical region has high diversity) and providing knowledge and protocols for the *in situ* maintenance of such diversity Only a limited role of SB 01 (and SB 02) in *in situ* conservation is appropriate given the other objectives and responsibility of the unit Moreover *in situ* conservation is not an endeavor to be undertaken lightly Conservation of genetic resources either as landraces by farmers or as wild species in preserves has a whole set of issues methodologies and constraints that have not been previously undertaken by CIAT Particularly for wild species there are other organizations (Ministries of the Environment conservation agencies) whose mission and experience make them much more suitable agencies to undertake conservation of species important to agrobiodiversity

6 Is the proposed research fully reflected in the project documents and do the work plans represent the project objectives?

Currently the research is fully and clearly reflected in the project documents and the work plans represent the project objectives But, in this context our interviews with staff revealed a g eat concern for the ability to complete specified research projects because of uncertainty in funding for any given project (This issue is discussed below)

7 Is projected output and impact well defined and feasible

The SB 01 Unit has a clear understanding of it s projected output and the impact and importance of its output The projected outputs are feasible given adequate resources

II The Research Program

The research of the SB 01 program is in several distinct areas united by the theme of conservation of genetic resources The unit has the significant and major responsibility of providing for germplasm conservation which includes both the introduction and propagation of new accessions into the collection, and the maintenance of the current collection Table 3 gives the current status of the germplasm collection at CIAT Maintenance of the collection is accomplished either by long term storage of seeds (beans and forage) or by tissue culture and field plots (cassava) There has been significant recent progress in this area by the modernization of facilities (cold storage seed germination room) and by the input of data in the SINGER system and the use of GIS data with passport information

The SB 01 unit also has the responsibility of distributing germplasm to NARS and other organizations Table 4 illustrates this function for the distribution of forage germplasm This work involves propagation of the material and certification of the health of the germplasm so that it can be safely utilized (without disease or pathogen) in another region The unit assures the safet of material by the seed health laboratory and by tissue culture production and monitoring of cassava

Table 3 Status of the Phaseolus beans and of the tropical forages germplasm collections conserved at GRU CIAT (1997)

Germplasm collection	Genera	Species	Origin No countries	Total No access
Phaseolus beans	1			
P vulgaris		1	91	25 454
Other cultivated spp		4	53	3 002
Wild spp		22	12	167
Subtotal	1	27	97	28 623[1]
Tropical Forages				
Legumes	102	614	69	18 559
Grasses	48	165	41	1 916
Subtotal	150	779	74	20 475
Manihot				
M esculenta	1	1	24	5 557
Wild spp	1	30	*	350
Subtotal	1	31	24*	5 867
Total	152	837	195	554 965

Table 4 Distribution of Forages germplasm (1994 1997)

	Number of Accessions (No of Requests)			
	1994	1995	1996	1997
Centre Staff in Host Country	1 895(52)	625(358)	569(350)	216(27)
Centre Staff in Other Countries	125(4)	9(1)	60(5)	
Other IARC s			115(1)	
NARS in Developing Countries	50 (28)	512(16)	548(17)	295(155)
NARS in Developed Countries	5(2)		97( )	54(2)	
Private Sector in Developing Countries	21(4)	55(11)	28(4)	(?)
Private Sector in Developed Countries	7(2)	54(4)		
Othe s (Includes Universities)	647(155)	100(15)	105(8)	48 (15)
TOTAL	5 251(117)	1 115 (85)	1 570(68)	1 05 (9)

Another responsibility of the unit is to develop new conservation technologies The unit has close collaborations with SB 02 and several types of genetic markers have been used to monitor the collection for duplicates (electrophoretic markers DNA fingerprinting and AFLP s) Other significant activities include *in vitro* preservation for cassava, storage effects on seed dormancy (cassava) zygotic embryo culture for safe international transfer (cassava) and pathogen detection in seeds (beans) The groups have also collaborated on studies of genetic diversity with both cultivated and wild germplasm of beans and cassava SB 01 has also been actively involved in training of researchers and in transferring the technology for germplasm conservation developed at CIAT Table 5 shows the recent training activities of the unit

Table 5 Number and type of capacity building activities

Type of capacity transfer	**Number of events**
Courses with input from project staff	13
Hands on training in GRU facilities	57
Research thesis supervised by SB 01 staff	18
Scientific communications in conferences workshops etc	31
Scientific posters in congresses	3

1 Are the proposed research activities and methodologies used appropriate to achieve the expected outputs?

The proposed research activities and methodologies in general are appropriate to achieve the expected outputs The GRU has good procedures in place for the placement of germplasm into the collection for the maintenance of the collection and for its distribution The work of SB 01 can serve as a model for future research on genetic diversity for a wide range of agriculturally important species

The proposed research of the unit is in the area of assaying biodiversity for appropriate collection strategies and in developing (in collaboration with SB 02) genetic markers Both of these areas of research are flourishing and are providing clear contributions to the general area of agrobiodiversity The studies of native and cultivated bean biodiversity and the identification of separate gene pools in several native species is an advancement that will have direct applications for the germplasm collection In view of these interesting basic scientific discoveries it is curious that there s very little direct collection of new accessions by the unit Because of the mass of basic genetic information gathered on wild bean species the scientists of SB 01 are clearly in the best

position to mount additional collecting trips They have the greatest understanding of genetic diversity of *Phaseolus* in the wild and it is the unit s mission to preserve biodiversity Given the rapid depletion of native germplasm it is urgent that accessions be collected expeditiously The unit has expressed a keen interest in increasing its collection activities

Another issue rests with the nature of the collections One issue that needs to be carefully addressed is the nature of sampling for a given species or crop At one end of the spectrum is the idea that only a single individual need be sampled because it represents the gene of the species and that multiple accession add little Such concepts of germplasm collections are reflections of species concepts in the past and are in ignorance of the mass of data, which indicates the high degree of variation within species The other extreme suggests that every population and every variety is distinct and ought to be collected and preserved Such concepts do not reflect current understandings on the reticulating nature of lineages CIAT because of its basic work in distribution of genetic variation is in a good position to determine how sampling and collection should be done based on the genetic structure of gene pool In the case of wild *Manihot* species the germplasm collection is often represented by only a few accessions and should be bolstered in collaboration with NARS

2 Is the research original and is the balance between basic and strategic research adequate?

Is the proposed science rigorous of international standards and is a peer review process in place to assure those standards?

SB 01 appropriately balances basic and strategic research The non curatorial aspect of the unit s work provides new conservation methodologies to other organizations and thus will have a wide effect on how conservation is practiced The work on genetic diversity in secondary and tertiary gene pools has importance both for basic and strategic research it furthers the understanding of basic plant genetics and it provides an example of how genetic variation is structured within a species Several of the studies are highly original The study of AFLP variation to assess variation and domestication in *Phaseolus* was the first study to use these new markers in such a manner The studies of germplasm genetic diversity at CIAT use a wide variety of molecular techniques reflecting the strength of the SB 02 unit Many of these studies now rest within the field of population genetics In this area CIAT would be greatly helped by additional expertise in the area of genomic and population genetic analysis Many of the issues in population studies rest not so much on technique as on sampling and data analysis The science conforms to international standards A peer review process is in place manuscripts are given to a committee of two anonymous colleagues who evaluate and comment on the manuscript before it is sent for publication

3 Are past research results and review recommendations used in present and planned activities?

The proposed program and research of SB 01 is strongly influenced by past research results For example the proposal for more intense germplasm sampling in *Phaseolus* stems from the research on AFLP markers that have indicated separate gene pools in several species Likewise research results indicate evidence for gene migration between cultivated forms of *Phaseolus* and some of the wild ancestors Such work can also be used to direct collecting efforts to weed crop complexes

The proposed activities of the SB 01 have also made use of past review recommendations The response of the SB 01 to the comments and recommendations of the external review panel of the CGIAR genebank operations of CIAT are discussed below

4 Have the recommendations of the review of the genebank been implemented?

The external review panel of the CGIAR genebank operations made several recommendations in its 1995 review of the genebank Many of these have been implemented and several have not We discuss only those areas where implementation is not complete

CGIAR Genebank Panel Comments

A *The Panel recognized that financial constraints are limiting CIAT s operation but thought that in relation to the Center s total budget the GRU is undefined*

The current panel is of the opinion that financial constraints are still limiting the operation of the genebank The genebank is the core activity of the GRU (SB 01) and is an activity that is essential for CIAT s role in CGIAR We view the genebank as the single most important activity of the Division of Genetic Research Strides have been made to increase facilities but several key areas need attention additional cold storage for seed renovation of seed cleaning areas and most importantly attention to computerization and mechanization of the work

B *The panel thought that there are dangers in making use of special project funding for key areas of conservation and research*

The ICER panel also shares this concern The genebank and germplasm conservation are core activities that are not always directly identifiable to a project The lack of a clear funding commitment to the genebank jeopardizes the conservation of germplasm that CIAT must maintain based on the FAO CIGAR agreement

C *The panel was satisfied that for* Phaseolus *forage and grass species CIAT s goal is to adhere to International Genebank Standards as endorsed by FAO and published jointly by FAO and IPGRI in 1994 Inadequate staff and funds have precluded complete achievement of these standards*

The SB 01 has responded by producing an Upgrading Plan The Upgrading plan is not yet entirely implemented due to financial limitations The Upgrading Plan includes

a. clearing backlogs and meeting standards of seed quantities
b seed viability and health monitoring
c long term conservation at CIAT
d safe duplication
e restoration

The previous panel set forth a series of 18 specific recommendations which have been addressed either by management or by the SB 01 Implementation of several of these recommendations awaits additional financial resources for the unit The current ICER was impressed with the earnest response of the SB 01 to the CIGAR genebank review The response of the SB 01 to the comments and recommendations of the CIGAR panel has lead to vast improvements in the maintenance and storage of collections other improvements are planned

CIGAR Genebank Panel Recommendations

We will not discuss each of the recommendations by the CIGAR panel but will highlight as examples some of the recommendations and the response of the SB 01

A CIAT should negotiate with ICA to permit first increase of forages in mesh houses to increase effective populations size and reduce genetic drift

The previous panel raised the issue of genetic drift in the management of forages and other crops Our field observations during this visit indicated a great concern by the SB 01 staff for eliminating genetic drift Seed collections are monitored on a per plant basis and then bulked only after equal representation is achieved Both the equal contribution of each plant to the gene pool and the overall inc ease in sample size of the collection is now adequate to prevent genetic drift

B *A pilot cryopreservation project for* Manihot *should be initiated as soon as possible*

This has been accomplished and cryopreservation is now effec ive for *Manihot* germplasm Several modifications have been made to the cryopreservation tec nique and now both control and recalcitrant genotypes can be effectively stored Currently studies of the long term viability of cryopreservation are underway It is hoped that this technology will soon be transferred o the routine storage of portions of he cassava germplasm collection

Other aspects of the CIGAR review panel s recommendations are currently being addressed or await implementation The CIGAR review panel suggested

Applied research should be initiated by CIAT to reduce costs for routine activities such as

- *drying in paper bags versus open drying boxes*
- *counting smaller samples to estimate total seed number with computer connections to scales and to enter seed number and seed weight per 100 seeds in the data base*
- *more mechanization in seed processing*
- *estimation of seed longevity of various species at temperatures above freezing to identify species where the active collection should be stored at –19C*
- *use of bar codes*
- *computer programs to enter germination results compute means and enter in data base*

Many of these improvements are yet to be implemented The SB 01 unit has given a very high priority to the computerization and mechanization of routine operations However these improvements can not be made without the hiring of a computer/data base specialist in this area Such a position had been in place but was eliminated due to budget cuts

The SB 01 unit has done a good job of improving the handling storage and maintenance of the FAO germplasm It has made many improvements in the curatorial facilities and procedures for germplasm conservation and this was done in the face of a declining budget The SB 01 unit has a tremendous obligation for maintain the FAO germplasm in trust and it meets this obligation with a strong sense of responsibility and dedication

5 Is research progress adequate and according to projected outputs and impact?

The progress of research has moved along quickly with several papers being published in refereed journals The progress of the germplasm conservation activities is discussed above

6 How are research outputs used and by whom

The research outputs are used both strategically by the community of researchers interested in agrobiodiversity and by basic scientists in population biology and enthnobotany The studies of *Phaseolus* gene pools are illustrative These studies have identified multiple gene pools within species this discovery leads to very practical recommendations for the collection of genetic diversity On the other hand such studies are inherently interesting to both enthnobotanists and population biologists as well The work has demonstrated multiple domestication which provides basic information on the development of agriculture The occurrence of two separate gene pools suggests some ancient lineage dive sification most likely associated with biogeographical factors which is of interest to population and evolutionary biologists

Project SB 02 **Enhancing the Understanding and Use of Agrobiodiversity Through Biotechnological Methods**

I PROJECT GOALS

Are the research goals and priorities clearly identified and is the process used to measure this adequate?

According to the documentation presented to the ICER, project SB 02 has the following goals and objectives

Project Goals to contribute to the improvement and use of genetic resources and to promote agrobiodiversity conservation through the integrated application of modern molecular and cellular biotechnologies in tropical countries

Related objectives identified by SB 02 are

Objective 1 Understanding the genetic diversity of wild and cultivated species for the use and conservation of improved genetic resources

Objective 2 Accessing exotic or novel genes and gene combinations to broaden the genetic base of cultivated crops

Objective 3 Collaborating with CIAT partners to access and enhance agrobiodiversity

The priorities of SB 02 came from on going projects prior to the transformation of the organizational system in Genetic Research from a program driven model to the present project system SB 02 unit was organized in the second half of 1996 The measurable outputs take into account the work developed with CIAT mandate crops and are clearly presented in the Annual Report and summarized as follows

Objective 1

OUTPUT 1 1 **Genetic diversity characterized at the intra and inter specific levels**

I) The wild bean (*Phaseolus*) core collection was characterized using seed protein and AFLP markers

- Major genetic groups were identified in Mesoamerica, Colombia, the northern Andes of Ecuador and northern Peru Germplasm from northern Peru was genetically the most distinct of all the geographical regions
  Colombian accessions appeared to be highly introgressed containing germplasm from the Mesoamerican and southern Andean gene pools

II) Studies of the molecular phylogeny of *Phaseolus* have been initiated Accessions of Phaseolus species can be grouped based on the region of geographic origin

- The South American species were clustered into two groups *P vulgaris* and *P costaricensis* and are clearly separate from *P lunatus* and and its closely related congeners
- The moleuclar data idicate the existence of two major gene pools in wild Lima beans The species *P augusti P bolivianus and P pachyrrizoides* do not form distinct geneic clusters but rather grade into each other in a continuum The three species are not clear cut entities warranting taxonomical ranking by species

II) A study of the genetic structure of both Mesoamerican and Andean common bean was carried out on the material in the core collection

- RAPD data provided new and more accurate quantification of the genetic distances between Mesoamerican races Race M was split into two distinct groups Races D and J were closely related but could be distinguished with RAPDs
- The Andean cultivated bean core collection was analyzed with AFLPs and showed that most landraces grouped closely together There is no systematic differentiation among accessions despite their having different geographical origins The results have lead to a new hypothesis on bean domestication in the Andean region that is currently being tested

IV) Genetic variability of Colombian and selected Central American and Brazilian *Manihot* species were evaluated by AFLPs and microsatellites to determine the species relationships and to provide insight into cassava domestication

- *M aesculifolia M brachyloba* and *M carthaginensis* were most distant from cassava (*M esculenta*) *M esculenta* subsp *flabellifolia* and *M esculenta* subsp *peruviana* were indistinguishable and were most closely related to the crop The latter finding supports recent taxonomic classification of *M flabellifolia* and *M peruviana* as subspecies of *M esculenta* and the hypothesis that ancestors of cassava can be found within this group The crop germplasm presented a narrower range of variation than most wild species Species specific bands that could be useful in detecting introgression and gene flow were also identified

V) AFLP fingerprinting was used to analyze African cassava germplasm and allowed better discrimination among accessions

- Estimating genetic similarities by AFLP in cassava accessions from Africa and Latin America was more informative than by other methods used to date such as isoenzymes RLFPs and RAPDs AFLP analysis could also detect possible genotypic duplications in 10 of the 20 cassava landraces studied

VI) A survey of the genetic diversity present among 18 major Cuban rice cultivars was conducted using isoenzyme RAPD and AFLP markers

- AFLP markers proved very efficient in detecting polymorphisms even among closely related cultivars The study revealed a high degree of genetic similarity among the cultivars which were all used for rice improvement programs conducted in Cuba

during the last 20 years These data, as well as previous studies conducted on Latin American rice varieties point to a very narrow genetic base in rice breeding programs

VII) A large collection of Colombian cassava bacterial blight (CBB) isolates have been characterized using DNA probes generated from the pathogen genome

- High levels of pathogen diversity at the molecular level are being related to geographic specialization of pathogen populations
- A very sensitive PCR based technique for detecting the CBB pathogen in cassava tissues was developed This diagnostic technique has an important practical use for the establishing clean germplasm propagules for the international movement of cassava materials

VIII) In a collaborative effort with CORPOICA Colombia, the genetic characterization and evaluation of variability of 36 *Passiflora* species and 100 genotypes of the Colombian *Musa* collection were carried out using RFLP and RAPD markers The findings contribute to a better understanding of the taxonomy of the *Passiflora* and to the clustering of the *Musa* accessions according to genome type

OUTPUT 1 2 **Useful genes and gene pools have been identified and/or localized and integrated with agroecological information**

I) Seed proteins were used to screen Andean bean germplasm for phaseolin types and Mexican wild *P vulgaris* for arcelin

- The main phaseolin types found in nuñas are T C and H followed by other types present at much lower frequencies New phaseolins found only in nuñas were also identified
- A new arcelin variant, arcelin 7 was found in some wild *P vulgaris* populations from Chiapas Mexico The wild accessions with arcelin 7 were resistant to the Mexican weevil

II) Common bean agronomic traits such as tolerance to low phosphorus are being tagged using mapping populations established with recombinant inbred lines (RILs) derived from the inter gene pool cross DOR 364 x G1 983 These lines are polymorphic among many combinations of Mesoamerican and Andean genotypes

- Several RAPDs and SCARs markers were identified for BGMV and CBB providing a first step towards marker assisted selection

III) Microsatellites sequences were isolated in Phaseolus and primers designed to provide access to high resolution markers for bean germplasm characterization population genetic studies and gene tagging

IV) Cassava genome studies were further refined by developing of he first molecular map of the crop

- The map consists of 20 linkage groups spanning 940 cM and is estimated to cover about 70% of the cassava genome The map was used to elucidate genome organization in cassava Initial data suggest that cassava is a fully diploidized segmental allopolyploid
- The saturation of the map is continuing with microsatellites developed at the University of Georgia and with Expressed Sequence Tags (ESTs) developed at CIAT

V) The characterization and mapping of genetic resistance to cassava bacterial blight (*Xanthomonas axonopodis pv manihotis* or Xam) was begun

- Preliminary results indicate a major gene on the M linkage group which explains 80% of variance for resistance to CBB The work is complemented by mapping receptor kinases to define the cassava xam pathosystem by using degenerate primers from the cloned rice gene Xa21 Significant homology to a gene associated with resistance to *Xanthomonas* in rice has been reported in cassava, but a role in the cassava *Xanthomonas* reaction has not yet been demonstrated Analyses are continuing utalizing degenerate primers synthesized over additional conserved domains that are homologous cassava cDNAs

VI) A strategy for developing durable resistance to rice blast was proposed by integrating the characterization of virulence in Colombian isolates MGR DNA fingerprinting of pathogen isolates and tagging of resistance genes with major Colombian MGR lineages

- The monitoring of the genetic structure and virulence diversity of pathogen populations was conducted on blast isolates recovered from 26 Latin American rice cultivars These cultivars exhibited complementary resistance to lineages of the pathogen
- Virulence analysis of more than 500 blast isolates showed no single isolate expressing compatibility with both Pi 1 and Pi 2 genes Testing the lineage exclusion hypothesis on stable blast resistance is under way by anayzing crosses made between several blast susceptible parents exhibiting complementary resistance

VII) A gene pyramiding program for incorporating blast resistance genes in to several commercial rice varieties of Latin America was initiated

- RFLP and microsatellite markers from the rice molecular map were used to screen two doubled haploids for tagging resistance genes
- One RIL mapping population was used to dissect the resistance of O Llanos 5 (a highly durable resistant commercial variety) RFLP SCAR, and AFLP markers linked to several resistance genes were identified

VIII) Genome research of *Brachiaria* species focused on tagging and fine mapping the apomixis locus with molecular markers and on localizing the apomixis locus on a complete *Brachiaria* genetic map constructed with hete ologous probes from rice and maize RFLP maps

- Two hybrid mapping populations were gene ated by crossing a *B br antha* and *a B decumbens* clone to the same tetraploidized sexual *B ru i ensis* biotype Linked primers were identified after screening 600 RAPD and 82 AFLP primer combinations using bulk segregant analysis

- A SCAR was designed from the RAPD primer linked to the apomictic phenotype in the *B ruziziensis* x *B brizantha* population at a distance estimated at 4 cM in *the B ruziziensis x B decumbens* population and 13 cM in the *B ruziziensis x B brizantha* population
- RFLP probes from the Cornell rice map linked with the SCAR and with the apomixis gene were also identified

Objective 2

OUTPUT 2 1 **Exotic genes and gene combinations accessed and utilized**

I) Viable fertile hybrid plants have been obtained following *backcrossing P vulgaris x P acutifolius* F1 hybrids to the common bean Interspecific hybridization was facilitated by certain genotypes of both species embryo culture and backcrossing strategy Congruity backcrosses increased the rate of fertile hybrids and the recombination of both genomes as shown by protein and molecular markers
- After several cycles of selection and pyramiding of resistance sources several lines highly resistant to bacterial blight (CBB) have been developed Other agronomic characters of the common bean parents have been retained
- Resistance to BGMV and leaf hoppers are important traits for broadening the genetic base of common bean by interspecific hybridization

II) A highly prolific meristematic common bean callus was produced following several subcultures of cotyledon nodes in a new medium with high levels of cytokinin Efficient ooting of regenerated shoots was possible following micrografting of stem tips onto decapitated seedlings Preliminary experiments of transformation using biolistics and *Agrobacterium tumefaciens* have shown the suitability of this tissue culture system for transformation of the common bean

III) Transgenic cassava plants were produced following *A tumefaciens* mediated transformation of somatic cotyledonary leaves of variety M Per 183 The plasmid used for transformation was pGV 1040 and expression of marker genes *gus* and *bar* was observed in regenerated plants Southern hybridization demonstrated the stable integration of T DNA mostly as single inserts Fully grown plants expressed high tolerance of the herbicide Basta (150 mg/l ppt) in greenhouse tests

IV) Integration of transgenic cassava into a broader pest and crop management approach is an alternative strategy for controling the cassava stem borer
- A binary vector (pBIGCRY) that harbors the chimeric gene cryIA(b) was constructed and placed it between the 35S CaMV promoter and a polydenilation signal from the nopaline synthase gene of *A tumefaciens* The construct contains the *gus* intron r porter gen and the *nptII* antibiotic resis ance gene
- Transformation studies of cassava variety Venezolana the mos important local cultivar in the Colombian North Coas were initiated

V) A cryopreservation technique for cassava was developed using chemical cryoprotection and dehydration cooling to recover viable plants from shoot tips of a range of cassava varieties

- The culture and dehydration of shoot tips before cryoprotection and freezing and the use of cytokinins in the recovery medium were critical to the successful recovery of plants from liquid nitrogen Plant recovery varies from 10% to 70% depending on the genotype
- Recalcitrant genotypes have been studied and their response to crypreservation significantly improved
- A rapid freezing protocol was recently developed and is currently being evaluated for genotypic response along with the use of encapsulation (alginate beads) of shoot tips

VI) Evaluation of the genetic stability of cassava cultures conserved *in vitro* for 10 years has shown no apparent genotypic variation at DNA level

VII) An advanced backcross method was implemented for rice The method is based on a successful demonstration by Tanksley in tomato of increasing yields by recovering positive alleles from wild species using molecular markers that otherwise would be overlooked, based on the phenotype of the parent, and identifying molecular markers for the alleles of interest to aid their incorporation

- Mapping populations from elite irrigated and upland rice varieties and three wild species (*O rufipogon O barthii* and *O glaberrima*) were developed Some BC2F2 families showed a transgressive segregation for yield, resulting in increases of as much as 15% The data were confirmed on BC2F3 families Preliminary QTL analysis provided information on the putative linkage between RFLP markers and yield components

VIII) A methodology for generating transgenic indica rice was developed

- Current resistance to RHBV (Rice Hoja Branca Virus) in commercial varieties is controlled by a single gene therefore broadening the resistance base against RHBV is of great importance Constructs containing the RHBV nuclear protein for cross protection and the anti sense RHBV NS4 major protein both viral genes were placed under the control of the 35S CaMV promoter and incorporated in transgenic plants using biolistics
- More than 150 plants were obtained from several transformation events Southern analysis indicated single and multiple gene insertions Segregation of 3 1 among offspring of transgenic plants was obtained These plants were challenged with RHBV in the greenhouse Resistant plants were selfed and their progeny challenged again with the virus Significant delay of disease development and reduced symptom occurred in transgenic plants compared with the nontransgenic control
- A few plants showed immunity to the virus

IX) Rice anther culture breeding has been established at CIAT for speeding up gene pool development recovering the fertility of wide crosses and producing permanent mapping populations for genetic tagging The response of indica rice genotypes to anther culture by modifying of the culture conditions was improved demonstrating that genes controlling response in japonicas can be introgressed into ind cas

X) The rice anther culture technology has been transferred to Latin American rice breeding programs with support from the RF Several Latin American and Caribbean countries have implemented anther culture for rice breeding

XI) Transgenic plants of *B decumbens* (4X apomictic) were generated using biolistic technology on isolated mature embryos In the experiments equal amounts of the pAct1D construct (containing the *gus* gene under the control of the actin 1 promoter actin 1 intron) and of the pTRA 151 construct (harboring the *hph* selective gene for hygromycin resistance and driven by the 35S CaMV promoter were used Southern analysis confirmed the integration of DNA

OUTPUT 2 2 **Mechanisms of genetic variability to biotic and abiotic stresses and quality factors searched identified and measured**

I) Differential display techniques to search for gene products specific to resistant genotypes to the bean weevil (*Acanthoscelides obtectus*) have been implemented Work with poly A(+) isolated during pod filling state was developed Transcription (RT) PCR products were separated and bands present in resistant, but absent in susceptible genotypes were isolated and used for probe hybridization Two bands out of 52 isolated bands gave positive hybridization in dot blot with bulked RNA from resistant *Phaseolus lunatus* genotypes Confirmation of positive hybridization is underway using Northern blots

II) Significant differences among genotypes for amylose content were mapped, and except for two genotypes differences existed for gelatinization temperature and maximum viscosity at the beginning with a tendency to stabilize afterwards

- Gels did not show structural changes nor syneresis during various storage periods The range of amylose content in 630 accessions from the cassava collection was 15% 28%
- Low amylose content was identified in a wild *Manihot* species

III) The feasibility of selecting and improving cassava genotypes with 2 mg/g of beta carotene in the roots and 30 times more in the leaves was demonstrated Genetically the transport of beta carotene to roots seems to be under the control of major genes and its accumulation is under quantitative genetic control Molecular marker assisted selection could contribute to breeding for high carotene cassava

IV)A rapid non destructive simple assay for cyanogenic potential in cassava was recently developed Using the enzyme based dip stick technique cyanogenic potential of more than 100 progenies was measured ranging from as low as 100 to as high as 2000 mg HCN/kg in root dry wt Gene mapping can now be integrated with breeding

V) Acid soil tolerance is a key trait for developing superior *Brachiar a* forage germplasm A collaborative project is searching for mechanisms result in *Brachiaria* tolerance to soil acidity The ove all approach includes

- designing a multiple stress nutrient solution to simulate acid soil conditions

- investigating a number of traits that might contribute to differential acid soil adaptation to P and N deficiencies with special focus on root architecture
- constructing a cDNA library enriched for acid soil stress induced genes from roots of the best adapted (*B decumbens*) cultivars

Initial results indicate

- significant increase in citric acid in root tissue in response to the presence of Al was detected Citric acid apparently does not accumulate only in root apices but also in mature parts of the root axes where it could be involved in Al detoxification
- Al P interaction in root apices and a possible link between Al toxicity and nutrient uptake capacity And, root acid phosphatase activity significantly increased in *B ruziziensis* only when responding to nutrient limited conditions

Objective 3

OUTPUT 3 1 **Networks conferences workshops and training courses on agrobiodiversity and biotechnology organized and conducted in cooperation with partners**

- Networks

The organization and promotion of and the participation in biotechnology networks is a key CIAT strategy for developing effective collaboration with institutions from both developed and developings The network approach provides opportunities for acquiring information capacity building and training on most aspects of biotechnology for a particular crop or group of crops

In 1988 CIAT initiated the Cassava Biotechnology Network (CBN) in 1990 CIAT founded the Beans Advanced Research Network (BARN) and since 1985 CIAT is an active member of the Rice Biotechnology Program a global effort by the Rockefeller Foundation

For CBN a full time coordinator maintains contact with stakeholders publishes newsletters organizes scientific meetings and coordinates developing country participation in capacity building programs and linkages with ARIs and CG centers especially CIAT and IITA The CBN has encouraged and/or promoted the participation of ARIs in cassava biotechnology research these have grown from a handful of laboratories in 1988 1990 to nearly 50 in 1996 1997 The CBN has organized three international scientific meetings on three continents and a small grants program for promoting cassava biotechnology research through collaboration on topics of high priority

The CBN membership has grown to more than 500 persons two thirds of whom work in 26 cassava growing countries including collaborators from applied disciplines and from NGOs and farmer processor organizations

• Training

As a basic element of CIAT s role to bridge biotechnology research with developing countries more than 650 scientists or technicians from 25 developing countries participated in international conferences regional workshops specialized training courses and in service training

• Research tools

CIAT has generated, or acquired and adapted, a range of research tools including genetic stocks genes gene constructs linkage maps and probes culture lines cloning vectors bacterial strains and the corresponding information and databases These materials (about 22 classes in all) have been fully available to CIAT partners under various transfer arrangements

• Partnership

To accomplish its mission and objectives the CIAT Biotechnology Research Unit, now the Project SB 02 has developed a wide spectrum of formal and informal collaborative mechanisms both within CIAT and with institutions public and private developed and developing countries

•Linkages with other CIAT projects genetic resources conservation (SB 01) increasing productivity (IP 1 IP 2 IP ɔ IP-4 and IP ɔ) integrated pest management (PE 1) soil conservation (PE 2) land use (PE 3) regional cooperation (SN 2) and participatory research (SN 3)

• Linkages with public institutions

  - International (5 IARCs and ɔ others)
  - NARS including ARIs (Colombia, 11 Other in South America,17 Central America and the Caribbean Region 9 Southeast Asia, 4 and Africa 2)
  - Public ARIs (Europe 12* and North America, 12*)
  - Linkages with private ARIs 6*)

* 12 linkages involved formal coope ation (some through projects)

• Fund raising

During 1994 1997 a range of organizations (including international foundations international institutes governmental bodies and regional agencies) funded the activities of Project SB 02 A total of 22 specific research activities were funded bv 17 organizations Nine activities received one time donations three projects ended in 1996 1997 while the extension of another is being negotiated

Does the research responds to stakeholders needs?

Given that the large community which interacts with CIAT ranges from small family farmers to industry driven large farmers from public funded research institutions (NARS ARIs) to private multinationals located in Latin America, Caribbean Asia, and Africa, SB 02 has tried to maintain a high level of responsiveness to stakeholders while keeping as close as possible to the CIAT mission

Are milestones well indicated and can their achievements be monitored?

SB 02 milestones are somewhat fluid in time due to the nature of the research being developed However the achievements can be clearly identified in all three major objectives as seen above

Are research objectives feasible within the indicated time frames?

Research objectives are clear but in some cases very ambitious The time frame is feasible given some extra support in personnel (see Section III) and that the maintenance of funding can be secured

Is the proposed research fully reflected in the project documents and do the workplans represent the project objectives?

The research proposals are fully reflected in the workplans and represent the respective objectives However there is a great anguish among the scientists due to the very short period covered by funding in each of the core funded activities (e g availability of funds reevaluated every January) Usually biotechnological results do not mature in short time periods and if forced to do so can lead to lower quality results

Are projects output and impact well defined and feasible?

The SB 02 annual report covers the 94 97 period The project outputs and impact have been well defined and presented Most of the research lines within Objectives 1 and 2 present a proposal for feasible future activities given that the funds can be provided

II *THE RESEARCH PROGRAM*

Are the proposed research activities and methodologies used appropriate to achieve the expected outputs ?

Objective 1 Understanding genetic diversity

(see comments on SB 01)

Objective 2 Broadening the genetic base of crops

In this topic the proposed research activities and methodology used are in general adequate The projects produced the first lines of transgenic plants covering three species *Manihot Brachiaria* and *Oryza* Preliminary steps were taken to identify the best tissue for transformation of *Phaseolus* Only with more experimental work, will the group be able to understand fully the complexity of introducing new genes into commercial varieties and be able to observe the pleiotrophic effects caused by the creation of many new loci Due to funds limitation and in order to increase the interaction with partners CIAT could contact NARS and other Institutes in the region (e g Cenargen/Embrapa (Br) Cinvestav (Mex)) which are developing state of the art transformation protocols for crops of the region This could avoid duplication efforts and speed up the outputs of projects Aspects regarding the IPR of the genetic material will be discussed in the appropriate section

Regarding the cryopreservation technique for cassava and the rice anther culture methodology CIAT has to be congratulated for the effort in developing the protocols that have reached a phase that they can be transferred to any interested partner The same is valid for the enzyme based dip stick technique for the detection of the cyanogenic potential in cassava

The results of the use of the advanced backcross method (Tanksley method) as applied to rice and beans deserve to be mentioned as some of the most convincing results showing the importance of the new DNA technology when applied as support for the use of genes from wild species for yield improvement

Is the research original and is the balance between basic and strategic research adequate?

The research proposals are original to our knowledge In Biotechnology it becomes very difficult to assure anyone for more than three to six months that the research is totally original The basic areas are covered within CIAT mandate crops but in some cases projects will have to broaden their focus Genomic interaction of the novel genes in transgenic plants scientific risk assessment upon environmental release of genetically modified plants application of QTLs in different genetic backgrounds and are some of the areas that need to receive much more attention given the quality of research results CIAT should maintain Viewing strategic research as research which has a strategy as to how to develop the desired products and deliver them to those who need them (G J Perslev CIAT BRU Review Report 1992) SB 02 has improved the contact with partners in the Latin America and Caribbean region in Europe and in the United States through pe sonal contacts during which the team leaders have taken good advantage of the opportunities to gain new knowledge and capabilities

The transfer of technology to NARS and other organ zations in LDCs has been developed into a horizontal collaborative activity which has evolved as much as possible for collaborative research projec s As part of this cooperation with NARS conferences

workshops and training courses constitute a strong component of information and technology dissemination

The Cassava Biotechnology Network (CBN) developed a strong orientation towards end user needs and perspectives It has carried out or promoted several case studies of priority setting and impact assessment with the participation of farmer organizations NGOs and NARS Some findings have become recommendations for research and development within and outside the Network

However we feel that much more can be done in that direction given that scientists can use sufficient funds to travel and participate from international meetings and interinstitutional agreements

Is the proposed science rigorous of international standards and is a peer review process in place to assure those standards?

See comments on SB 01 for peer review and above for comments on scientific rigor

Are past research results and review recommendations used in present and planned activities?

Taken as a milestone the CIAT BRU review report (1992) many of the recommendations have been followed in the scientific review of the projects However probably due to changes in the *modus operandi* from programs to projects due to the growing internal demand from the Natural Resources newly created Directorate and to the changing mission from applied breeding to agrobiodiversity screening and prebreeding it seems that SB 02 has spread its activities much too thin and therefore lost focus A priority setting exercise is taking place within the group as proposed in the document Genome Research in Agrobiodiversity at CIAT presented to the ICER Panel and should be continued

Is research progress adequate and according to projected outputs and impact?

Research progress could be more adequate if SB 02 teams could complement some positions with postdoctoral fellows and in some cases hire a new very specialized person (see Section III) As discussed before SB 02 was structured in the second half of 1996 and carried most of the projected outputs and impact of the Biotechnology Research Unit (BRU) The outputs presented in the Annual Report introduce all the results obtained in the 94 97 period without a time scale reference Therefore it became very difficult to individually judge the outputs

As outputs listed for the next three years SB 02 l sts

Genetic structure characterized within and between gene pools of *Phaseolus* and *Manihot* using molecular markers

Genetic diversity of cassava bacterial blight pathogen characterized and resistance genes identified using molecular markers
Genetic diversity of rice blast pathogen characterized and resistance genes identified using molecular markers
Molecular mapping of apomixis gene(s) and genes for resistance to spittle bug in *Brachiaria*
Agroecological information integrated with genetic diversity using GIS and molecular markers (beans cassava, and tropical forages)
Transgenic rice with resistance to RHBV field tested in Latin America and incorporated into IPM schemes
Novel genes (Bt, proteinase inhibitors etc) accessed and utilized in IPM schemes for insect resistance by genetic transformation in cassava, beans rice and *Brachiaria*
Novel genes (starch quality carbohydrate metabolism postharvest conservation seedling vigor etc) accessed and utilized for quality modifications using genetic transformation of cassava, beans and rice
Apomixis gene(s) isolated and cloned for homologous (*Brachiaria*) and heterologous (other crop spp) transformations
QTLs for yield and quality traits identified and utilized in rice beans and cassava
Useful traits (biotic/abiotic stress resistance) transferred through interspecific hybridization in *Phaseolus*
Field studies of risk assessment (biosafety) organized with the cooperation of the biotech private sector and NARS
Cellular and molecular genetic techniques developed for assessing and enhancing agrobiodiversity (novel DNA markers biomolecular statistics genetic engineering)
Databases maps probes strains assembled and made available to partners
Capacity building activities in conservation technologies and processes organized with national partners
Awareness programs and capacity building of NARS organized for assessing and enhancing agrobiodiversity through molecular and cellular techniques

How are research outputs used and by whom?

The immediate clients of SB 02 are CIAT scientists working in germplasm development, sustainable productivity and natural resources management projects Transfer of technology in this case is through involvement of CIAT scientists as early as possible in the process of acquiring and developing research Once a given technology has been developed for routine use it is shifted to other CIAT projects or units Some more basic aspects of the technology remain under Project SB 2 as a way of saving capital and operational resources

Is the quantity and quality of the various research publications adequate ?

The average number of publications pe scientist belonging to SB 02 could be higher giving the qualifications of research members and the infrastructure available However we unde stand that the group has many more activities such as organization of the external training workshops in house training production of nume ous reports preparations for reviews and of many project proposals for external funding We find

the group very geared to produce more and better publications if they could only see some of the heavy bureaucratical burden reduced

Is the research work adequately linked with the work in the IP projects ?

As shown in the Annual Report 94 97 and very clearly marked in the Medium Term Plan 1998 2000 SB projects IP projects and PE projects are planed to correlate well both by using partially dedicated common personnel and research results

Are the projects making adequate use of socio economic input ?

SB 02 benefits from the direct contact that CIAT maintains with stakeholders A major contribution comes from CBN in the case of cassava where major decisions have been taken based on direct demands from the small farmer For the other crops priority is given to projects which are likely to have major socio-economic impacts

III *RESOURCES AVAILABLE*

Is the right organization in place and can the expected outputs be delivered with the available resources (facilities, staff) ?

Facilities and organization

As clearly explained in the MTP 1998 2000 (p 80) CIAT has undergone a stepwise review of its internal organization At the moment the project based management is in place with possible alternatives such the formation of Scientific Units under discussion because scientists felt that projects alone would not be enough to sustain the internal organization However a scientific unit is an affinity group rather than a formal operational entity

ICER was presented with a proposal basically prepared by SB 01 and SB 02 scientists (Agrobiodiversity Team) which introduces a more formal design to organize the infrastructure management and account for new internal and external demands that are forcing CIAT to respond to new challenges

To accommodate changes the document suggests the maintenance of the **Genetic Resources Unit** to give support to SB 01 and other related projects and the establishment of two entities the **Genome Research Laboratory** and the **Biodiversity Assessment Regional Laboratory** in substitution for the actual Biotechnology Research Unit which at present gives support to SB 01 SB 02 and other related projects

The Genome Research Laboratory will house activities linked to genome characterization genome modification and clonal propaga ion of plants and will be run with CIAT s approved budget while the Biodive sity As essment Regional Laborator will be implemented and equipped through joint partne s contribution to house activities related to crops outside CIAT s mandate It will depend on additional resources provided by outside sources

We find that the proposed structure will give the Agrobiodiversity Team the extended flexibility they need to participate in the very fast moving biotechnology world It will re focus their activities to mandate crops allowing at the same time for the opening of a new window of opportunities which will signal to the internal and external public (donors and partners) that while prepared to respond to the challenge the Team will only do it if outside funding and human resources can be contemplated

The document also proposes the change of the current SB 02 project tittle to *Genome Research for Promising Tropical Crops*

The domain of this project includes basic responsibilities at CIAT such as monitoring advanced research in plant molecular and cellular biology worldwide bringing to CIAT and developing countries selected outputs with potential pay off in terms of applications outsourcing of special services in public and private ARIs (e g large scale sequencing genetic constructs for transformation etc) biosafety in DNA research and testing of transgenic plants and updating and training of CIAT personnel in biotechnology

The genomic work carried out in this project will be linked through projects with the research of national institutions in developing countries In dealing with nonmandate crops the role of project SB 02 will consist of providing the necessary biotechnology inputs for integration into crop improvement at the national and regional levels

This project will use molecular/cellular genetic tools for assessment modification, and mass propagation of agrobiodiversity in research areas such as analysis of diversity and relationship with the spatial distribution of genetic resources genotyping genetic resources with value in prebreeding strategies identification and localization of genes gene combinations and chromosome parts responsible for agronomic traits development of marker assisted selection strategies genetic transformation using single genes first later on more complex transformation using map based cloned genes clonal multiplication of plants by bioreactor and artificial seed technologies

Staff

SB 02 comprises a team of 11 75 scientists/year composed of 5 scientists from the core and 6 75 scientists belonging to special projects To be able to respond to the new demands described above the Team needs to maintain the present positions and assure the opening of at least three postdoctoral positions

Specifically the maintenance of the molecular genetics and the plant breeding (QTLs) positions are cri cal for the development of on going mandate crops related lines of esearch The suppor of a population genetic st is strongly needed and the acquisit on of a molecular biolog st is required to espond to the growing demands If the later is not possible due to funding contingencies the Team needs to garantee this support by outsourcing with ARIs or within the CG system

Budget (see general comments)

How do projects exploit strategic alliances with NARSs Universities NGOs and private sector ?

To meet the challenges posed by the application of biotechnology to agrobiodiversity Project SB 02 has developed collaborative linkages with a range of institutions worldwide During 1994-1997 the following linkages* were established by Project SB 02 (see details in the Annual Report 94 97)

(i) With public sector partner institutions

- 5 IARCs and 3 other international organizations
- 10 Colombian institutions
- 17 institutions in other South American countries 9 from Central America, Mexico and the Caribbean,
- 4 institutions from Southeast Asian and 2 from Africa
- 12 Advanced Research Institutions (ARIs) of 7 countries in Europe
- 11 ARIs in North America

(ii) With private ARIs collaborative linkages have been established with 6 pr vate biotechnology organizations in 4 countries

(*) Very often collaboration involved developing formal projects with special funding

Links with NGO s have been established through the Cassava Biotechnology Network

APPENDIX I

TERMS OF REFERENCE OF THE REVIEW PANEL

INTERNALLY COMMISSIONED EXTERNAL REVIEW (ICER) 1997

INTRODUCTION

CIAT's research evaluation framework includes two major dimensions research strategy and quality of science The strategic review process evaluates if CIAT has the right goals meets stakeholder needs is feasible has adequate projected outputs and the right resources and organization to deliver these The scientific quality review concerns issues such as is our science rigorous cutting edge and of high international standards are the methods used optimal and is the peer review process appropriate The Internally Commissioned External Review (ICER) concerns a review of the quality of science

The quality and the relevance of the research program is monitored by the BOT through among others mechanisms the Internally Commissioned External Review (ICER) An ICER is conducted by outside consultants their selection and terms of reference are BOT approved. CIAT's BOT adopted a schedule in which annual ICERs evaluate progressively the entire research program of the center over a five year cycle to coincide with the EPMR. The schedule for the ICER for the next five years is attached TAC in deliberating this recently put as condition to assign value to the ICER that they must be provided with names and TOR of the panel and receive the report and management response to the recommendations

THE 1997 REVIEW

The 1997 ICER will concern the research area Saving Agro biodiversity which is mainly concentrated in projects SB 1 (Integrated conservation of neo tropical genetic resources) and SB 2 (Crop germplasm development through increased utilization of biodiversity) This includes most of the germplasm conservation and biotechnology activities of the center The review will also cover pre breeding activities (broadening the genetic base of the mandate crops of the CIAT commodities beans cassava, rice and tropical forages) which forms part of projects IP 1 5

The event is scheduled to take place November 17 21 This date was chosen as the earlier proposed date would have coincided with major international biotechnology events

TERMS OF REFERENCE OF THE CONSULTANTS

The consultants to conduct the ICER will be required to deliver a written report of their findings with recommendations at the end of their assignment Their review shall extend to the following concerns

I Project goals

Are the research goals and priorities clearly identified and is the process to measure

this adequate
Does the research respond to the stakeholders needs
Are milestones well indicated and can their achievement be monitored
Are the research objectives feasible within the indicated time frames (risk assessment)
Is research attention to in situ conservation adequate
Is the proposed research fully reflected in the project documents and do the workplans represent the project objectives
Are projected output and impact well defined and feasible

II The research program

Are the proposed research activities and methodologies used appropriate to achieve the expected outputs
Is the research original, and is the balance between basic and strategic research adequate
Is the proposed science rigorous of international standards and is a peer review process in place to assure those standards
Are past research results and review recommendations used in present and planned activities
Have the recommendations of the review of the genebank been implemented
Is research progress adequate and according to projected outputs and impact
How are the research outputs used and by whom
Is the quantity and quality of the various research publications adequate
Is the research work adequately linked with the work in the IP projects
Are the projects making adequate use of GIS tools and socio-economic input
Is the germplasm CIAT holds in trust adequately documented and made available
Is the genetic resources activity of CIAT adequately linked to the System wide Genetic Resources Program and SINGER

III Resources available

Is the right organization in place and can the expected outputs be delivered with the available resources (budget, facilities staff)
How do the projects exploit strategic alliances with NARS Universities NGOs and the private sector

APPENDIX II

SCHEDULE FOR THE REVIEW PANEL

Internally Commissioned External Review
CIAT Projects on Saving Biodiversity SB-01 & SB-02
17 – 21 November 1997

Sunday 16

Reserved for Panel Work Examination of Reports and TORs

Monday 17

08 00	Telecommunication with Dr Wallace Beverdorf
08 30 10 00	Meetings with Directores and Project Managers
10 00 12 00	SB 01/02 Project Staff Brief Presentations
14 00 17 00	Reserved for Panel Work

Tuesday 18

08 00 10 00	Genetic Resources Unit Drs D G Debouc C L Guevara and R. Hidalgo
10 00 12 00	Biotechnology Research Unit Drs W Roca, J Tohme Z Lentini M Fregene I Sanchez, F Angel A Mejia, S Beebe C Iglesias C Martinez
14 00 16 00	Visit to Greenhouse and Field with SB 02 Biotechnology
17 00 18 00	Happy Hour' VIP Room

Wednesday 19

08 00 10 30	Panel Work with Drs W Roca and D G Debouck
11 00 12 00	Panel Work with other CIAT Scientists Drs John Miles Fernando Correa, Anthony Bellotti
13 30 15 00	Visit to Field and Genetic Resources Unit
1 00 16 00	Seminar Dr A M Thro CBN (Narino Room)

Thursday 20

08 00 09 30	Orientation of Future Work and Vision (Tayrona Room) Meeting with Drs W Roca, D Debouck A Bellotti S Beebe M Fregene C Iglesias Z Lentini A Mejía, I Sánchez, A M Thro J Tohme V Verdier F Angel
10 15 10 45	Telecommunication with Dr Wallace Beverdorf
10 45 11 30	Brief Presentation of Cryopreservation R. Escobar Biotechnology Lab
11 30	Reserved for Panel Work
17 00 18 00	"Happy Hour" Consultations with CIAT Scientists VIP Room

Friday 21

08 00 12 00	Reserved for Panel Work
13 00 14 30	Presentation of Recommendations by Panel to the Director General (Dr G Scobie Office)
14 30 17 00	Reserved for Panel Work Final Report
20 00	Dinner at Director General s Residence

Saturday 22

Departures

APPENDIX III

ADDRESSES OF THE PANEL MEMBERS

DR. BARBARA SCHAAL
Professor
Department of Biology
Washington University
St Louis U S A

DR. KEN ICHI HAYASHI
Board Member of ISNAR
Advisor to JIRCAS JAPAN
Former DG National Institute of Agrobiological Resources JAPAN

DR. MARIA JOSE AMSTALDEN SAMPAIO Ph D
Advisor to Director of EMBRAPA
Biotechnology & Biosafety
EMBRAPA Brasilia
Brazil

CIAT RESPONSES TO THE RECOMMENDATIONS OF THE EPMR AND ICER ON RESOURCE MANAGEMENT RESEARCH

(Reviewed and revised February 1996)

RECOMMENDATION	RESPONSE
1 **Research Management**	
1.1 All Programs report to DDG Research (this implies the abolishment of the AD RMP position) ICER #1	1.1 The DG proposes that a director for Natural Resources be included in the new Management Team. As the ICER notes (p. 6) integration is achieved principally through the project. Political visibility is experienced by having a D NR
1.2 Establish Associate Director Research Support and Information to whom Units and SRGs report (this also implies the abolishment of the AD RMR position) **EPMR #1**	1.2 The DG does not feel that creating an additional directorate position for research support is justified. The issue of the information system is under separate review
1 Use of matrix of Program by Units and SRGs **EPMR #11**	1.3 SAP 96 proposes a matrix of project by Programs and Units. The Pest and Disease Management SRG, the soils component of the Production Systems and Soil Management SRG and the Land Management SRG are converted into Units. The need for maintaining SRG type groupings in germplasm development, genetic diversity and production systems will be decided during the course of 1996. The outcome will be reported to the Program Committee of the Board in November
2 **Research Programs**	
2.1 Consolidate NRM programs **EPMR #3**	2.1 SAP 96 consolidates projects and pools scientific competencies into a soils and nutrition unit. Programs retain identity for mandate area goals and strategy but operationally are largely consolidated through projects
2.2 Convert Land Management to Program or Unit EPMR #3 ICER #	2.2 SAP96 converts the Land Management SRG into Unit

CIAT RESPONSES TO THE RECOMMENDATIONS (cont)

RECOMMENDATION	RESPONSE
3 **Research Support Units**	
3 1 Establish a Soils Unit **EPMR #4 ICER #2**	3 1 SAP96 creates a Soils and Plant Nutrition Unit
3 2 Establish a GIS Unit **ICER #2**	3 2 Functions of systems maintenance may be moved to realm of Chief Information Officer pending a thorough analysis Research functions would remain fully integrated in Land Management Unit
3 3 Establish Scientific Data Management Decision Support System Unit **EPMR #9**	3 3 A draft proposal for an integrated information systems unit drawing together all areas of information management and servicing has been prepared as part of SAP96 The proposal is under consideration The DC will report to the Program Committee of the Board in November 1996 on the decisions taken
3 4 Merge the BRU and GRU **ICER #2**	3 4 The merger proposal was reviewed internally by the Genetic Diversity SRG and submitted to the POC for consideration The POC endorsed the recommendation not to merge the BRU and GRU The DC instructed that this recommendation be incorporated into SAP96
3 5 Recruit Head of GRU **EPMR #5**	3 5 Appointment of the GRU Head will be finalized following approval of SAP96
3 6 Merge VRU and PPM SRG into IPM Unit **ICER #2**	3 6 This recommendation has been incorporated into the SAP96 proposal
4 **Scientific Resource Groups**	
4 1 SRCs should not be permanent entities **ICER #5**	4 1 See response to recommendation 1 3 Prior to SAP96 the SRG Leaders in consultation with scientists reviewed the role and function of SRGs Some of the recommendations are incorporated into SAP96 Others will be taken into account in defining the future of scientific competency type groupings at CIAT during 1996

CIAT RESPONSES TO THE RECOMMENDATIONS (cont)

RECOMMENDATION	RESPONSE
5 **Research Strategy Content and Staffing**	
5 1 Reformulate Forest Margin research **ICER #6**	5 1 As part of reformulation with partners of Global ASB Project greater emphasis being put on assessing environmental consequences of land use change and less on technology development
5 2 Undertake forage seed research **EPMR #2**	5 2 SAP9C which is based on carefully considered priorities does not include resources for forage seed research In the future this research might be undertaken using a Visiting Scientist (Research Fellow or Post Doctoral Fellow) position IPGRI s intention of placing a seed physiologist at CIAT was also thwarted by funding constraints
5 3 High prior ty for fundina of soil biologist **EPMR #4**	5 3 Soil biology research is being initiated even though SAP96 unable to assign re ources for senior scientist position
5 4 i) Hillsides research **ICER #7** a) Hillsides should evaluate CIAL methodology b) Hillsides should standardize soils and systems research	5 4 i) Hillsides a) Monitoring and evaluation mechanisms being built into CIALs b) SAP96 achieves by consolidating soils and systems research into interprogram projects
ii) Savannas research **ICER #9** a) Savanna research should continue in Brazil and Colombia **ICER #9** b) Methods in Brazil and Colombia should be standardized c) Should make greater use of socio economic information in savannas d) Need greater complementarity with Hillsides in soils and systems methods	ii) Savannas a) SAP96 continues savanna research in Brazil and Colombia b) In annual workplans for 1996 methods have been standardized as far as po ible among different labs including forest margins as well c) SAP96 retains socioeconomic studies as key part of Lowlands Land Dynamics project d) SAP96 consolidates soils and systems research into interprogram projects

CIAT RESPONSES TO THE RECOMMENDATIONS (cont)

RECOMMENDATION	RESPONSE
iii) Land management research **ICER #8** a) Emphasize interaction with CIAT Programs **ICER #8**	iii) Land management a) SAP96 makes explicit assignment of LM resources to collaborative research with Programs and makes Unit formally accountable to Programs through written workplans and annual performance evaluation
b) Complete diagnostic studies in Amazon	b) Continues to be research priority
iv) Higher priority for BNF in Africa **EPMR #1**	iv) Project proposals are being prepared with potential collaboration with European and Australian institutions
v) More attention to epidemiology of virus diseases **EPMR #8**	v) This consideration has been taken account of in the workplan of the VRU epidemiology studies are underway or will be initiated on hoja blanca virus whitefly transmitted virus and the rice entorchamiento virus
vi) Field trials of transgenic material only with national approval **EPMR #7**	vi) This is CIAT policy
C **Research Administration**	
6 1 Engage scientific staff in project definition and ensure that they are aware of all aspects of project management and budgeting **EPMR #12**	6 1 SAP96 recognizes that further progress needs to be made towards achieving a fully projects based approach to research planning budgeting execution and evaluation A process has been defined to implement this
6 2 Improve Performance assessment system **EPMR #15**	6 2 Performance assessment is one element that will be reviewed as part of the process which will be implemented to strengthen project based research management See Section V of SAP96
6 3 Program and Operations Committee to Monitor Staff Numbers by Program and Discipline **EPMR #14**	6 3 During the preparation of SAP96 the Scientific Resources Coordinating Committee made up of the SRG Leaders performed this function The Heads of Research Units will in future have this responsibility (see Section V of SAP96)
6 4 Formulate Strategic Plan for Information System **EPMR #16**	6 4 See response to recommendation 3 3

CIAT RESPONSE TO THE REPORT OF THE INTERNALLY COMMISSIONED EXTERNAL REVIEW OF NATURAL RESOURCE MANAGEMENT RESEARCH

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(respicer 8)

INTRODUCTION

The report of the Panel of the 1995 Internally Commissioned External Review (ICER) of Natural Resources Management at CIAT incorporates many recommendations and observations which require careful analysis and response Since this review comes only months after the CGIAR commissioned EPMR of CIAT the ICER report will be considered here in light of the findings of the earlier EPMR report

The ICER panel view of the great urgency for research to improve natural resources management to achieve agricultural sustainability is shared by CIAT Morovever it is noted that the ICER Panel finds Natural Resources Management Research at CIAT is of high quality and is starting to have an impact especially for example the rice pasture protype cropping system in the acid soil savannas and the organization of CIALs in the hillsides (p 39)

Similarly the EPMR credited CIAT for its well conceived initiatives in natural resource management research (EPMR p xi) and noted important contributions both to methodologies and direct impacts that have already emerged from this research despite the fact that conventionally impact is only expected from NRM research over the longer term (EPMR pp 35 39 41)

Both the ICER and the EPMR endorse CIAT s initiative to address natural resource management research issues through a new approach (EPMR p xiii ICER pp 4 39 40) Likewise they concui with the need to expand further this effoit but not at the expense of the commodity programs (EPMR pp 43 104 ICER p 40)

ORGANIZATIONAL STRUCTURE

The ICER chose to focus first on organizational structure which was also an issue considered by the EPMR The ICER endorsed the current structure of a Hillsides Program and a Tropical Lowlands Program and recommended that the Land Management SRG be converted to a Program This corresponds to option a) that the EPMR identified for consideration (EPMR p 43)

This option is fully consistent with the CIAT Strategic and Mid Term Plans and has the further advantage of permitting continuity to allow these new Programs to carry forward the research projects that have been carefully and soundly elaborated and are now being implemented Although the ICER made some important observations with respect to the research projects of the Hillsides and Lowlands Programs it did not question the fundamental orientation strategy or the capacity of the current organizational structure of the agroecosystems programs to successfully deliver planned outputs

The ICER recommendation for a Land Management Program would resolve an existing institutional anomaly and is one of the options suggested by the EPMR (the other being to establish a Land Management Unit (EPMR p 42)) The ICER report states that the role of the Land Management SRG should go beyond that of servicing CIAT Programs (p 30) but that it should place emphasis on interactions with the other six Programs (p33) Thus converting the Land Management SRG to a Program may stike an appropriate balance

The ICER also made several recommendations with respect to Units which focus primarily on providing services to the Programs It recommended disassociating the Units from the SRGs and the formation of new Units for Soils GIS IPM and a combined BRU/GRU (ICER pp 7-9) The last is the subject of a separate ongoing analysis and is perhaps outside of the strict TOR of the ICER so will not be treated here

A Soils Unit was proposed in the CIAT 1994 Action Plan and was recommended by the EPMR and the ICER (EPMR p 44 ICER p 9) As envisioned in the background paper prepared by CIAT for the ICER such a unit would be responsible for the operations of a soils laboratory as a forum for center wide issues related to analytical procedures and inter program projects and as a point of articulation with the Systemwide Soil Water and Nutrient

Management Program

It is not clear whether in common with other existing CIAT Units principal staff would be assigned to the Unit the degree to which the Unit would implement projects or the relation of the Unit to the Production Systems and Soils Management SRG which for example also is intended to serve as a forum for center wide issues Clarification of these issues should preceed the establishment of a Soils Unit

GIS studies have constituted the largest part of Land Management Research at CIAT since its inception Moreover while part of Land Management numerous GIS studies of great value have been requested by commodity and agroecosystem programs and have been successfully completed Thus it is neither clear that GIS need necessarily be a separate unit solely because it is of interest to other programs (ICER p 39) nor is it clear that a Land Management Program would be a viable entity without the GIS studies capacity Conversely the EPMR saw GIS research as central to the agenda of the Land Management Group (EPMR pp 40 41)

The recommendation by the ICER to create an IPM Unit is the first time the creation of such a Unit has been formally broached (ICER p 8) The schedule of the ICER panel did not include the opportunity to explore this issue in depth but nonetheless there could be merit in this idea

In addition to its organizational recommendations with respect to Programs and Units the ICER also proposed that SRGs not be permanent organizational entities but rather that they voluntarily form and disband in response to needs percieved by members or by the DDG-Research (ICER p 9) Because the issue of the role of the SRGs is really of a center wide nature rather than referring specifically to natural resources management research it will not be considered in detail here It was also a topic considered by the EPMR (EPMR pp 51 52)

Finally the ICER recommended that all Programs report to the DDG-Research in order to focus the Center s work on sustainable land use ' (ICER pp 7 41) This is similar to an EPMR proposal (EPMR p 81) The structure of senior management will of course be a major early concern of the incoming Director General

RESEARCH PROGRAMS

Besides organizational recommendations the ICER also gave careful consideration to the research projects of Tropical Lowlands Hillsides and Land Management Their recommendations and analysis of these programs will now be considered in turn followed by a review of some cross program research issues raised by the ICER

Tropical Lowlands Forest Margins

The ICER reaffirmed that it is worthwhile to mitigate deforestation in the tropical lowlands and suggested significant changes that they perceived as having more potential for attaining this objective with a greater committment of resources (ICER p 22)

Probably the most far reaching recommendations of the ICER were made with respect to the forest margins research in the Tropical Lowlands Program The ICER recommended that forest margins research be fundamentally reformulated (ICER p 41) and in particular that research on prototype sustainable cropping systems for the forest margins in Acre Rondonia be dropped (ICER p 21) This view has no parallel in the EPMR report

The main reason for these recommendations is found when ICER cites CIAT research at the Acre-Rondonia site indicating that forest clearence appears to be driven there principally by land speculation Consequently the Panel does not see great prospects for mitigating forest clearance through the generation of more sustainable agricultural systems

CIAT sees the potential for intensified agricultural systems to mitigate forest clearance as an issue that requires research Certainly improved technology alone will not suffice to stop the destruction of tropical forests Awareness of this fact is a major force behind CIAT's interest in land use and policy studies since the inception of its natural resources programs

However it is not plausible to suppose that improved technology has no role in improving natural resources management in the forest margins either in Acre-Rondonia in particular or elsewhere in the tropical forest margins Generation of improved systems could have a significant impact both on the incomes and welfare of settlers in the forest margins as well as on the natural resource base which degrades severely under curent practices

In this context CIAT intends to shift the emphasis on research in the forest margins from the testing of components for prototype systems to greater concern with understanding the underlying processes of degradation and reclamation of the resource base particularly soils resources Moreover CIAT will as recommended by the ICER continue diagnostic studies of agricultural land use in the forest margins in part to better understand how the availability of improved technology could change land use practices

CIAT s emhasis on the forest margins has always been on the already cleared lands and its concern has been to improve the management of these resources that have already been converted from natural vegetation to agriculture Nothing is to be gained by mismanaging and further degrading resources that have already been converted to agriculture In CIAT's view it is worthwhile for its own sake to conserve and enhance the productivity of these resources and to improve the incomes and welfare of the small settlers who manage these resources Achievement of such an objective could also have a spillover of affecting the rate of further clearance of forests

A second significant suggestion made by the ICER is that CIAT should tranfer its forest margins research to another site because the system at Acre-Rondonia is not <u>per se</u> truly a slash and burn system (ICER p 22) It is true that the systems in Tropical America differ from the classic slash and burn systems of Asia and Africa in that pastures are part of the systems but the underlying similarities remain In the tropical Americas these systems are based on forest clearance for cropping (or pastures) and periodic re burning after land has passed through a fallow state which is typically pastures that degrade into the equivalent of bush fallow

Moreover CIAT's research in Acre Rondonia is part of a global program involving both national programs and other CGIAR centers CIAT's activities can not be understood without a full appreciation of this context which includes a long period of careful joint diagnosis by a number of institutions which led to the selection of the Acre-Rondonia site It would be no light matter for CIAT to unilaterally leave this site for another

Indeed the ICER recommendation that CIAT consider a comphrehensive approach for the entire Amazon basin with other institutions including CIFOR ICRAF and IFPRI (ICER p22) should

be seen in the light that the current work at the specific Acre Rondonia site is the result of careful inter institutional planning that focussed on Acre-Rondonia as an initial benchmark site within such a wider perspective as advocated by the ICER This was the view of the EPMR (EPMR p 38)

With respect to a more comphrehensive approach to the Amazon it is worth noting that the EPMR expressed concern about the limited resources available to CIAT and recommended that the number of reseach sites for NRM be reduced and urged consolidation of research to one site per agroecosystem (EPMR pp 39 43 44)

CIAT fully accepts the ICER view that land use studies are a priority in the forest margins and intends to strengthen efforts in this regard CIAT recognizes the ICER concern about the prototype systems research and intends to deemphasize it in order to give greater attention to studying soil resource degradation and reclamation processes However the research at the Acre Rondonia site is the result of a careful planning process and the product of a significant inter-institutional committment upon which CIAT can not renege without exhautive analysis thorough consultation and compeling considerations which have yet to be fully articulated

<u>Tropical Lowlands, Savannas</u>

ICER found this research to be ambitious but well conceived and producing high quality results with good balance between strategic and applied research (ICER p 10) The EPMR cited important contributions to methodology as well as direct impacts from this reesearch (EPMR p 39)

CIAT agrees with the ICER recommendation to maintain two savanna study sites one each in Brazil and Colombia because of significant climate soil and socioeconomic differences between them (ICER p 43) This contrasts with the EPMR report which had proposed focussing all savanna research on a single site in order to conserve resources (EPMR p 39)

CIAT notes the ICER s concern to give greater attention to work in the Cerrados of Brazil even at the expense of reducing effoits in Colombia (ICER p 43) It should be pointed out that there is a large and well qualified team of Brazilian researchers both at EMBRAPA-CPAC and the Federal university of Uberlandia Moreover it should be mentioned that two special projects have been funded

to strengthen research in the Cerrados that also tap the capacities of advanced research organizations The EPMR did not express a view on the relative balance between research in the Cerrados and the llanos

CIAT shares the ICER's view of the importance of standardized methods and measurements between the long term sites in Colombia and Brazil (ICER pp 13-14 43) These recommendations are appreciated and will be taken seriously and adopted to the extent possible though it must also be recognized that CIAT s research partners in each location also may have their own specific research objectives that must be taken into account in the design of experiments that CIAT conducts with them

CIAT concurs with the weight given by the ICER to the study of land degradation (ICER p 15) This is a main topic of research carried out in the Agropastoral Network in on farm trials in Colombia and in trials in Carimagua that were not visited by the panel due to time constraints

CIAT acknowledges the importance of socio-economic information in the design and evaluation of savannas research (ICER p 43) Such analysis has been a priority for the Lowlands Program and will continue to receive considerable attention

It should be pointed out that though the CultiCore does not include a pure grass treatment as observed by the ICER (ICER p 13) other cooperative trials with CORPOICA in the Colombian llanos do include pure grass pasture treatments

<u>Hillsides Program</u>

The ICER found the achievements of the particpatory research project as encouraging and its strategy appropriate while it considered the objectives of the other projects as worthwhile (ICER pp 26 28 30) The EPMR considered that the Hillsides Program research on involving smallholder communities was cutting edge research which had already led to the adoption of many innovative methods (EPMR p 35)

The ICER recommends that the Hillsides Program should focus on monitoring and evaluating the CIAL methodology (ie farmer led research committees) (ICER p 42) The ICER rightly notes that the CIAT product is the methodology not the CIALs themselves at a particular site (ICER p 26) The ICER also observes that There

has been careful monitoring and evaluation of the inputs into creating consolidating and maintaining the CIALs ' (ICER p 24)

Indeed as thus indicated by the ICER studying the effectiveness of the CIAL participatory research approach has been a major focus of the Program so that this recommedation is essentially an endorsement of an ongoing body of research For example CIAT would point out that options for streamlining the creation process of CIALs have already been a research topic (ICER p 24)

CIAT does not view the CIALs as being validated when they are independent of or completely separate from national research institutions as implied by the ICER (p 24) CIALs can play important roles in testing technical options or articulating farmer needs to the research system but the CIALs are designed to be permanently linked to the formal research system which is the source of supply for new technical alternatives

More broadly though it should be pointed out that participatory research is only one of four Hillside Projects with the lowest allocation of senior scientist time It would be therefore misleading to represent the main focus or major balance of Hillside Program research as the participatory research project although much of the ICER report on Hillsides is devoted to that subject

The process of establishment of CIALs is now largely spontaneous and does not depend on the use of CIAT prestige to catalyze their formation (ICER p 27) While it is recommended to study the time required for developing CIALs (ICER p 25) this has already been done Similarly the question of reportable intermediate outputs (ICER p 25) can be answered through studies that have already been done that show that participatory farmer managed trials are less expensive than researcher managed on farm trials and yield a high quality of trial results in terms of statistical interpretability

Furthermore CIAT s research experience indicates that the CIAL methodolgy is largely validated and sees this as a rather mature research effort that is now advanced into a transfer stage rather than a long term high risk research venture (ICER p 25) Not just at CIAT but also at other CGIAR centers NARS and grassroots organizations participatory methods have been developed and refined into a comphrehensive package of techniques that are being utilized throughout the world for application to

participatory plant breeding IPM research soil conservation programs and to improve adaptive research in NARS and NGOs

The comments of the ICER on risk might be intended to be addressed to the CIPSLA initiative for community watershed management which is indeed in a pilot research phase Nonetheless even here there are already measurable intermediate outputs emerging in terms of the establishment of protective barriers along watercourses and the reclamation of fragile subsystems by local partner institutions It is not clear that these intermediate outputs came fully to the attention of the panel (ICER p 27)

CIAT welcomes the recognition that natural resource management at the watershed level is a real issue which needs to be addressed despite its complexity (ICER p 28) Focus on key elements is sound advice and the approach of studying sub catchments is already that of the Hillsides Program

CIAT appreciates the potentially ambitious nature of utilizing a suite of models to support watershed level resource management decision making a point also noted by the EPMR (ICER pp 27 42 EPMR pp 35-36)

CIAT agrees with the ICER view to identify a few major entry points to simplify the analysis of the inevitable complexity of watershed decision making but CIAT maintains that adoption of sustainable land management practices is often contingent on off site effects which are therefore too important to be completely ignored even though they may not be fully modeled or measured in detail (ICER p 28)

With respect to prototype systems research it is not correct that the trials being conducted are based solely on CIAT mandate crops (ICER p 28) Moreover CIAT would emphasize again that this research does not aim to develop recommendations linked to specific commodities but rather to understand the principles of sustainable land management involving combinations of plant prototypes (eg short cycle-shallow rooted perennial-deep rooted)

Finally CIAT sees the relative importance of soil erosion and soil chemical quality problems as an empirical issue that demands research rather than simply following the conventional wisdom that controling soil erosion is necessarily the main entry point

for regenerating tropical hillside agricultural systems (ICER p 29)

Land Management

Both the ICER and the EPMR endorsed CIAT s research approach in Land Management the EPMR noting that CIAT s GIS team has earned a leadership role both in the region and the CGIAR (EPMR p 42) while the ICER saw an importnt role for this research in providing an NRM focus to other Programs through its studies at progressive levels of aggegation (ICER pp 33-34)

CIAT wholeheartedly endorses the ICER view that Land Management research should place emphasis on interactions with the other six programs and should as far as possible restrict its focus to the hillside and lowland ecoregions of tropical America while at the same time not being limited to servicing CIAT Programs (ICER pp 30 42) The EPMR similarly saw support to other programs as a top but not sole priority for Land Management research (EPMR pp 42-43)

CIAT interprets the role of Land Management research depicted in the ICER proposed organogram as reflecting issues of scope and of conducting research on scales at the farming system and above rather than any sense of importance or power in relation to the other Programs The EPMR urged a clarification and strengthening of the channels of interaction between Land Management and other CIAT organizational enetities (EPMR p 42)

The precision and frequency of updating of the GIS data bases is an issue of which CIAT is aware (ICER p 30) Clearly different levels of precision will be appropriate for different analyses These data bases are seen as a key international public good for the production of which CIAT has established a clear comparative advantage

CIAT accepts the ICER recommendation to continue diagnostic study of land use in the south-west Brazilian Amazon and its warm endorsement of the results achieved so far (ICER pp 42 31) CIAT would point out that the recent initiation of similar research in Peru is consistent with the ICER view on the potential for wider studies in the Amazon basin (ICER pp 22 31)

CIAT welcomes the ICER view that despite being beyond CIAT s traditional scope of concern the project on sustainability

ındıcators recently ınıtıated ın collaboratıon wıth UNEP ıs research of a strategıc nature of consıderable value to CIAT s agenda (ICER p 32)

CROSS PROGRAM ISSUES

The ICER Panel s vısıon of strıvıng for greater ıntegratıon between commodıty research and natural resource management research (ICER pp 6) ıs a strong objectıve of CIAT The ICER notes the relatıon between forages and savanna research as a model of cooperatıon sees CIAT s rıce research strategy as provıdıng an ımportant element for the Lowlands and encourages lınks between Hıllsıdes and beans and cassava research (ICER pp 35-37) The role of ımproved forages ın the hıllsıdes and forest margıns ıs another potentıal lınkage that also ıs deservıng of note

Although the ICER ıs skeptıcal of the potentıal contrıbutıon of commodıty ınputs to the prototype systems projects ın the forest margıns and hıllsıdes (ICER pp 20 28) ıt does poınt to opportunıtıes to lınk IPM to hıllsıdes cassava and rıce (ICER p 36)

Research partnershıps wıth a wıde range of natıonal ınstıtutıons advanced research organızatıons and other CGIAR centers are a vıtal part of CIAT s stategy to deal wıth the complexıty of natural resource management ıssues Yet CIAT does not dıspute the EPMR and ICER vıew that thıs entaıls sıgnıfıcant transactıons costs (ICER p 38 EPMR p 66)

Nevertheless ıt ıs CIAT s fundamental convıctıon that ımproved natural resources management can be achıeved only through a multı-ınstıtutıonal effort The alternatıve to a multı ınstıtutıonal approach ıs contınued ınabılıty to adequately address the complex problems of natural resources management Properly managed CIAT s efforts ın catalyzıng ınter ınstıtutıonal collaboratıon wıll lever the ımpact of ıts own work rather than be a deadweıght transactıon cost

Workıng wıth other ınstıtutıons wıll contınue to be a way to multıply CIAT's own ımpact but ıs not an end ın ıtself For example ICIRSAT s work on ımporved sorghum wıll be a dırect ınput to CIAT s savanna research just as ILRI s proposed work on lıvestock wıll dırectly complement CIAT s forages research The real costs recently ıncurred ın establıshıng these new

collaborations are in the future likely to be repaid manyfold To insure this outcome CIAT strongly shares the ICER view that it must pick its partners carefully and for sound reasons (ICER p 39)

CIAT agrees with the importance the ICER attached to achieving complementarity in process level studies between the Lowlands and the Hillsides Programs (ICER p 43) The fact that the same scientist is the Project Officer for the Prototype Systems projects of the two programs is one example of how this is being addressed Another example is the use by the Hillsides Program of the same methods as the Lowlands Program for a study of soil macrofauna diversity and cross-program collaborative research on bio-economic modeling at the cropping and farm systems levels of analysis

CIAT accepts the desirability of insuring a high degree of standardization in methods particularly in soils research though it recognizes that complete uniformity is neither possible nor necesssarily desirable

The ICER view on the importance of soil biology studies is well taken (ICER p 14) Earlier this year CIAT sought TAC endorsement for adding such a position but TAC indicated that it would have to come at the expense of another position rather than as an addition

CIAT shares the view of the importance of economic analysis in natural resources management research (ICER p 33) How to address this issue will receive particular attention