Land Management Unit

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OVERVIEW

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CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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* Left during 1996.

CONTENT

INTRODUCTION

Gilberto C. Gallopín, Head

Sustainable agriculture requires the operation of critical nutrient recycling mechanisms, preservation of soils, pollination of crops, regulation of hydrological cycles, and the maintenance of a large genetic library to cope with new pests and hazards. All these requirements are exclusively met by healthy ecosystems. On the other hand, farmlands and wildlands offer to humans significant goods beyond food and fibers. We do not live by food and fiber alone: we also need unpolluted air and water, flood regulation provided by healthy watersheds, and a functional atmosphere to protect us from global warming and harmful radiation. We also need healthy rural lands as sources of spiritual inspiration and renewal. These services are part of our total life-support system. In summary, environmental management and protection are required not only for the sustainability of agricultural production but for our very survival and well-being.

Therefore, agriculture, as a crucial component of sustainable development, needs to blend its traditional economic goals with ecological and social objectives and principles. Maximization of product must respond to the need for preservation of our life-support system. A different approach could mean disaster. In Latin America, attempts to maximize yields as the exclusive goal are already facing severe environmental and social backlashes. Ironically, in a region where perhaps more than anywhere else lasting socioeconomic development depends upon sustainable land use, land-use mediated transformation of the landscape is the driving factor of the region's environmental degradation, from soil erosion to biodiversity loss.

As a result of our growing understanding of the human-nature bonding, societies and institutions throughout the world are evolving toward greater environmental responsibility. This is CIAT's recent experience, still in development. It is the Land Management Unit's purpose to help establish and enhance CIAT's renewal of its institutional approach toward agriculture in the tropics.

This year's report intends to stress change and cooperation in LMU. For better orientation, a fact section is offered. Tables and diagrams have been incorporated to facilitate executive reading and emphasize links. Since LMU's activities belong within common, cooperative project boundaries, accomplishments are summarized in two project-oriented activity-achievement tables. A section on LMU's approach to research on land use dynamics in tropical Latin America offers an overview of the concepts embraced by the Unit, and how are they operative and pertinent to CIAT and the sustainable agriculture endeavor. Finally, detail contributed by LMU's staff is provided in a volume bound separately.

EXECUTIVE SUMMARY

As a consequence of the rearrangements associated with CIAT's Structural Adjustment Plan, during 1996 the Land Management Scientific Resources Group became the Land Management Unit. Despite increased financial constraints and general turbulence, the Unit continued improving on its scientific, technical, and institutional capacities.

A complete summary of LMU's core project (P22) activities and achievements during the period is presented in Table I, ordered by expected outputs and activity groups. LMU sub-projects and cooperative activities within the context of other CIAT projects are summarized in Table II. Here we review the most significant progress during the period.

Activities

The rainforest-margin region of **Pucallpa (Peru)** was confirmed as LMU's **Land Use Dynamics in Latin America** (P22) project case study site. Multi-disciplinary work started by mid 1996. A survey of literature on Pucallpa was performed, rendering about 300 references. Drs. Sam Fujisaka and Erik Veneklaas visited Pucallpa, performed interviews and inventory surveys, and collected basic ecological and socioeconomic data. Socioeconomic and land-use data from Pucallpa were collected using the same methods than in Brazil (see previous report), to allow their comparison. A paper reporting land use and deforestation results at Brazil was submitted to the journal "Biodiversity and Conservation".

Development of **Latin American Map coverages** continued apace. We obtained maps of third order administrative units for each country, digitized them and adjusted them to the boundaries of the Digital Chart of the World (DCW). These now form a seamless coverage of about 11,000 units for the continent. This is available on request and will shortly be posted on the World Wide Web. Watershed coverages from the in country UNESCO studies are being digitized on contract from UNEP. These will likewise be adjusted to the DCW and made available through CIAT, UNEP and UNESCO. Collection of population data was completed, and we are in the process of obtaining poverty data in collaboration with ECLAC (Economic Commission for Latin America and the Caribbean). The most recent and geographically detailed crop distribution data were collected for the 20 mainland countries.

Dr. Manuel Winograd continued coordinating the CIAT-UNEP joint project on **environmental and sustainability indicators**. Twenty eight regional and governmental institutions were contacted for the creation of a network of users and developers of environmental and sustainability indicators. A roster of institutions was produced and specific agreements were established with five of them. A paper on the

analytical framework of environmental and sustainability indicators was prepared and presented at a regional workshop in Mexico, hosted by the project and the World Bank. A paper on the theoretical basis of indicators (Gallopín, 1996) was accepted for publication.

Besides its own projects, LMU collaborated in several other CIAT core projects. Within the context of the Bean Program's PROFRIZA project (P6), a great effort was spent in the development of an experimental approach to community based **conservation of bean germplasm** in Cajamarca, Peru. About 275 cultivars were catalogued, and the research site was GPS-surveyed in order to develop a digital elevation model (DEM), that will allow land-use and environmental-risk quantification. Collaboration with the Bean Program also extended to P7, in Ecuador and Ethiopia. There, a research on the utility of scientific recommendations in comparison to peasants' own decisions in poor and risky conditions demonstrated that peasants have developed sound processes of decision-making, which sometimes are superior to agricultural research recommendations (Fujisaka, 1996). This very significant result should guide our efforts toward more peasant-oriented research and priority-setting.

Our understanding of genetic diversity for better **conservation and use of genetic resources** (P14) continued strengthening with the use of improved GIS-supported environmental characterization techniques. These techniques allow the mapping and prediction of sites where relatives of target species or genera can be found. A paper delineating the mapping methods developed by LMU was accepted (Jones et al., 1996) and the mapping techniques were successfully applied to *Stylosanthes*, *Manihot*, and to a major pest of cassava. In addition to the climate data that currently support the techniques, further variables, such as soil features and human disturbance will be incorporated shortly.

The GIS facility performed several airborne and satellite image processing in support to CIAT's LMU, Hillsides, Tropical Lowlands and Bean programs. In particular, large-scale orthophotos and digital elevation models (DEMs) were obtained for the first time in our history. Increased technological skill allowed the processing of 55 aerial photo pairs and the production of 700 Km^2 of 5-m resolution DEMs. Satellite image processing delivered 75,000 Km^2 of actualized land cover data in record times and at very low cost.

A national level GIS of Honduras was completed. The GIS includes full cartographic coverage at a 1:500,000 scale. Linked data include censuses for agriculture (1974 and 1993) and population and housing (1974 and 1988), at the municipio level. More than 3,000,000 individual household records were processed up to aldea level (3,700 aldeas) producing the most accurate national level socioeconomic GIS in Latin America. Land cover for Honduras is actually being generated based on recent remote sensing imagery. Spatial analysis of the data will allow cross-scale modeling and generation of

rule based data reduction, for application to poverty targeting, land use change study, market analysis, and a wealth of other applications in data scarce environments.

Remote sensing work continued in the Cauca Valley looking for better ways to derive maps for land cover in hillsides areas. Although much work has been done in remote sensing on easier terrain there is a desperate need for better ways to characterize small plots on steep slopes. Drs. M. Langford and W. Bell will be publishing some early results in an upcoming issue of the International Journal of Remote Sensing.

Finally, in an attempt to provide CIAT with a greater understanding of the accuracy and costs of DEMs which are produced for use in hillside regions, a two-year project was completed. DEMs are by far the most expensive component of a GIS, and there was a need for a method to select the optimum combination of map scale, contour interval and cell resolution adequate to agreed standards. Sound empirical rules have been derived based on rigorous comparative analysis of the DEMs, for both altitude and slope variables.

New Projects

A new special project was approved by CIDA. The project addresses the "Development and application of an integrated conceptual framework for tropical agroecosystem research based on complex systems theories". The project is one of four approved projects out of eleven CGIAR projects submitted to CIDA. The project has already started.

IDB recently approved a project entitled "Targeting rural poverty and natural resource management research" with the objective of creating a decision support system for prioritizing poverty eradication efforts in Latin America.

The Land Management activities of the Ecoregional Project (funded by IDB) were initiated. Dr. Glenn G. Hyman was recruited as a Postdoctoral Fellow and initiated activities related to a land degradation survey of Latin America.

Dr. Bell recently prepared a proposal for DGIS, Netherlands for consideration under their Ecoregional Initiative entitled "Methodologies for integrating data across geographic scales in a data-rich environment: Examples from Honduras."

Institutional Relations

During the last two years, we have witnessed a permanent strengthening of our links

with the extended family of NARs and environmental institutions. A complete list of LMU's current cooperating institutions is offered at the end of this volume.

During this period, the previously formed links with UNEP (United Nations Environment Program) and the University of Guelph (Canada) continued rendering fruit. CIAT became one of a selected group of UNEP-coordinated Collaborating Centers for International Environmental Assessment, Reporting and Forecasting. A joint project with Guelph was funded by CIDA and has already started.

Links with the University of Leicester were further developed and Dr. M. Langford spent a six month leave at CIAT during the second half of 1995 and he will return for a sabbatical during the second half of 1997 to continue his work on remote sensing in areas of steep slope and small plots in Cauca.

Collaboration with the University of Birmingham, the Royal Botanic Gardens at Kew and CSIRO will be continued with the return of Mark Sawkins to further work on the mapping of *Stylosanthes* germplasm.

Four more agreements with institutions of the region were developed by the Unit and signed by CIAT. From regional to local, they include:

- *IICA (Inter-American Institute for Cooperation in Agriculture).* A Letter of Understanding for cooperation in relation to the modelling, scenario, indicator, and GIS activities of the Unit was signed by both CIAT and IICA.

- *Ministry of the Environment, Brazil.* As a follow up of former conversations, a letter from the "Secretaria de Coordenação dos Assuntos do Meio Ambiente" inviting collaboration with CIAT was received, and positively responded. The Head of the Unit was appointed as CIAT's contact person.

- *National Planning Department, Colombia.* A Letter of Agreement, followed by a Contract, were signed. Cooperation on environmental and sustainability indicators is ongoing.

- *CARDER - Corporación Autónoma de Risaralda, Colombia* (Autonomous Corporation for the Department of Risaralda). A Letter of Agreement and a Contract were signed with this subnational governmental institution. Cooperation has been completed in the area of environmental indicators.

A complete account of LMU's activities, within a project-oriented context follows in tabular format. More detail on specific activities and products can be found in the **Detail** volume of this report.

TABLE I. LMU P22 PROJECT SUMMARY

P 22 "SUSTAINABILITY AND LAND USE DYNAMICS IN LATIN AMERICA"		
PURPOSE To improve policy and decision making for sustainable land and environmental management in Latin America through the scientific analysis of land and environmental patterns, anticipated dynamics, and policy indicators.		
OUTPUT 1 **ENVIRONMENTAL OPPORTUNITIES AND CONSTRAINTS IDENTIFIED AND ASSESSED**		
ACTIVITIES	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
1.1 Diagnosing Agroecosystem Health in Priority Areas		
	• CIDA approved Special Project (in cooperation with the University of Guelph, Canada). • Canadian Research Associate recruited in August 1996.	• An extensive bibliographical survey on agroecosystem health was finished and will soon be widely available.
1.2 Performing Field Characterization of Study Sites		
Yucao (Colombian Llanos)	• Ecological characterization of gallery forests started in September 1996. • Research proposal "Assessment of environmental services and the impact of agricultural intensification in the Colombian savanna" (restricted core project) submitted to GTZ for funding.	• Although gallery forests and streams provide key ecological services (sediment buffers, wildlife habitat) and valuable resources (dry season forage and water for cattle, game, timber, fuelwood), an integrated ecological research of them had never been carried out.
Pucallpa (Peruvian Amazon)	• Data collected during June-August and November 1996.	• Data from Pucallpa will allow a comparative study with sites in Brazil. These Amazonian sites differ in time of colonization, accessibility, land policies, etcetera

1.3 Preparing Digital Ecological Maps at Different Scales (Local to Regional)		
Meta (Colombian Llanos) Characterization: • Analyze TM imagery and perform GIS analysis. • Implement GIS support for ecological characterization of Llanos. • Characterize spatial relations between agroecosystems.	• TM image (dated January 1996) analyzed for ecological characterization and spatial relations between landscape units. • TM scene geo-referenced by ground truthing with a Global Positioning System (GPS). • Land-cover map produced.	• Forests play important role in glasshouse-effect CO_2 sequestration: Their carbon content per unit area is one order of magnitude greater than for savanna grassland. • Forests cover a significant proportion (up to 20%) of the area in the study region. • Extensively managed savanna is still much more abundant than improved pastures.
Latin American Map: • Compile Latin American watershed coverage. • Compile Latin American administrative units down to third order. • Digitize potential agricultural yields and ecological factors.	• Contract from UNEP to digitize catchment boundaries from in-country studies of hydrography (initiated by UNESCO) undertaken by LMU. • Watershed coverage maps for Argentina, Bolivia, Brazil, Ecuador, Paraguay, Peru, and Mexico received. River network for each country extracted and catchment boundaries adjusted to conform with this coverage. • Administrative unit source maps from each country obtained.	• Because different base maps are used in each country, rivers and streamlines did not match between countries. Therefore a common base map (Digital Chart of the World at 1:1 000 000) used. • Maps of countries (at left) now digitized and fitted to common base map. • Fully documented administrative unit files available on request and will soon be available through the World Wide Web (WWW) from the CGIAR/Global Resource Inventory Database (GRID) of the UNEP server in Arendal, Norway.

Central America Soils and Terrain Coverage (SOTER).	• SOTER map of Central America compiled from March to July 1996, under contract for ISRIC.	• We carefully correlated all soil series to the FAO classification. Thus, this map will adequately complement the present FAO 1:5 000 000 soil map of the world.

OUTPUT 2
LAND-USE PATTERNS AND THEIR SPATIAL DISTRIBUTION CLASSIFIED, DOCUMENTED, AND CORRELATED WITH ENVIRONMENTAL AND SOCIOECONOMIC DATA

ACTIVITIES	ACCOMPLISHMENTS	HIGHLIGHTS
2.1 Characterizing and Mapping Land-Use Patterns in Hillsides, Forest Margins, and Savannas		
Brazil: Characterizing and Quantifying Land Use and Deforestation	• Data collected in Acre and Rondonia analyzed. • Landsat TM images acquired and analyzed for two contrasting regions of Brazilian Cerrados and land-use maps derived.	• Biodiversity loss due to slash-and-burn is considerable but reversible, as long as significant primary forest remains and secondary forest is allowed to regrow. This is not granted by massive conversion to pastures.
Peru:	• LandSat TM image (1993) obtained and used in analysis of deforestation rates and patterns.	• Deforestation continues at high rates in the colonies studied. Forces driving deforestation include policies related to road construction, colonization, cattle ranching, formation of large haciendas, and timber exploitation. • Factors such as terrorism and coca production in Pucallpa appear to affect land uses.

2.2 Implementing Digital Maps of Land Use, Environmental Degradation, and Poverty for Latin America		
Population Data for Natural Resource and Agricultural Development	• Discussions with ECLAC regarding their collaboration in processing poverty data for Latin America are well under way. • Population data for Mexico, Argentina, Chile, Bolivia, Ecuador, and Guyana collected. Data being organized down to third-level administrative unit.	• Latin America Data sampler being prepared to be distributed as a CDROM with GIS software included. • New collected data complement already acquired data for rest of countries.
Land Degradation Survey:	• Bibliography of land degradation in Latin America developed. • Land degradation mailing list developed. • Call for participation in survey broadcasted in November. • Land degradation survey questionnaire under development.	• Bibliography holds over 150 references. "Gray" literature was carefully screened. • Mailing list database now contains over 500 addresses for experts throughout Latin America. • LMU (Glenn Hyman) moderates Internet discussion on the use of GIS and Remote Sensing for the study of natural resource degradation. • Survey will ask experts to assess the nature of land degradation problems and their geographic extension. • The land degradation survey and maps will be the most comprehensive of their kind for Latin America.

Latin American Crop Density Mapping:	• List of contact persons developed for each Latin American country. • Most recent crop distribution data at the finest available geographic resolution collected for the 20 mainland Latin American countries.	• Over 40% of the tabular crop data have been linked to third-level administrative division maps in a vector GIS.
2.3 Performing Quantitative Analysis of Potential Sustainable Land Use for the Ecoregion		
	Presentation made at the Conference Integración Fluvial de Sur America (IFSA). Paper to be published in IFSA proceedings.	Comparing potential agricultural yields with net aboveground primary productivity suggest that, in principal, tropical and subtropical savannas and grasslands are the ecosystems with a higher comparative advantage for agriculture.

OUTPUT 3 DETERMINANTS, DYNAMICS, AND IMPACTS OF LAND USE IN LATIN AMERICA CHARACTERIZED AND STRATEGIC OPTIONS ASSESSED		
ACTIVITIES	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
3.1 Developing a Holistic Framework for Understanding Land-Use Dynamics in Latin America		
Peru	• Peruvian researcher recruited. • Bibliographic search completed.	• Internal electronic database available to all researchers on Pucallpa.
3.2 Analyzing Historical Land-Use Changes		
Peru (Pucallpa)	• Data collected added to previous information and analyzed preliminarily.	
3.3 Identifying Major Ecological and Socioeconomic Determinants of Land Use and Farmer Decision Making		
	• Analysis of dynamics of the agricultural frontier and of future land use in the Amazon and the savannas of Brazil made based on land simulation models and economic and ecological considerations.	• Identified key elements of favorable policies and technologies.
3.4 Assessing Ecological Impacts of Land Use		
Assessing Ecological Impacts of Land Conversion in Pucallpa and the Llanos	• GIS and remote sensing elements of study undertaken. • Watershed visited in August 1996. • Partial data required for modelling already available.	• Preliminary assessment of water balances will be ready by December 1996.
3.5 Developing Explanatory Simulation Models of Land-Use Dynamics		
	• Computer programmer recruited. • Simulation language "M" implemented and demonstration given to interested CIAT senior staff.	• Draft simulation modelling of farm-level land use dynamics is underway. • "M" is now fully operational, allowing users with no programming expertise to construct complex simulation models.

3.6 Identifying and Assessing Strategies and Policy Options for Sustainable Agroecosystem Management		
Continue research in scenario methodology	• A global scenario draft document produced.	• The range of qualitatively different global futures is much wider than commonly anticipated; a "conventional development scenario" is unlikely to materialize.
OUTPUT 4 **POLICY-RELEVANT ENVIRONMENTAL AND SUSTAINABILITY INDICATORS DEFINED AND REPORTED**		
ACTIVITIES	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
4.1 Promoting a Network of Regional and National Institutions that Develop or Demand Indicators		
The Network: • Define network mechanisms • Identify institutions • Produce document	• Twenty eight regional institutions and governmental offices contacted and consulted. • Roster of institutions and experts who produce / use data and indicators developed and distributed broadly (150 copies).	• Agreements with five institutions (national and regional) established. • Roster will be periodically updated. • World Wide Web homepage developed in order to promote networking and disseminate project activities.
4.2 Developing a Conceptual Framework in Consultation with the Network		
Finalizing the Conceptual Framework	• Analytical framework developed. • Framework background paper submitted to selected institutions for input.	• Analytical framework was presented at the regional workshop on "Use and Development of Environmental and Sustainability Indicators" (Mexico, February 1996).
4.3 Defining a Set of Environmental and Sustainability Indicators at Field Level		
Creating and Improving Databases through Regional Collaboration	• Assessment of environmental, social, and economic data availability at the regional level underway. • Extensive survey of existing environmental data, databases, and digital maps at the national level performed in Colombia, Venezuela, Mexico, Costa Rica, Santa Lucia (Caribbean), Chile, Argentina, Brazil, Peru, Uruguay, and Paraguay.	• At least 14 leading regional and international environmental institutions already contacted.

Research Indicator Theoretical Basis	• A paper on the theory of environmental and sustainability indicators (Gallopin 1966) was accepted for publication. • Non-numerical indicators can be as rigorous as numerical ones, and perform better in many situations. • The paper discusses the concept of situational indicators as the simplest true indicators of sustainability.	• Results presented at the International Meeting on Environmental Indicators organized by the Scientific Committee for Problems of the Environment (SCOPE). Contributions will appear in published book.
4.4 Developing Digital Maps of Environmental and Socioeconomic Indicators for Latin America		
	• Set of 100 indicators defined in consultation with regional and national institutions. • Digital maps for 85 indicators produced.	
4.5 Testing Selected Agroecosystem Indicators at Field Level		
Developing Indicators at National Level (Colombia)	• Agreement of technical cooperation signed between CIAT and Colombia's National Planning Office (DNP).	• Analytical framework for monitoring the management of natural resources and the environment in Colombia presented to the Ministry of Environment to assess its use.
Developing Indicators at Local Level (Risaralda, Colombia)	• Agreement for technical cooperation signed between CIAT and the Regional Autonomous Corporation of Risaralda (CARDER-Ministry of the Environment of Colombia).	
Investigating Soil Carbon as Indicator	• Soil samples of the Forages Program in Carimagua, the Tropical Lowlands Program in Primavera, and the cassava soil conservation project in Santander de Quilichao and Mondomo (Colombian sites) were analyzed.	• Partial, preliminary results suggest that improved pastures in savannas do not increase soil organic matter.

TABLE II. LMU COLLABORATIVE ACTIVITY SUMMARY

P5 IMPROVING BEAN PRODUCTIVITY IN LATIN AMERICA AND THE CARIBBEAN THROUGH GENE POOL DEVELOPMENT AND REGIONAL NETWORKS		
BACKGROUND	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
CIAT's Bean Program collaborates with the National Agricultural Research Systems (NARS) of the Andean region through participation in the Proyecto de Frijol para la Zona Andina (PROFRIZA). The LMU is helping with a pilot project at El Inca in Ecuador where soil erosion was thought to be a major problem. We were interested in measuring the position of runoff channels.	• Farmer interviews and farm visits used to understand land use and crop management practices. • GIS used to create land-use-by-slope database to better understand water run-off patterns.	
Within PROFRIZA and with a local NGO, the LMU is also conducting research on bean biodiversity and initiating participatory in situ conservation in the Namora area of the Cajamarca Valley of Peru.	• Orthophotos created from a series of DEMs made of the area	• Research on bean biodiversity leading to participatory in situ conservation in this area.

P 6
IMPROVING AND SUSTAINING COMMON BEAN PRODUCTIVITY IN LATIN AMERICA AND THE CARIBBEAN BY DEPLOYING IMPROVED GENE POOLS AND BY SUPPORTING REGIONAL NETWORKS IN APPLIED RESEARCH

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
Small-scale maize-and-bean farmers in the Cajamarca Valley of Peru sow a high number of mostly farmer-selected traditional bean cultivars. Diversity of cultivars is an important means for farmers to maintain food security. This diversity can also assist germplasm search for resistance to diseases, pests, and abiotic stresses.	• Great effort in 1996 spent in developing an experimental approach to community - based participatory cultivar conservation. • Initial collection of about 275 bean cultivars catalogued by photograph and number. • Some 1000 entries of farmers' seed sown in December 1995, to multiply seed, determine duplicates, and record agronomic characteristics. • Research site surveyed to develop a digital elevation model (DEM).	• Successfully multiplied seed characterized in September will be sown in December 1996 by interested farmer groups who take part in the participatory, in situ, conservation research. • Individual farmers will retain half the resulting seed. The remainder will be made available to other farmers in the community via exchanges in kind. • The DEM will illuminate and quantify land use patterns, detail areas degraded or under erosion risk, and help in the land-use planning and soil conservation efforts of our partners and local farmers.

P 7
IMPROVING AND SUSTAINING COMMON BEAN PRODUCTIVITY IN SUB-SAHARAN AFRICA BY DEPLOYING IMPROVED GENE POOLS, DEVELOPING IMPROVED CROPPING SYSTEMS, AND BY SUPPORTING REGIONAL NETWORKS IN APPLIED RESEARCH

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
Research with –among others– Ethiopia's Institute of Agricultural Research (IAR) at Nazret, and with Ecuador's Instituto Nacional de Investigaciones Agropecuarias (INIAP) conducted in 1994 and 1995 (and reported on last year) led to questioning if research is a help or hindrance to efficient farmers in high-risk systems.	• Research accomplished and a paper prepared and accepted for publication (Fujisaka, 1997).	• Some groups of resource-poor farmers in risky environments have developed sound, rational problem-solving practices. In such cases, agricultural research may lead to recommendations that are only equal to or even inferior to farmers' practices.

P 10

UTILIZATION OF TROPICAL GRASSES AND LEGUMES IN PRODUCTION SYSTEMS

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
The land-use dynamics characterization research in Pucallpa, Peru was also conducted with a goal of understanding the current dual purpose livestock systems in the area, to help research planning.	• Farmer interviews established main constraint as lack of feed resources in the dry season. • Preliminary results from Pucallpa combined and compared to similar data from Brazil. Results and methods presented in workshop.	• The project organized and held at CIAT the workshop "Taller sobre Metodologias para Investigacion en Fincas con Sistemas de Produccion Animal de Doble Proposito".

P 14

UNDERSTANDING GENETIC DIVERSITY FOR IMPROVED CONSERVATION AND USE OF GENETIC RESOURCES

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
The LM. 's involvement in mapping germplasm and biodiversity goes back to 1994, when Dr. Nick Galwey visited CIAT. We investigated the possibility of mapping the distribution of wild *Phaseolus vulgaris* (the common bean). We developed a number of useful techniques for relating germplasm and herbarium collection data to CIAT's climate database.	• Original paper delineating germplasm mapping methods (Jones et al., 1996) accepted for publication. • Mapping techniques applied to the study of *Stylosanthes* (a tropical forage legume) and *Manihot* (cassava), also to a major pest of cassava and other crops.	• GIS-supported combination of location data from germplasm / herbaria collections to CIAT's climate database for Latin America, allows predicting sites where wild relatives of valuable species are likely to be found. • Further variables such as soil characteristics and human disturbance will be incorporated in future studies. The technique holds considerable promise in identifying key areas for in situ conservation.

P 20 COMMUNITY MANAGEMENT OF WATERSHED RESOURCES IN HILLSIDE AGRICULTURE		
BACKGROUND	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
To serve as a background for the survey and fieldwork associated with area work of the Hillsides Program study in Honduras, a complete agroecological classification of the country is underway. The process requires an accurate Digital Elevation Model (DEM), a coverage of interpolated climate data related to the DEM, a coverage of soils data related to a reliable soils map, and a coverage of agricultural and population census data related to a map of administrative areas and census tracts.	• Accuracy of DEM-derived altitude and slope values evaluated. • Collaborated with Leicester Environmental Remote Sensing Unit (LERSU) to investigate implementation of land-cover mapping in the Andean tropical hillsides using satellite remotely sensed imagery.	• Established model type suitable for Hillsides Program. • Users provided with an awareness of the level of accuracy they can expect of a DEM. • Some accuracy figures now available on remote-sensing imagery.
	• GIS with extensive database created for Honduras at national level.	• A provisional interface organized where non-expert GIS users can use the information to perform simple statistics and spatial analysis operations.
	• Spot heights, contour lines, and stream lines from the Honduras 1:500 000 topographic map digitized. DEM fitted to the data. • Complete coverages of soil depth, cation exchange capacity (CEC), organic matter (OM), pH, slope, drainage, and permeability constructed. • All stations from the CIAT Climate database within 1 degree (about 110 km) of the Honduras boundary extracted. • A few critical variables from the Honduran Censo Agropecuario 1994 incorporated.	• A final classification map should be available in early 1997. • A user-friendly software package could be constructed, to enable this type of analysis to be undertaken more frequently. Meanwhile, we continue to gain experience with the technique, aiming at identifying error trapping methods. In this way we will gradually be able to supply a product with a potential for widespread use.

To date, most of the work using GIS and Remote Sensing has focussed on Honduras. We have now begun land-cover mapping in the Nicaraguan hillsides.	• A preliminary classification produced.	

LAND MANAGEMENT - CASSAVA PROGRAM COOPERATIVE SUB-PROJECT CASSAVA ENVIRONMENTAL CLASSIFICATION

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
• For many years the Agroecological Studies Unit (now LMU) produced relatively complex environmental classifications for the major CIAT commodities. One of these was initially produced for cassava in 1986. In June 1996, the Cassava Program approached the LMU to resolve a seeming discrepancy between CIAT and IITA classifications.	• With CIAT scientists' participation, a simplified environmental classification for cassava produced. • Simplified classification maps for Latin America and for Africa produced, and best cassava production estimates superimposed.	• We found that a large proportion of African cassava, but little Latin American cassava, is grown on acid soils. This points towards a rethinking of our breeding efforts in cassava: IITA might place greater emphasis on acid lands, drawing on CIAT's expertise in breeding for the Latin American acid lands.

CIAT / CIP / University of Kassel Project
DEVELOPMENT OF A GEOGRAPHIC INFORMATION SYSTEM COVERAGE FOR NATURAL RESOURCE MANAGEMENT IN THE ANDES

BACKGROUND	ACCOMPLISHMENTS	HIGHLIGHTS
The high cost of collecting soil attribute data has created a need for methods of inferring soil characteristics using available secondary data and existing theory on soil genesis, where climate plays an important part. However, because of the accidented terrain of the Andean region, markedly different climates are often found in close proximity in relatively small areas. Interpolated climate files presently available from CIAT database have a precision of only about 18 km. To resolve the full climatic range of the region, a dataset with much higher precision is needed.	• A topographical dataset obtained and being checked. Climate data will shortly be interpolated to it. • A pilot study site selected and geographic coordinates measured in the field with a Global Positioning System (GPS). • A digital terrain analysis realized to get contour lines, slope, aspect, range, profile, and plan curvature. • Land use assessed by aerial photo interpretation.	• The dataset is a DEM from the Eros Data Center at Sioux Falls with a precision of about 1 km. • The pilot study area is located in the Hillsides Program activity site in Southern Colombia's Cordillera Central. Thus, the geographic analysis will have immediate application and feedback from ongoing applied research.

COLLABORATIVE IRRI-MYANMAR PROJECT COMMUNITY-BASED NATURAL RESOURCE MANAGEMENT		
BACKGROUND	**ACCOMPLISHMENTS**	**HIGHLIGHTS**
The LMU is collaborating with IRRI to prepare this research proposal. Fieldwork and proposal preparation served to emphasize that moving form farming systems research to community-based, natural research management research implies some needed and useful modifications in research approach.	• Farmers interviewed using rapid rural appraisal approach. • Participatory research activities also undergone. • An outline of research activities proposed.	• Based on published results of fieldwork, the International Development Research Center (IDRC) approved funding for the IRRI project.

LAND MANAGEMENT UNIT FACTS

This section offers orientation on the nature and evolution of CIAT's Land Management Unit.

Historical Background

Keeping pace with this decade's integrated view of agricultural production as the interplay of human societies and the environment, CIAT launched in 1991 a new strategic plan for the 1990s, announcing a greater research effort on natural resource management and the environment. This new effort was devised to impulse the significance of CIAT's tradition in tropical germplasm development into the 21st Century.

The strategy included the creation of four new programs on Forest Margins, Hillsides, Savannas, and Land Use. The latter incorporated the former Agroecological Studies Unit (created in 1989), including CIAT's GIS facility, the leader among the CGIAR institutes. In 1994, as an outcome of a new Action Framework approved by the Board of Trustees, the Land Use Program became the Land Management Scientific Resources Group. Finally, this year, the Group turned into the Land Management Unit (LMU).

Goal of the LMU

To improve the management of land resources in tropical Latin America, so that it happens in a sustainable way, and to protect and enhance the environmental base for development.

Clients and Services

The main clients of the LMU are policy makers at the national and regional levels, as well as national-level agricultural research and development organizations (NARDs) throughout tropical Latin America. Also, the LMU actively collaborates with partner programs at CIAT and CGIAR.

Current LMU's services include, among others: GIS-supported assessment of the status and diversity of renewable natural resources (including CIAT commodities), modelling of land-use trends and impacts, prediction of outcomes from renewable natural resource policies, and development of socioeconomic and environmental indicators for the planning and monitoring of sustainable land use. Concomitantly, LMU's staff takes

active part in a number of international endeavors for the development of the theory and practice of sustainable land use.

LMU's Approach

In terms of strategic natural resources, tropical Latin America contains the world's largest species richness, tropical forest cover, and fresh water supply. At the same time, the region features one of the most rapidly changing agricultural frontiers in the planet.

While fast socioeconomic development is undoubtedly needed, the only guaranty for lasting development in tropical Latin America lies in the sound use of its natural resource base: Latin America's wealth in biological diversity. It is a cause of serious concern that most of this century's land use in tropical Latin America has led to severe losses in the region's natural capital.

Within this context, LMU intends to understand the socioeconomic and environmental determinants and impacts of land management, monitor and predict land use changes, and assess their implications for technology development and diffusion. The scales involved focus on the farm, the landscape, and the region. A few selected LMU activities (such as the tropical climate database) have a global scope. LMU shares CIAT's emphasis on tropical Latin America's savanna, hillside, and forest margin agroecosystems.

Land use results of a complex, dynamic system of linkages between humans and nature, between humans at different levels of decision and in different moments in history, and between the components of nature themselves, from genes to ecosystems. No exclusive method or disciplinary approach can deal with such complexity and transform it for good. As the Green Revolution has taught us, partial solutions, focused on arbitrary subsets of the land management complex, face serious failure in the long-term. Thus, LMU's approach privileges the interdisciplinary integration of information at different scales in time and space.

Rather than defining policy, the Unit's endeavor consists in the identification of mechanisms and entry points for effective action and policy. Within this context, five research themes (RT) and two research-support themes (RST) have been identified and devised to better serve CIAT and the world's tropical agriculture community. They are (see Diagram 1):

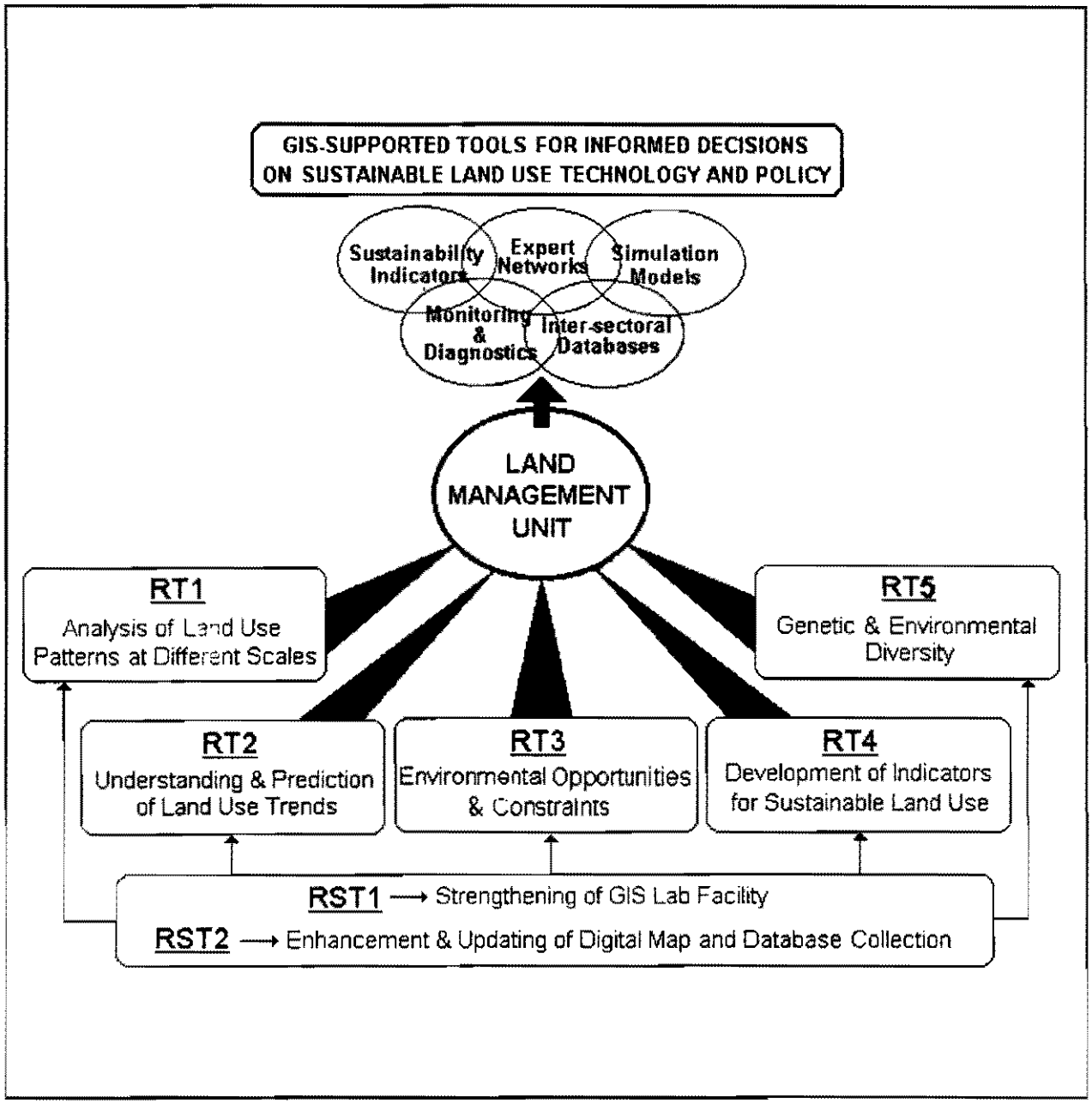

Diagram 1. LMU's Research Themes (RT), Research Support Themes (RST), and main outputs.

RT1. Analysis of existing tropical land use patterns at local, regional, continental, and global scales.

RT2. Understanding and prediction of trends in land use.

RT3. Identification of environmental opportunities and constraints.

RT4. Development of indicators of sustainable land use.

RT5. Genetic diversity and environment characterization

RST1. Strengthening of CIAT's GIS laboratory facility.

RST2. Maintenance and updating of the existing digital maps and databases.

Currently, LMU's main outputs are in the form of organized and analyzed data, as well as structured indicators and predictors, which are made available to policy makers and to the technology-generating community (such as CIAT itself), both at the national and international level.

An interdisciplinary, holistic understanding of the agricultural aspects of tropical land management cannot come out of isolated work. Thus, LMU is also actively engaged in the enhancement of collaboration with other CIAT and CGIAR initiatives, and in the development of meaningful partnerships throughout the world (see Diagram 2).

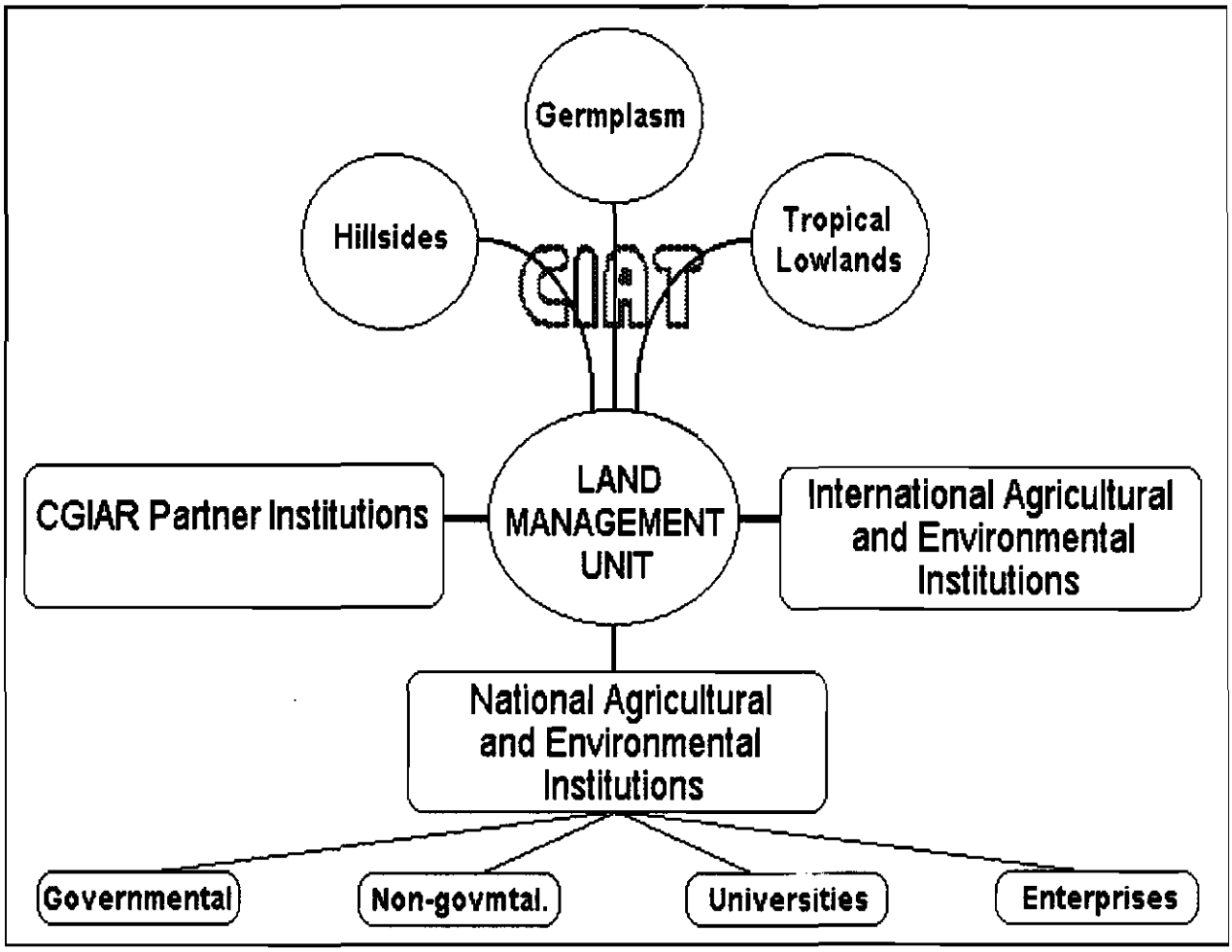

Diagram 2. LMU's cooperation universe.

Organizational Strategy

In order to accomplish its commitments and take better advantage of its resources, the LMU has adopted a five-objective organizational strategy:

1. To build upon the original capacity in spatial analysis and agricultural land use;

2. To gradually move from an emphasis on service to an emphasis in proactive cooperation both within and out of CIAT, by generating specific projects;

3. To gradually broaden LMU's original scope, integrating ecological and socio-economic approaches, as well as new tools and capacity for inter-sectoral analysis and modelling;

4. To actively search sources of external funding for the consolidation of research priorities and new projects; and

5. To develop a dynamic network with a broad scope of scientific and policy institutions (governmental, academic, NGOs) working on sustainable land use.

Achievements

Some of the most significant achievements of the Land Management Unit to date are:

1. D*efinition of CIAT's* ***priority agroecosystems***. A GIS-supported analysis of regional inter-sectoral variables was balanced against CIAT commodity priorities to help the decision.

2. *Digital coverage of Latin American* ***protected areas***. We found that montane rainforest, dry tropical forest, highlands, savannas and traditional agricultural lands have diminishing undisturbed areas; their ecosystems are under-represented within protected areas.

3. *Digital updatable map of* ***land use and resource degradation*** *in Latin America*. We are building what will probably be the most detailed and up-to-date socio-ecological map of the region; a powerful research and decision tool.

4. *Participatory proposal for the* ***sustainable use*** *of savannas*. The project proposal "Strategies for Sustainable Agricultural Land Use in the Lowland Savannas of South America" was developed with direct input from a wealth of Latin American GOs and

NGOs from Venezuela, Colombia, Brazil and Bolivia, as well as several international agricultural research institutions.

5. *Development of **rainfall prediction** models.* These models are essential for agricultural risk assessment. They have been used in Burkina Faso and interfaced to FAO's Famine Early Warning System.

6. *Development of **land quality** indicators (LQIs).* LMU joined CIMMYT, GASE (an environmental NGO), and the World Bank in the wide discussion and preparation of a methodological document and specific project proposals for the use of LQIs in tropical Latin America.

7. *World trade in **plant nutrients**.* We concluded that developing countries (particularly famine-ridden Africa) in many cases export to the developed world more major plant nutrients than they import.

8. *Location of **major crop wild relatives**.* A powerful technique developed by LMU allows the prediction of sites where genetically-rich wild relatives of major commodities can be found.

LMU'S RESEARCH STRATEGY

In order to advance CIAT's strategic commitment to natural resource research in the 1990s, at least two conditions must be met: (1) a broad, permanent discussion of views and approaches to natural resource research, and how they apply to the tropical agriculture context; and (2) a project-oriented application and evaluation of specific approaches within CIAT, which will provide specific data upon which decisions can be made, simultaneously contributing to build CIAT's expertise in this relatively new area.

In consequence, in this section we offer an overall view of the conceptual and operative strategy that organizes LMU. This strategy intends to efficiently blend our analysis of the hottest land use problems in tropical Latin America, a multi-component approach to research, and LMU's comparative advantages in terms of expertise, links and facilities. A simple diagram of the strategy identification process is offered below.

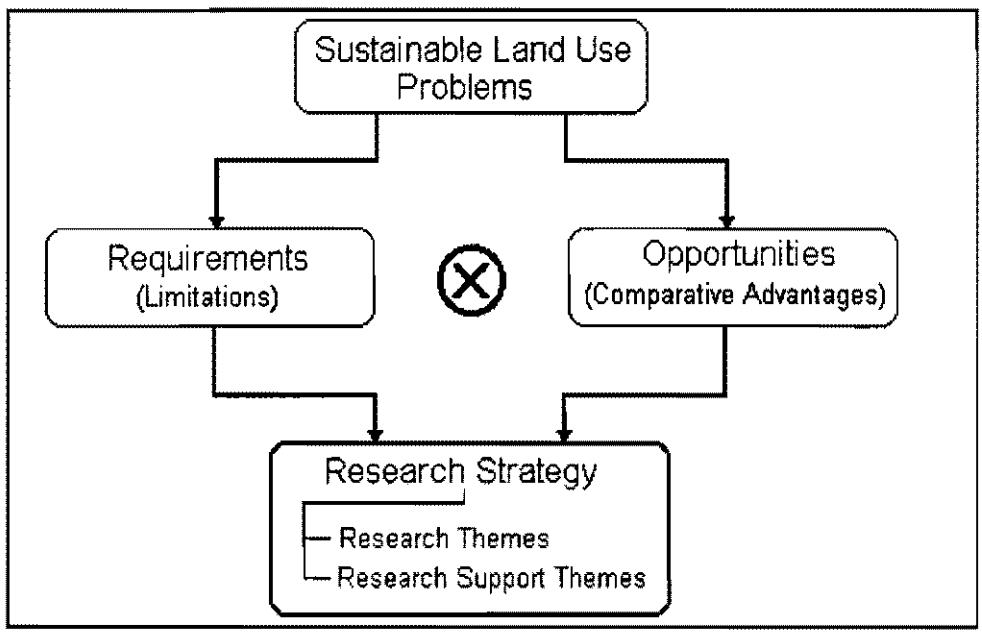

Diagram 3. Graphic representation of LMU's research strategy identification process.

The Problems

Three main groups of problems are faced for the development of guidelines for sustainable land use policy and technology in tropical Latin America. They are:

The time-horizons problem

First, rapid economic changes, structural adjustment, and other regional processes are causing a collapse in the time-horizons of the development policies in Latin America. This conspires against the careful consideration of the ecological costs of development; costs that reach their peak in the medium and long term, and often doom governmental initiatives in the region. Many of the present patterns of land use in tropical America are destroying the ecological base for development at accelerated rates, and at the same time generating gross economic inefficiencies and acute social problems, as the drug-traffic boom, the increase in rural-immigrant shanty-town gang violence, and a brand new wave of guerrilla movements demonstrate.

The scale/complexity problem

Second, the patterns of land use are influenced by many factors operating at different scales. These factors often interlink across scales in non-obvious ways. For instance, an Amazonian colonist's decision of land allocation between alternative annual crops may be simultaneously influenced by soil fertility (a site specific phenomenon), availability of labor (a local phenomenon influenced by national and regional socioeconomic processes), and the national currency exchange rate (a complex output of national and regional macroeconomic processes and policies). In the example, the three sets of factors are not only different in their spatial dimension, but also in their time dimension, from the parsimonious rates of geology to the hurried rates of modern human history. Scientists have coined the terms "complexity" and "hierarchy" to identify these multitudinous, multi-level systems.

From a different angle, while knowledge about individual factors affecting the rates, identity and consequences of land use has been accumulating, the interactions between the different **types** of factors are much less understood. Thus, in the above example, one factor (soil fertility) is mainly ecological, but human-influenced; a second one (labor) is both economic and cultural, but influenced by ecological circumstances; and the third one (exchange rate) is both politic and macroeconomical. Attempts to change some causal factors in isolation are often ineffective or, worse, they backfire.

The treatment of the interactions between different hierarchies and different-natured components in complex systems represents a difficult theoretical problem of great

practical importance. Hierarchy and complexity are essential to the understanding of the mutual interactions between the macro-level processes and the local patterns of land use, and for the identification of guidelines to articulate "top-down" and "bottom-up" policy approaches to sustainable agricultural development.

The data problem

A third major problem results from the sustainable land use endeavor: There is a scarcity of scientific data allowing the comparison of production potentials between sustainable land use and current productive practices. Lack of data also hinders the estimation of the capital needed to achieve sustainable development in the region. One major factor of data scarcity is the fact that agricultural production and yield statistics are usually provided according to political and administrative boundaries, bearing little or no relation to the ecological units determining some of the major productive opportunities and limitations. This situation seriously hampers the integration of ecological and economic considerations in the search for sustainable production systems.

On the other hand, the setting of policies for sustainable land use in tropical America requires some way of measuring, estimating and monitoring the degree to which the criterion of sustainability is being fulfilled. While some indicators of specific conditions exist, no satisfactory overall indicators of sustainable land use are yet available.

The Needs

From the above set of problems, we have extracted a set of research priority needs or requirements for the achievement of sustainable land use in the region. They impinge directly on CIAT's mission, priorities and comparative advantages. A short discussion of them follows:

First, an overall analysis of land use patterns in relation to environmental factors is necessary at a range of scales and precision. This requires building on the existing CIAT spatial databases and identifying further sources of data to enable a characterization of the region and an ability to study and map sustainability issues at several scales. Incorporating the human factor in the analysis is critical for understanding land use dynamics; hence, socioeconomic data will have to be part of the spatial databases.

Second, a systemic approach rather than an emphasis in isolated factors could greatly help to devise new kinds of interventions aimed at sustainability. Ideally, these will be based more in the simultaneous application of gentle actions along a whole causal circuit than on massive interventions upon an arbitrarily isolated factor or set of factors.

Third, evidence arising from studies on the behavior of complex systems suggests that fast and drastic structural change may happen to land use patterns, not just as a response to powerful external factors, but as a feature of the systems themselves. Then, it becomes of practical importance to know the degree to which deep structural changes can be anticipated and to recognize the factors or processes responsible for them. Situations approaching the threshold of structural changes should be treated specially, both in technological and policy terms. While well-managed structural thresholds supply opportunities of renewal and improvement, their "surprising" nature has often led to a permanent impoverishment of the affected system.

Therefore, under practical terms, one major priority is to develop, apply and test a set of multi-level indicators of sustainable land use. A holistic set is necessary, as not individual measurement can cope with the complexity of land use, its impacts, and opportunities. This requires meeting at least three conditions: (1) Different indicators must be developed within the context of a meaningful conceptual framework. Otherwise, we risk ending with a "shopping list" set of indicators, with only circumstantial relations between them. (2) Specific indicators must be developed and offered in a context immediately relevant to decision-making. In other words, they should not be purely descriptive or analytical, but they must offer insights on trends and on the impact of alternative policy scenarios. (3) We must devise efficient methods for using and combining the indicators, in order to optimize their information value. As sustainability is a systemic property rather than a property of any single component, synthetic meta-indicators will be required.

Fifth, the emphasis in decision-making within the context of complex dynamics calls for a greater development of computerized simulation models of land use. These controlled environments must have the ability to pre-test alternative policy scenarios and predict their likely outcomes. Together with the indicators, they will provide a basic but powerful set of inter-linked tools designed to inform applied policy and technology research on land use.

The Opportunities

The Unit has a strong installed capacity and a number of ongoing activities related to the identification and description of trends in land use. GIS-supported geographical databases based upon field studies are available and enhancing. At LMU, GIS analysis has already been performed both synchronically (at different places for the same date) and diachronically (comparing land use in the same area through time).

In addition to the Unit's own expertise in complex systems theory, we keep a strong working relationship with a number of major scientists and institutions involved in the

development and application of theory and methods for the understanding of hierarchical, complex dynamics, within the specific context of the sustainable management of renewable natural resources, with an emphasis in agriculture.

CIAT's history has determined an emphasis in the development of biophysical technology, with a lower emphasis in socio-economics. Consequently, LMU's professional expertise is biased toward the ecology of land use in tropical Latin America. However, the Unit combines senior and junior professionals from rather different backgrounds and disciplines, including the social sciences. Some members of the team have specific inter-disciplinary training. This will allow setting the basis of a holistic, integrated approach to the ecology and socio-economics of land use in tropical Latin America.

The Strategy

Undoubtedly, a basic priority in LMU must be the evolution of land-use research methodology. Thus, methodological development is a permanent effort. In addition, out of a balance between the problems of land use in Latin America, the priority research needs in this field, and CIAT's LMU comparative advantages, five strategic research themes and two research-support themes have been identified for the 1990s. The basic underlying logic connecting the different themes is represented in Diagram 4. A short discussion of each theme follows.

Research themes (RTs)

RT1. Analysis of existing tropical land use patterns at local, regional, continental, and global scales

This theme concentrates on the understanding of land use patterns and their relations with society and nature, in terms of impacts and opportunities for the development of sustainable land use. GIS and remote sensor information will be combined with ground data to determine processes and priorities.

Important progress to date includes: (1) a GIS-supported contribution to the definition of the priority agroecosystems for CIAT research; (2) a large scale characterization of forest margin areas in Brazil, for the selection of focal agroecosystem study sites; (3) the construction of an updatable digital map on land use and degradation in Latin America.

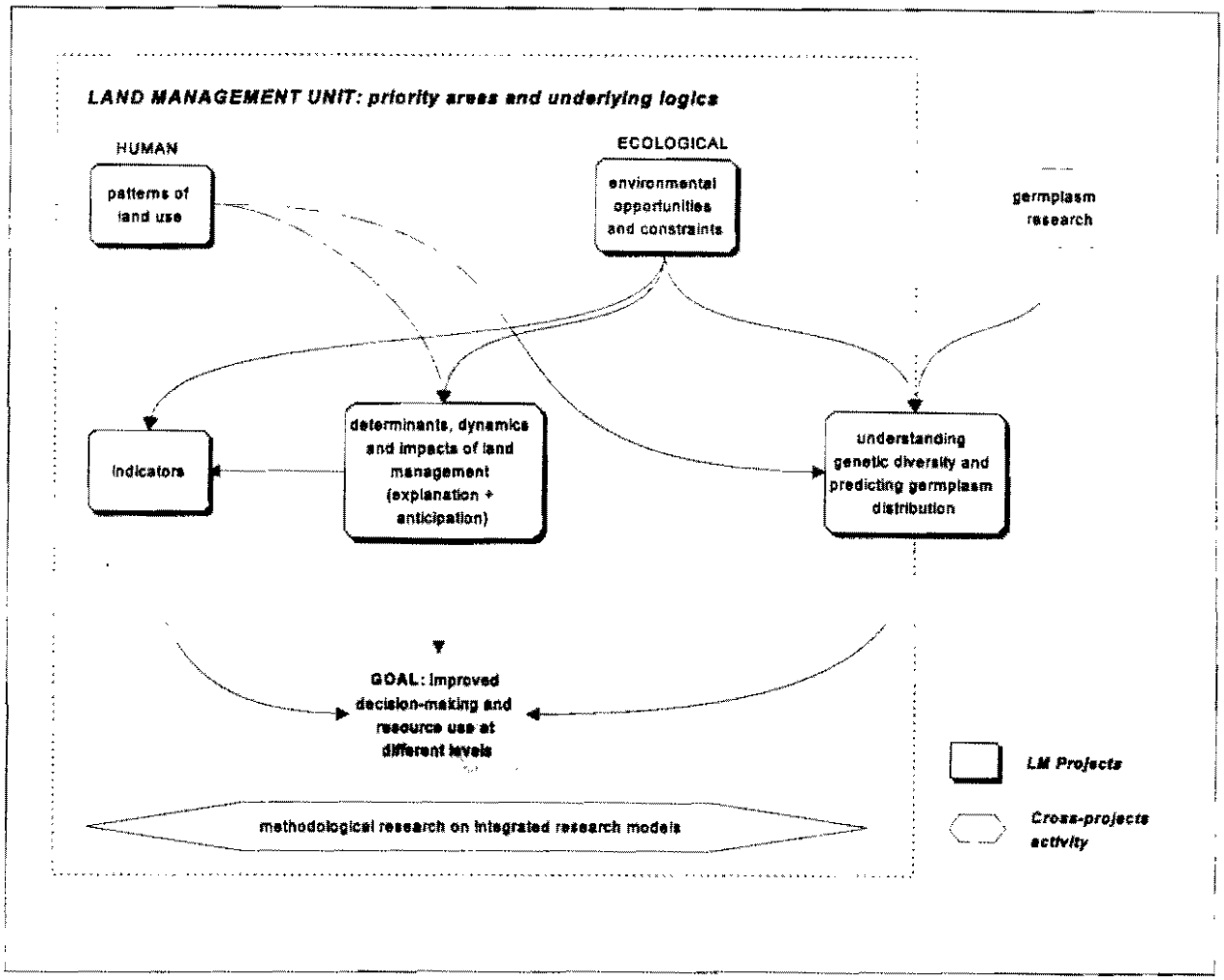

Diagram 4. Logical linkages in LMU's research themes.

RT2. Understanding and prediction of trends in land use

This theme is being pursued at different levels, from the farming system to the agroecosystem. This theme is the central issue of LMU's core project (P 22). The Unit is also contributing to this research theme through the field study of the behavior of rural producers in relation to land use and agricultural practices. Simple dynamical simulation modeling and scenario analysis of land use in Latin America and in the tropical Lowlands have been already developed by the Unit.

Important progress to date includes: (1) a diagnostic of agricultural land use in the Southwestern Brazilian Amazon; (2) the participatory development of a collaborative

project proposal for the study of sustainable strategies of land use in the lowland savannas of Latin America (Bolivia, Brazil, Colombia, and Venezuela); (3) collaboration with the Bean Program's PROFRIZA network for participatory characterization of farmer production systems in Colombia, Ecuador, Peru, Venezuela, and Bolivia.

RT3. Environmental opportunities and constraints

Agricultural land use in Latin America faces a number of environmental constraints such as acid soils, climatic constraints, steep slopes, biological hazards, etc. On the other hand, agricultural development could also benefit from the region's environmental opportunities, such as high genetic diversity, unique ecological niches for production, whole-year growing season, valuable germplasm resources, etc. This theme concentrates in identifying and assessing the major environmental opportunities and constraints in the region at different scales, as well as to identify the necessary action to restore environmental quality.

RT4. Development of indicators of sustainable land use

The Unit initiated activities in this research theme by preparing an inter-institutional background paper on Land Quality Indicators, and organizing an international Workshop at CIAT, together with the World Bank. During that workshop, an initial identification of LQI for the tropical hillsides and savannas was made. Also, LMU took part in the organization of a CIAT-wide discussion on sustainability indicators at different levels of aggregation (resulting in the identification of common interests across Programs, Units and Scientific Resources Groups). One PhD student is working at CIAT on indicators of soil sustainability for the tropical lowlands and hillsides of Latin America. Papers on the theoretical aspects of indicators have been prepared, and a Regional Project on Environmental and Sustainability Indicators for Latin America and the Caribbean has been launched with the support of UNEP. We have a continuing involvement with the World Bank as partners in the Land Quality Indicators Project (LQI).

Important progress to date includes: (1) a CIAT-wide participatory process for the definition of a research strategy on indicators of sustainable agriculture; (2) the evaluation of soil carbon as an early indicator of land degradation in the Latin American hillsides and savannas; and (3) an assessment of the world trade in major plant nutrients (N, P, K) embodied in agricultural products and inputs.

RT5. Genetic diversity and environmental characterization

Besides collaboration in projects in Resource Management Research, collaboration with projects in the Germplasm Division is also significant. Research on germplasm spatial distribution and germplasm environment mapping involves the development of specialized techniques. The coexistence in the same institution of expertise in GIS and in germplasm research gives CIAT the unique opportunity to apply advanced techniques of GIS and environmental classification to the characterization and maintenance of genetic diversity.

Important progress to date includes: (1) the environmental classification of CIAT commodities; and (2) the development of predictive methods for the identification of sites with potential as sources of wild relatives of CIAT's commodities.

Research-support themes (RSTs)

RST1. Strengthening of the GIS laboratory facility

The GIS Lab has reached a satisfactory state, being well equipped in terms of hardware and software to perform the current and planned activities. Maintaining a core of local staff adept at using these tools is paramount.

RST2. Maintenance and updating of the existing digital maps and databases

Maintenance and updating of digital maps and databases is going on. Purchase of specialized software (Splus and Neural Nets) and dedicated high-speed workstations is being planned. The possibility of local area parallel processing using machines already in the network is a tantalizing prospect.

Research Prospects

RT1 Analysis of existing tropical land use patterns at local, regional, continental, and global scales

We foresee an expansion of the current studies, to cover also the ecoregional level. This involves the accomplishment of ongoing or already approved projects and initiatives, such as (1) the production of the digital map of land use, resource degradation, poverty and ecology for Latin America; (2) the proposed cooperation with Bolivia, Brazil, Colombia, Venezuela and the Netherlands within the SSALLSSA (Strategies for the Sustainable Agricultural Land Use in the Lowland Savannas of South

America) project; (3) the possible installation at CIAT of the Dutch IMAGE 2.0 climate/land use model; and (4) the enhancement of cooperation with UNEP within the region.

RT2 Understanding and prediction of trends in land use

Four perspectives of progress relate to this research theme. First, we want to develop the Unit's capacity to build up and use GIS-supported nonlinear computer land-use simulation models with the ability to include biophysical, technological, socio-economic, and policy factors. These models should be used as tools for understanding and anticipating land use trends and for assessing possible policy options. Second, we shall deepen our exploration of the applicative value of complex systems theories to agroecosystem dynamics. Also, we shall explore the utility of the concept of agroecosystem health for agricultural research planning. Third, we shall study the role of cross-scale interactions in land use dynamics. Finally, we shall focus on the development of methodologies in land-use scenario analysis at the regional and national levels, with the expected continuing cooperation of the UNEP-GEO project.

RT3 Environmental opportunities and constraints

Analysis of existing data and performance of research specific to this theme was initiated very recently, in relation to the development of LMU's project P 22.

RT4 Development of indicators of sustainable land use

A Regional Project on sustainability indicators will foster a wide participatory network including national and regional organizations and experts. The project will also develop a regional methodological framework, enhance national and regional capacity to generate and use environmental sustainability information, catalyze exchanges between producers and users of sustainability indicators, and produce a bi-annual report on the state and progress of sustainable development in Latin America and the Caribbean. This will represent a major step forward in our endeavor. At a more theoretical level, the envisaged activities in relation to complex systems could suggest new systemic indicators of sustainable use.

RT5 Genetic diversity and environmental characterization

We will develop additional databases to include germplasm and its environment, and to develop user-friendly methods for interfacing genetic diversity and spatial information.

This particular CIAT-core prospect (but also the expressed above), leads directly to the permanent necessity of securing the funds for maintaining and documenting the progress of CIAT's GIS facility, whose healthy functioning requires significant human and financial resources.

COOPERATING PROGRAMS AND INSTITUTIONS 1995-1996

CIAT -

- Bean Program
- Cassava Program
- Hillsides Program
- Tropical Lowlands Program

ASPADERUC - Asociacion para el Desarrollo Rural de Cajamarca (Peru)

CCAD - Central American Commission on Environment and Development (Guatemala)

CARDER - Corporacion Autonoma Regional del Risaralda (Colombia)

Centre for Environmental Information and Statistics, Ministry of the Environment (Venezuela)

Colegio Verde de Villa de Leyva (NGO, Colombia)

CSIRO - Commonwealth Scientific and Industrial Research Organisation (Australia)

DNP - Departamento Nacional de Planeacion (Colombia)

ECLAC - Economic Commission for Latin America and the Caribbean

EMBRAPA - Brazilian Agricultural Research Enterprise (Brazil)

GRID-ARENDAL - Global Resource Information Database (Norway)

Hohenheim University, Stuttgart (Germany)

IAR - Institute of Agricultural Research (Ethiopia)

IGBP (International Geosphere-Biosphere Programme)/HDP(Human Dimensions of Global Environmental Change Programme) Land-use/Cover Change joint project (LUCC), and IGBP/DIS soils database.

IICA - Interamerican Institute for Agriculture Cooperation / GTZ Project (Costa Rica)

ICRAF - International Centre for Research in Agroforestry

ICRISAT - International Crops Research Institute for the Semi-Arid Tropics (India)

IDEAM - Institute of Environmental Studies, Ministry of the Environment (Colombia)

IFPRI - International Food Policy Research Institute

IGAC - Instituto Geográfico "Agustín Codazzi" (Colombia)

ILRI - International Livestock Research Institute

Instituto Italo-Latino Americano (Italy)

INEGI - National Institute of Statistics, Geography and Informatics (Mexico)

Instituto Nacional de Estadística e Informatica (Peru)

INIA - Instituto Nacional de Investigacion Agraria (Peru)

INIAP - Instituto Nacional de Investigaciones Agropecuarias (Ecuador)

INPE - Instituto Nacional de Pesquisas Espaciais (Brazil)

IDRC - International Development Research Centre (Canada)

IRRI - International Rice Research Institute (Philippines)

IIASA - International Institute for Applied Systems Analysis (Austria)

Ministerio de Bienestar Social (Ecuador)

Ministerio del Medio Ambiente (Colombia)

Ministry of the Environment and Legal Amazonia (Brazil)

Ministry of Science, Technology and the Environment (Cuba)

Myanmar Agricultural Service

UNDP/CONARE/Defensoria del Pueblo Project on Human Sustainable Development (Costa Rica)

National Institute of Ecology (Mexico)

National Geophysical Data Centre (USA)

PALMAVEN, Maracay (Venezuela)

RIVM - Dutch National Institute of Public Health and Environmental Protection (Netherlands)

Royal Botanic Gardens, Kew (England)

SEMARNAP - National Secretary on Environment, Natural Resources and Fisheries (Mexico)

TCA - Amazonian Cooperation Treaty

The World Bank

The Earth Council (Costa Rica, International NGO)

The Inter-American Group on Sustainable Development of Agriculture and the Natural Resources

TSBF - Tropical Soil Biology and Fertility Programme

UN Department for Policy Coordination and Sustainable Development (DPCSD)

UNEP - United Nations Environment Programme. Headquarters (Kenya) and Regional Office for Latin America and the Caribbean (Mexico)

United Nations University (Japan)

Universidad Catolica de Chile (Chile)

University of Birmingham (England)

University of Guelph (Canada)

University of Georgia, GIS Laboratory, Artificial Intelligence Department, Athens, Ga. (USA)

University of Kassel (Germany)

University of Leicester, Geography Department (UK)

University of Washington, Seattle (USA)

World Conservation Monitoring Centre (UK)

WRI - World Resources Institute (USA)

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