Sustainable Upland Agriculture Through the Eyes of the CIAT Hillsides Agroecological Program

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Introduction

The conceptual approach of defining agro-ecoregions for aiding priority setting by the IARC's is not new. For many years the commodity programs at CIAT defined crop improvement priorities based upon their collective knowledge ranging from photoperiod and temperature requirements to pest and disease pressure to market preference. With the organization of the Agroecological Unit at CIAT in 1983, the heuristic approach of the commodity programs was formalized and improved through digital characterization, categorization and mapping. Environmental and system variables like climate and soil properties were made explicit and were combined with "dot density" thematic maps (Fig.1) to assess the distributions of crop by constraint (Table 1 & 2). The results were state-of-the-knowledge inventories at the continental scale in the form of published crop "atlases" as well as digitized GIS coverages (CIAT, 1992).

A second strategic use of agroecological zoning by the CIAT commodity programs was to compare and contrast commodity environments. An example of this is the project defining homologous cassava regions across Africa and Brazil. (P.Jones, per. comm.).

Commodity focused agro-ecological zoning has also been used to characterize, categorize and map more desegregated geographical scales or "micro-regions". An example of this is the IDRC funded Paraguay cassava project (Carter, 1986).

CIAT's Hillside Agroecological Program

Arguably the most ambitious CIAT agro-ecological zoning project has been the characterization, categorization and mapping project that resulted in the creation of three new agro-ecoregional programs, i.e., The Hillsides (Fig.2), Forest Margins and Savannas Programs (Jones, *et al.*, 1991).

The goal of the Hillsides Program is to improve the welfare of the hillsides farming community be developing sustainable, commercially viable agricultural production systems. Income-generating activities that permit capital accumulation and agricultural intensification, while conserving soil and water resources, are the key to resolving the hillsides' environmental problems. Numerous technologies to conserve soil and water exist, but farmers seldom adopt them without policy inducements. Studies to identify instruments for policy adoption will be a necessary adjunct to technology development in the field.

TABLE 1. The 2nd Approximation of Rice Distribution in Latin America by the Season Length (Number of Consecutive Wet Months where P>1.2 PET).

CULTURAL SYSTEM						
Wet Months	Irrigated	Lowland rainfed	Mecha-nized	Traditional (Manual)	Frontier (Manual)	Total
0	187	8	6	4	4	209
1 to 3	216	16	89	48	5	374
4 to 6	956	328	1699	519	291	3793
7 to 9	788	40	1586	202	404	3020
10 to 12	546	25	160	29	44	804
Total	2693	417	3540	802	748	8200

TABLE 2. The 2nd Approximation of Rice Distribution in Latin America by Soil Restriction, based on the FAO Soil Legend.

CULTURAL SYSTEM						
Soil Restriction	Irrigated	Lowland rainfed	Mechanized	Traditional (Manual)	Frontier (Manual)	Total
None	1467	169	840	294	186	2956
Acidity	610	167	1968	293	486	3524
Physical	551	72	716	187	75	1601
Acidity and Physical	1	0	2	0	0	3
Salinity	64	9	14	28	1	116
Total	2693	417	3540	802	748	8200

Given the complexity of the socioeconomic, technical and environmental problems of the hillsides, initiatives to improve their natural resource management must be part of the overall regional development plans which consider agricultural and nonagricultural activities. This requires strong interinstitutional and intersectorial cooperation to permit accurate identification of the problems and deployment of adequate staff and other resources for their solution. Many other organizations -- especially nongovernment ones -- already have activities in the hillsides. As a result, development of appropriate models for interinstitutional collaboration to maximize impact is an important feature of the program's agenda.

The objectives of the Hillside Program are:

1. To characterize the mechanisms leading to resource degradation and asses technological options.

2. To generate agroecologically and economically viable components acceptable to farmers for soil and water conservation and management practices.

3. To strengthen the capacity of national systems to generate and transfer resource-enhancing technology.

Hillside Resource Degradation Evaluation

The most recent eco-regional characterization and mapping carried out by the newly created Land Use Program (LUP) and the Hillsides Program was an assessment of the state of degradation in the hillsides of tropical America for strategic planning purposes. The definition of hillsides was extended from the original restricted one used for the natural resource planning exercise (Appendix 1). This was necessary to give a broader overview of the problems in Central America and the andean region. All land between 800m and 2000m excluding highlands in Brazil, Chile, Argentina and the Guyana shield. And areas with less than 3 growing season months were excluded. The image of rainy months (rainfall >60mm) was calculated from the CIAT climate database. An image of soil depth was calculated from the image of dominant FAO soil units held in the database in conjunction with tables of soil properties developed by the LUP. The levels of degradation were estimated from the 'World Map on the Status of Human-Induced Soil Degradation' UNEP/ISRIC 1990. This map was digitized and transposed to geographic coordinates. Images of the various types of degradation were formed. These were analyzed to extract and tabulate the areas involved in water, wind and chemical degradation at various levels of severity. Also extracted were the base causes of the degradation and the rates of degradation in the recent past.

Of the 92,000,000ha mapped as hillsides in this study, water erosion was by far the most important effect. Very small areas of wind erosion or chemical deterioration were noted. Moderate water erosion which strongly reduces agricultural productivity but which can be corrected at the farm level was found to occur in 14,000,000ha. Strong water erosion unreclaimable at the farm level accounted for 11,600,000ha. Together some 26 percent of the total area was subject to serious erosion.

The main causes were equally deforestation, overgrazing and agricultural activity.

Hierarchal Agro-ecosystem Analysis

The evolution of the agro-ecological work carried out by the original Agro-ecological Support Unit and the newly created Land Use Program was driven by internal CIAT demand for decision support information. Recently, however, CIAT, and particularly the Hillsides and LUP have begun to organize some of their information requirements based upon hierarchal ecological systems theory which hypothesizes that natural systems are organized hierarchally in which sub-systems are coupled or linked by asynchronous rate processes (Fig.3). The practical consequence is that lower level processes determine the potential of higher level systems while higher level processes constrain lower level system behavior (Levin, 1992, Bradley, 1991, Müller, 1992).

Our particular interest in hierarchially systems theory evolved from years of observations that, when carrying out commodity constraints on-farm research, we could often demonstrate significant production responses at the plot level, and yet farmers did not adopt the component technologies. One of the reasons is now well known. Farmers are responsible for making decisions at a "higher" system level, the farm level. In simple hierarchal system theory terms, what happens at the "plot" level has an almost immediate impact on a farmer's potential income. However, at the farm-system level, there are multiple objectives for land, labor and capital which may "constrain" or limit the adoption of production-increasing technologies. It may be that after observing the apparent success of a few "innovative" farmer-neighbors, the innovation is tested and adopted. If there is widespread adoption, the farm system may actually shift to a new state or land utilization type (LUT)[1]. The above observation has now become common knowledge although its formalization through hierarchal theory remains to be done.

[1] A LUT is a type of land use defined in greater detail than that of land use (FAO, 1976). A LUT consists of a given physical, economic and social setting, e.g., including assumptions on market orientation, capital and labor intensity, technical knowledge and attitude, land tenure and income.

For the CIAT Hillsides and Land Use Programs, the conceptual extension of hierarchal systems theory to higher agrosystems seems intuitively obvious. Specifically, individual farms are components of a system that can be characterized as a "land utilization type". A hillside watershed of 100,000ha may be made up of several component LUT's. And higher level sub-systems can be defined on up to and including CIAT's definition of "Hillsides" which is itself a subsystem of a Latin American agro-ecosystem. The question is, "Where does all this lead with respect to our understanding of sustainable resource management?"

The simple answer is that concomitant with a hierarchy of geographic scale is a hierarchy of multiple decision-makers and by implication, a hierarchy of multiple-objectives and information needs. For example, crop management requires information at the individual plot scale while watershed managers are generally satisfied with information about stream quality and flow for catchments of at least 100000ha in area. Credit lenders work within guidelines that may best be characterized by land utilization type while national policy decisions require information at a much more aggregated scale. The point is that the information must be internally consistent, albeit of greatly varying detail. For example, detailed studies of erosion losses at the standard Wischmeier (1959) field plot scale of 22m by 11m may indicate potential losses of up to 100$tha^{-1}yr^{-1}$ but it is naive to extrapolate those results to estimate the social costs and consequences of sedimentation mobilization and transport at the scale of watersheds of even a few tens of hectares. With no wish to diminish the importance of the social costs of erosion, it is possible that as little as 5-10% of the mobilized sediment actually leaves the system as suspended sediment (Jenny, 1980).

A much more challenging, and potentially much more rewarding application of the concepts of hierarchal systems theory is to test hypotheses relating to the processes that couple or link the different levels of subsystems and actually *form* and *define* the behavior of the system. In the specific case of CIAT, a long-running, commodity oriented soil conservation project carried out by the University of Hohenheim and the CIAT Cassava Program has resulted in greater understanding of the relative rates of soil loss by water erosion under different small scale cassava management strategies (Reining, 1992). This knowledge in and of itself is useful, and some general projections about the sustainability of the different cassava production technologies can be proposed. On the other hand, in the watershed study area, which is in the northern part of the Department of Cauca in southwest Colombia, cassava covers about 2.5% of the non-forested area (UMATA, 1992) which is not to suggest that it is not of vital socio-economic importance. The point is that the sustainability of cassava as a component in the land use system may have less to do with loss of productivity of cassava plots due to erosion and more to do with the quantity and quality of the water resource available for cassava starch production not to mention for domestic needs. The water resource issue, which may eventually determine the "sustainability" of cassava production, can only be understood at the higher level of the catchment system, which in the case of the Hillside agro-ecosystem, is characterized by its heterogeneity of land use.

Watershed Systems and Sustainability

Water is arguably the dominate factor in agricultural production which, by that fact alone, would make it a resource of utmost social importance. Water, however, has multiple and often times conflicting uses. The CIAT Hillsides Program works closely with a local regional government organization, Corporación Autónoma Regional del Cauca (CVC), which is responsible for hydroelectric generation, natural resource management, and technical assistance to the agricultural sector among other things. Table 3 is data from CVC which clearly show the relationships between conflicting uses for water for the geographic region around CIAT. Also notable is the dependence, particularly for domestic use, upon surface water which is generally more susceptible to contamination by land misuse.

TABLE 3. ACTUAL WATER USE IN THE JURISDICTION OF C.V.C.

USE	SURFACE WATER	GROUND WATER	TOTAL
	--------------- liters	per	second ----------------
Irrigation	147661	100825	248486
Industrial	4943	9082	14025
Domestic	11755	4391	16146
Energy generation	150986		150986
Other	6527		6527
TOTAL	321872	11498	436170

The geographical limits of watershed drainage systems vary tremendously in Latin America from as little as a hectare to as much as the Amazon system which drains half the continent. The CIAT Hillsides Program has selected as a primary research site, the 106,000ha Río Ovejas watershed in southwest Colombia (Fig.4).

The Río Ovejas watershed is typical of many hillside agroecosystems in the Andes. Primary environmental characteristics include steep topography, microclimate variability and ecological complexity. Secondary environmental characteristics include microclimatic "niches" high in biodiversity and environmental risk. Socio-economic characteristics include low resilience; poor physical accessibility and transportation, decentralized economies prone to marginalization but at the same time, rich prospects for use of ecological "niches". Culturally, the inhabitants are sensitive to ecological variations and they have a good functional knowledge of local environments. The population density of the watershed is estimated at 48peoplekm^{-2}.

The Río Ovejas currently drains into the Río Cauca which helped form one of the most productive interandean valleys throughout the Andes. In 1990 a plan was accepted by CVC to divert the Río Ovejas, at a cost of US$25M, so that it would flow into a reservoir used for hydroelectric generation. At the same time, another regional government organization has developed a small irrigation district for fifteen small farmers in the region with prospects for constructing more systems which has the potential of greatly increasing the productivity of some of the watershed. No one seems to have noted the fact that water transpired by irrigated crops will not be available to generate hydroelectric power.

Vegetation management is the key to understanding and managing the hydrological cycle at any watershed level. Temporal and spatial organization, however, is more important than the relative proportion of the vegetative components of the system. This is simply a way of saying that a watershed is more than the sum of its individual parts; it is an agro-ecosystem. Unfortunately a lingering and legitimate criticism of the "agroecosystems" approach to research is that it promotes examination of "all" interrelated properties with the result that it delays practical solutions to problems, and that the solutions proposed are too complex to be adopted. The CIAT Hillsides Agro-ecosystem Program hopes to avoid those pitfalls by improving and expanding farmer participatory research on environmentally friendly agriculture and sustainable resource use.

Farmer Participation in Resource Management Research

An issue specifically addressed by the CIAT Hillsides Program is how to improve the adoption by farmers of conservation practices via the development of participatory R & D approaches. One study for which we have results was the assessment of the acceptability to farmers of conservation technologies already available and promoted by local NGO's.

It is axiomatic that environmental degradation is a serious problem wherever rural poverty, population growth, and land degradation together lead to further impoverishment of environment and society in a familiar vicious circle (Blaikie and Brookfield, 1987). When the private benefits of conservation practices are too delayed or minimal for farmers' to adopt them, because poverty imposes a short-term horizon on farmer-decision making, then environmental degradation results in the long-term.

The range of technological options for improved land management available to the extension worker and to the farmer is very wide: from reforestation through agroforestry, to contour earth structures, grass strips, contour cultivation, ground covers and a wide range of combinations of these practices. Yet, in many situations, usually the most critical in terms of degree of degradation, these 'established' practices are **not being adopted by resource-poor** farmers. A number of other experiences described in the literature (Bellows, 1992; Rist, 1991; Ashby, 1985; Barbier, 1990; Barrow, 1991; Fujisaka, 1989; Moldenhauer, 1988; Napier et al 1991; Rivera and Gomez, 1992; Fujisaka, 1991) show that key elements of success in promoting adoption of conservation practices among resource-poor farmers include: (a) farmer-to-farmer transfer of information about practices; (b) technology thoroughly evaluated by and adapted to local conditions with farmers (without this, farmer-to-farmer transfer cannot be achieved); (c) local participation in the design of recommendations, transfer strategies, subsidies and regulatory controls; (d) creation of a new opportunity, or reinforcement of an existing opportunity to invest in improving production, income, labor-use, livelihood security or some other objective important locally, via the use of the conservation practices in question; (e) attention to, and if necessary, intervention in marketing, in particular farm-gate prices, or policy which affects these, which may vitally assist or impede the investment strategy referred to in (d) above (Laing & Ashby, 1993).

One reason for lack of adoption may be that technical recommendations for soil conservation have been designed to maximize conservation, resulting in additional costs to farmers without a positive cost-benefit ratio. One way to improve adoption might be therefore, to adapt existing techniques to achieve a trade-off acceptable to farmers (ie. less than maximum achievable conservation but greater utility to farmers).

This study was carried out to test the hypothesis that participatory research methods, designed for germplasm evaluation and now being widely disseminated for that purpose, can be applied to the evaluation of soil conservation techniques to help identify farmers' decision-making criteria for acceptable "trade-offs". Specifically the study addressed the question of whether using participatory evaluations by farmers, adjustments could be made to recommended techniques for soil conservation live barriers, which would increase their adoption.

Study site

This study was carried out in the Rio Ovejas watershed in Cauca, Colombia where for ten years or more, the natural resource management GO (CVC) and the Coffee Federation have recommended Cassava growers to plant live barriers incorporating "citronella" (Cymbopogon nandus) and "limoncillo" (Cymbopogon citrutus). A survey of the entire population of farmers who could be identified as users of this technique in three principal municipios of the watershed where cassava is an important crop was carried out in 1991. The survey identified twenty-two farmers using live barriers, and showed that in all except 2 cases, use was associated with receipt of credit and/or technical assistance with this requirement. Virtually no spontaneous adoption of live barriers was occurring (ie. no barriers planted without associated credit or extension assistance requirements).

Methods

Extension agents of the CVC were trained in methods of participatory evaluation, with their agreement to suspend recommendations and to allow farmers flexibility in determining whether and how to establish live contour barriers. The method of preference ranking was utilized to obtain an acceptability score for ranking a number of optional materials, in addition to "*limoncillo*" and "*citronella*", which were being tested in an on-farm trial in Mondomo by the CIAT cassava program, for incorporation into live barriers. Farmers to participate in the evaluations were initially selected by local agricultural research committees (CIAL) as individuals potentially interested in improved soil management practices. After the first round of evaluations by these farmers, participants were volunteers. Farmers were taken to the on-farm trial where preference ranking of materials was conducted, after they had spent time examining the trial and discussing the characteristics of the optional materials with information supplied by extension agents taking part in the interviews. Farmers had the option to select one or more materials for experimentation on their own farm, and to determine the location, spacing and extent of their experimental barrier.

After the first round of evaluations, materials for live barriers were sold to farmers at cost, with the agreement that they would give other farmers seed planting material if requested, for a period of one year. Follow-up visits were conducted by extension agents to observe establishment of barriers and to conduct a second evaluation interview; whether or not farmers extended barriers voluntarily, and whether a farmer had supplied seed material to others was determined. Spontaneous adoption was monitored by following up farmers who were planting live barriers at the recommendation of participants in the evaluation interviews. A total of 75 farmers were interviewed.

Results

The first round of evaluation interviews produced a preference ranking of materials shown in Table 4. Although Vetevier grass is technically the best option in terms of soil erosion control, it was ranked in last place by farmers, who preferred a cut-and-carry forage grass "pasto Telembi" (*Axonopus scoparius* var. Telembi) for incorporation into live barriers. Interviews showed that farmers' criteria for accepting live contour barriers were primarily related to the short-term utility they could obtain from materials included in the contour barriers; to the rapidity with which plants in barriers established, the more rapid the better; and to the degree of competition with the associated crop. Farmers also observed that barriers helped to retain soil moisture. Furthermore, farmers chose to locate conservation barriers in relatively good soil, as opposed to poor, degraded soils.

The area in meters planted by farmers in 1992-3 shown in Table 4 includes the 75 farmers interviewed, and an additional 46 farmers who are experimenting with live barriers as a result of the participatory evaluations. The ranking of materials with respect to meters planted is similar to that obtained from the preference ranking interviews, showing that this technique provides a reliable picture of farmers' decision-making.

Follow-up of the 75 farmers interviewed showed, as summarized in Table 5, that 39% had decided in 1993 to repeat the practice in another plot. An additional 29 farmers had implemented the practice as a result of a recommendation by another farmer, independent of contact with extension agents. The follow-up identified another 21 farmers planting live barriers on their own initiative, without extension contact or a recommendation from farmers participating in the interviews.

In summary, a process of spontaneous adoption appears to have begun. Credit programs requiring live barriers also increased their activities in the same period, and the number of farmers planting these with credit increased to 42 in the same period. Thus the number of farmers adopting the practice without credit incentives (N= 75) exceeds the number adopting with a credit incentive.

Conclusions

Results to date show that participatory evaluations of soil conservation techniques can be a powerful tool for improving rates of spontaneous adoption, if farmers' criteria for acceptability of optional techniques are taken into consideration. In this study, a forage grass was found to be acceptable to farmers who were uninterested in materials previously recommended for live barriers. Once this material was made available, the number of users increased from 22 to 121, a five-fold increase, in three planting seasons, including 75 farmers adopting spontaneously without direct intervention by extension agents. This result suggest that there may be significant, unrealized potential in the existing array of technologies for conservation which meet with little success in terms of farmer adoption, a potential which could be "unlocked" by involving farmers in research to identify acceptable adaptations.

TABLE 4. Ranking of optional materials for incorporation into live soil conservation barriers and area sown by farmers, 1992-3, Cauca, Colombia.

Material	Acceptability Score (1992)	Area planted 1992-3 (meters)
Pasto Telembi	93	37,865
Sugar Cane	67	9090
Citronella	51	1920
Pineapple	40	1060
King grass	20	0
Limoncillo	23	1600
Vetevier	6	600

TABLE 5. Spontaneous adoption on live barriers 1992-3 by farmers, independent of extension intervention.

Farmers planting barriers:	N	%
■ repeating practice in another plot	29	39
■ via farmers recommendation	29	39
■ via independent initiative	17	22
Total	75	100

Development of Multiple Stakeholder, Community-Based Organizations

The concept of hierarchal ecological systems theory developed with a strong biophysical bias. Likewise, definitions of "sustainability" for agriculture typically focus on the biophysical dimensions of productivity and resource conservation, while the human dimension is captured in economic terms, such as the concern for intergenerational equity (Harrington, 1992). Reflections on the "usefulness" of the concept can be found that completely overlook the organizational implications (eg. Dixon and Fallon, 1989) although others recognize that the sustainability concept involves reorganization of social institutions, and that institutional innovations are the key to solving the problem of overuse of common property resources (Lynam and Herdt, 1989). It would seem that if natural systems are organized hierarchally, to solve problems that cross natural scales might most effectively be addressed by an organization of stakeholders or decision makers that paralleled the natural organizational structure.

As an example, one of the major issues is the organizational requirements for research which involves a search for alternatives to increased use of agrochemical inputs. As Lynam and Herdt (1989) point out, the demands on research capacity will necessarily be larger than in the past, because sustainable alternative technologies are "environmentally sensitive and require in-situ adjustment". Nowhere is the requirement for micro-level, in-situ adjustment of technology more exacting than in the hillside agroecosystem, characterized by great edaphoclimatic and sociocultural diversity.

Increasing the demand for adaptive research capacity to meet a sustainable agriculture research agenda, at the same time that international and national systems are radically "down-sizing", implies a need for fundamental reorganization of research to meet this demand.

Innovative approaches to organizing for sustainable agriculture are likely to require attention to features of sustainable systems that are recognized with respect to the biosystem, and which can be translated into organizational terms. For example, system diversity needs to be improved in terms of the types of organizations that are brought together in a "system" for adaptive research. Improved energy cycling, in terms of the efficient use of human skills, and more rapid flows of information which regulate feedback mechanism within and among diverse institutions, are all likely to be features of "sustainable" institutional systems. "Capacity for response" in organizational terms implies improved capacity to innovate and to incorporate change. Traditional agricultural research systems in the public sector are seldom characterized by internal diversity, efficient use of human resources, rapid information flows or ready incorporation of new ideas. Improving the capacity of research to deliver sustainable technological innovations will require the development of new ways of organizing around these basic principles.

Moreover, the adoption of "alternative" technologies is likely to require organizational transformations at the interface between research systems and users. Conservation technologies, especially in the context of hillside watershed management, may generate positive benefits (such as improvements in the quantity and quality of water) which elude individual farmers but may be captured through collective organization. An example is an IPM system which requires coordinated action by groups of farmers to achieve effective pest control, economically attractive for the individual.

This study is an attempt to identify strategic principles of organizing for sustainable agriculture, from a case study based on action research with a group of institutions in the Rio Ovejas watershed, in Cauca Department, Colombia.

Methodological approach

The case study involves monitoring the process of institutional changes, and the relationship between such changes and the transformation of resource management in a pilot micro-catchment area, the Rio Cabuyal, selected by the institutions concerned. The micro-catchment area covers approximately 3000 ha, where an estimated 1000 families, mostly small farmers reside.

The process of institutional innovation being implemented, aims to incorporate some of the principles referred to above. For example, increasing the diversity of functional linkages among institutions; introducing mechanisms for changing the characteristics of information flow among different points in the institutional "system"; introducing new ways of bringing complementary resources together to perform tasks around commonly defined objectives. Integral to the approach is the introduction of institutionalized mechanisms for participation of community-based organizations, in planning and implementing adaptive research.

Activities and progress to date

A workshop held in 1992 of the more than 50 organizations with programs in Río Ovejas, led to the organization of a local consortium "CIPASLA" (Consorcio Interinstitucional para Agriculture Sostenible en Laderas). In March 1993 a planning workshop was conducted, in which key institutions, including NGO's, GO's and community leaders, identified common objectives and joint projects to achieve these. An organizational framework was developed with an interinstitutional steering committee, a coordinator to manage projects, and a committee representing community organizations. The consortium began to implement joint projects in August 1993.

Monitoring of the organizational process shows that new roles and functions have been developed as a result. This in turn is related to new, horizontal (as opposed to top-down) information flows, among different types of institutions, and between farmers, their organizations and other institutions. One effect of these has been to generate changes in the value system so that conservation practices are being tried which are beneficial to the group, even if costly for the individual. CIPASLA initiated an active search for information to permit its members to define a common strategy for investment which links incentives for improved resource management with joint projects in a coherent fashion, in November, 1993.

A rapid participatory diagnosis was carried out after training staff of CIPASLA institutions in this method, in twenty-one communities in the CIPASLA pilot area, the microcatchment Cabuyal. The results showed that inhabitants in the lower watershed communities, where soils are severely degraded and water is scarce, prioritized natural resource degradation problems in the diagnosis. In contrast, upper watershed communities where ecologically damaging slash-and-burn agriculture is still practiced, prioritized problems in health and education above natural resource degradation. The results were utilized by CIPASLA to promote dialogue between the upper and lower watershed communities, with the result that farmer-to-farmer transfer of available conservation practices is being initiated in the upper watershed by farmers from the lower watershed.

Future research will identify methods to monitor both in quantitative and qualitative terms, the evolution of this organizational model and its impact on the acceptance of conservation practices in the study area.

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APPENDIX 1.

Well watered mid altitude hillsides. Classes 17 and 20

There are the following:

Laderas Cattle Coffee	Poor Soil	3.02 Mha
Laderas Cattle Coffee	Good Soil	3.52 Mha
High Grazing Shift. Cult.	Poor Soil	7.01 Mha
High Grazing Shift. Cult.	Good Soil	2.90 Mha
	Total	15.43

There are found throughout Central America the Caribbean and the Andes. The cluster also includes areas from Classes 14 and 23 which were not analyzed in this study but are judged to be similar.

Even at this level of classification these areas are highly heterogeneous. Natural vegetation is mostly seasonal forest although in some cases humid or pre-montane forest. A small proportion, about 10%, of this remains.

Access is generally good but is least in the shifting cultivation poor soil areas. Population is highest in the coffee areas and quite low in the non coffee poor soil region. Land distribution is uniformly skewed with approximately 80% of the farmers holding roughly 20% of the land. Isolation is generally low to moderate although poor mountain roads give long travel times in some areas.

Perennial crops account for up to 30% of the area, even in the better non coffee areas. Annual crops, beans, maize, cassava, etc. are grown on 5% to 20% and between 20% to 60% of the land is in pastures.

Bush fallow accounts for the remaining lands and may be from 10% to 30% depending on the area.

Approximately 50% of the area can be classed as rolling with up to 40-50% steep nevertheless there is generally about 10% of the area which is flat.

Problems

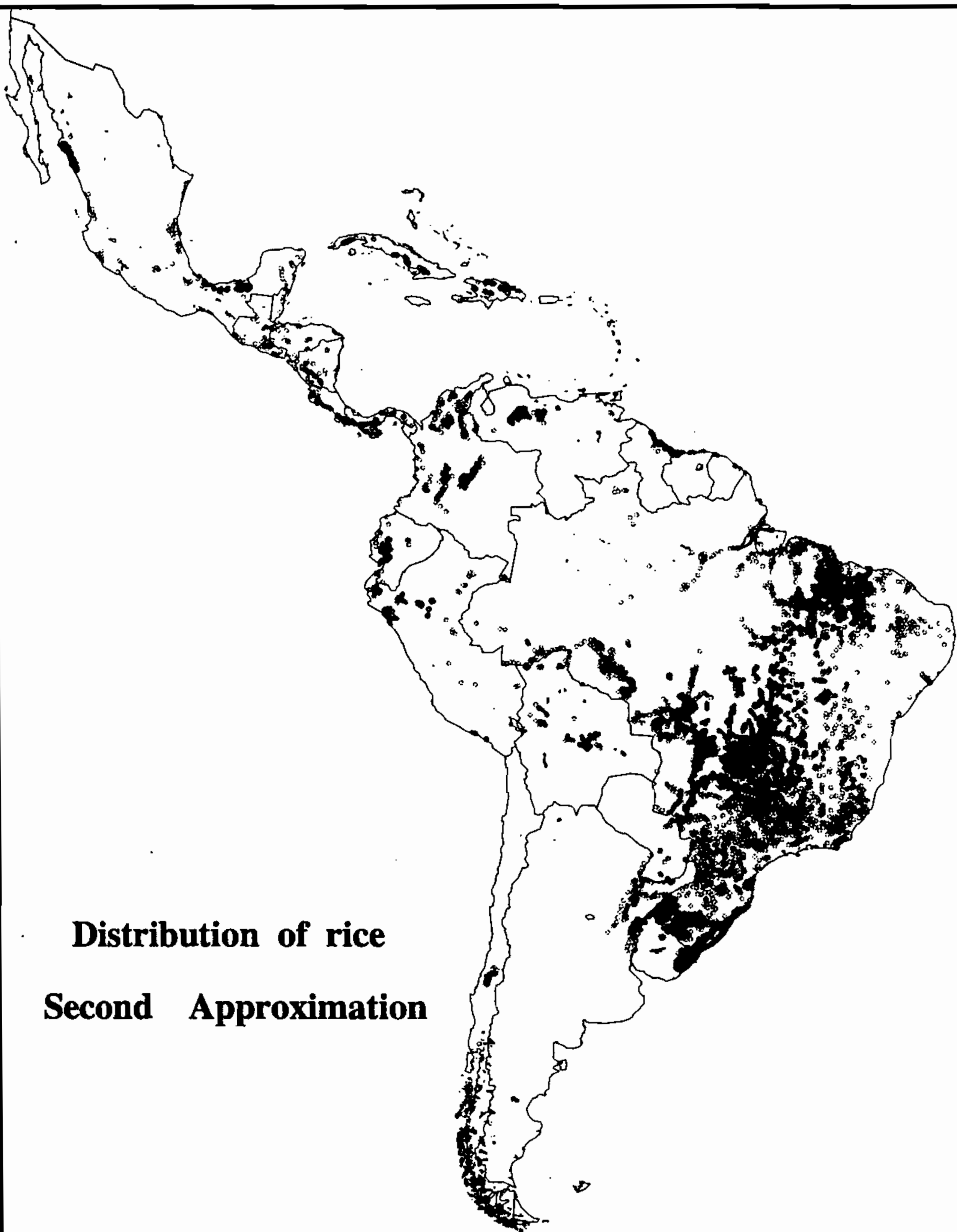
1. Erosion is a serious problem almost everywhere due to:

   a) Overgrazing on steep pastures
   b) Fire fallow clearance
   c) Poorly managed cultivation
   d) In some case poorly managed coffee

2. Pesticide overuse is prevalent in the coffee crop.

3. Although most of the remaining forest is on steep lands, there is still pressure for felling.

4. Coffee washings are a frequent pollutant of streams and rivers.



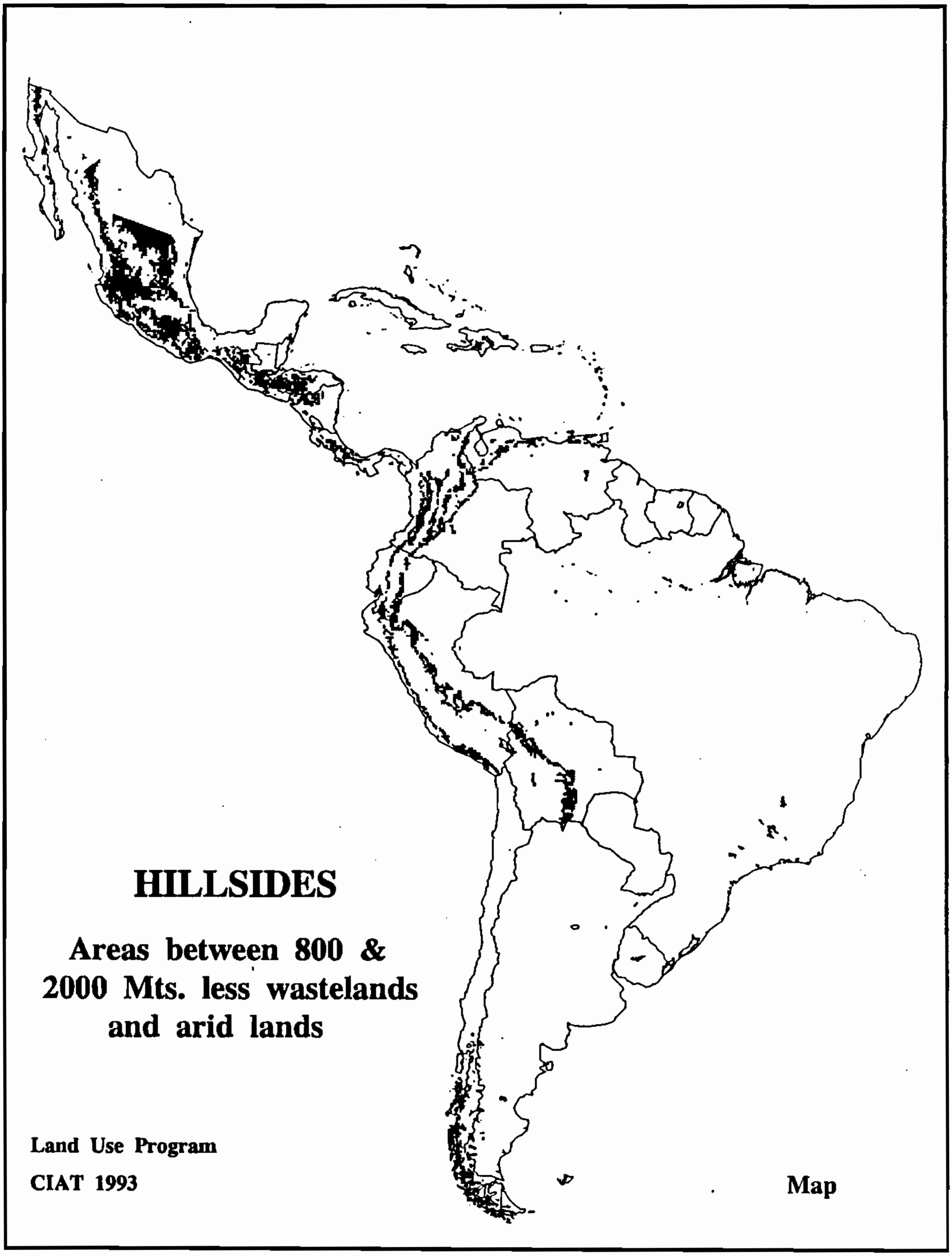
Distribution of rice

Second Approximation

Land Use Program

CIAT 1993

Map



HILLSIDES
Areas between 800 & 2000 Mts. less wastelands and arid lands
Land Use Program
CIAT 1993
Map

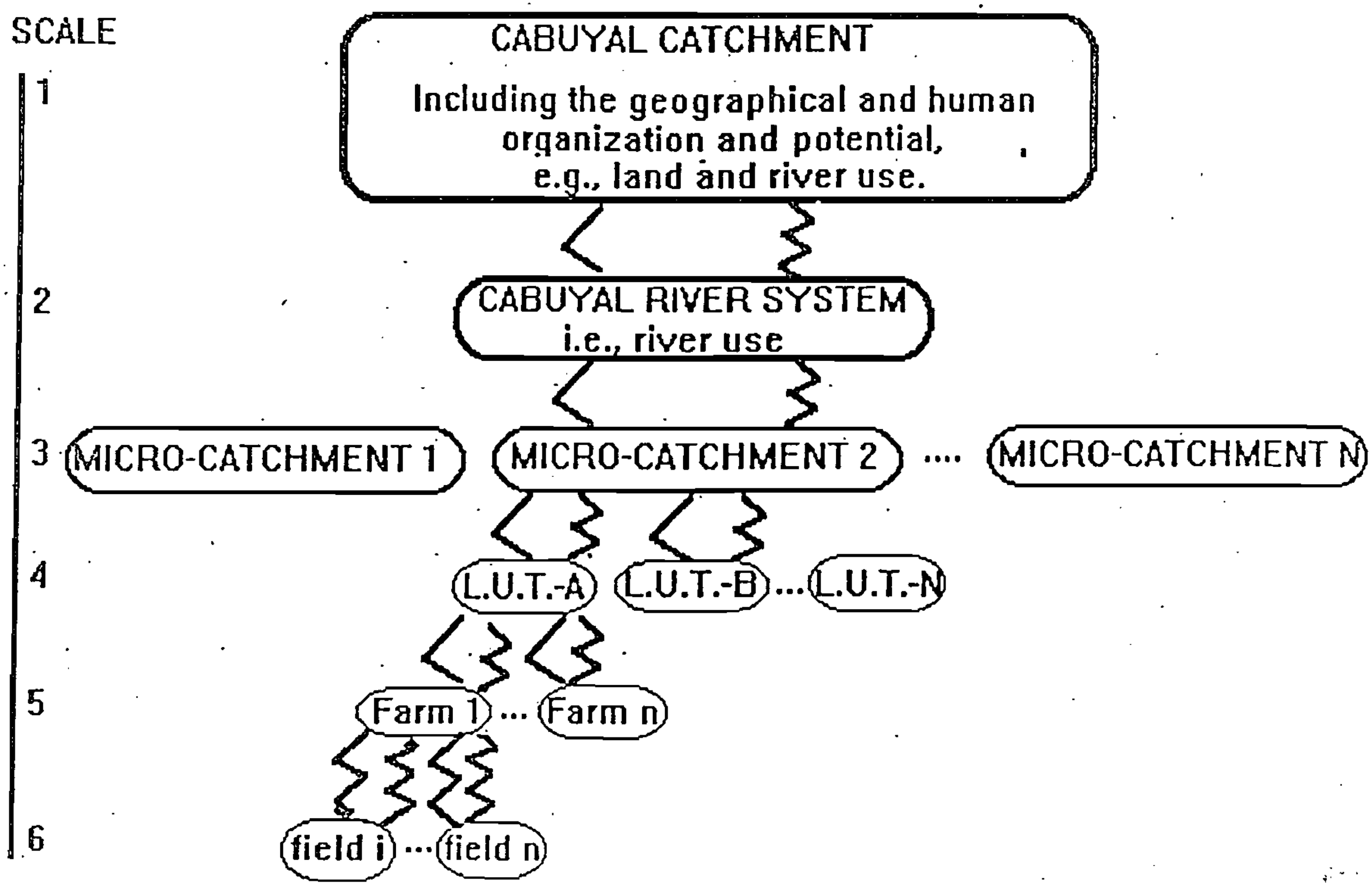
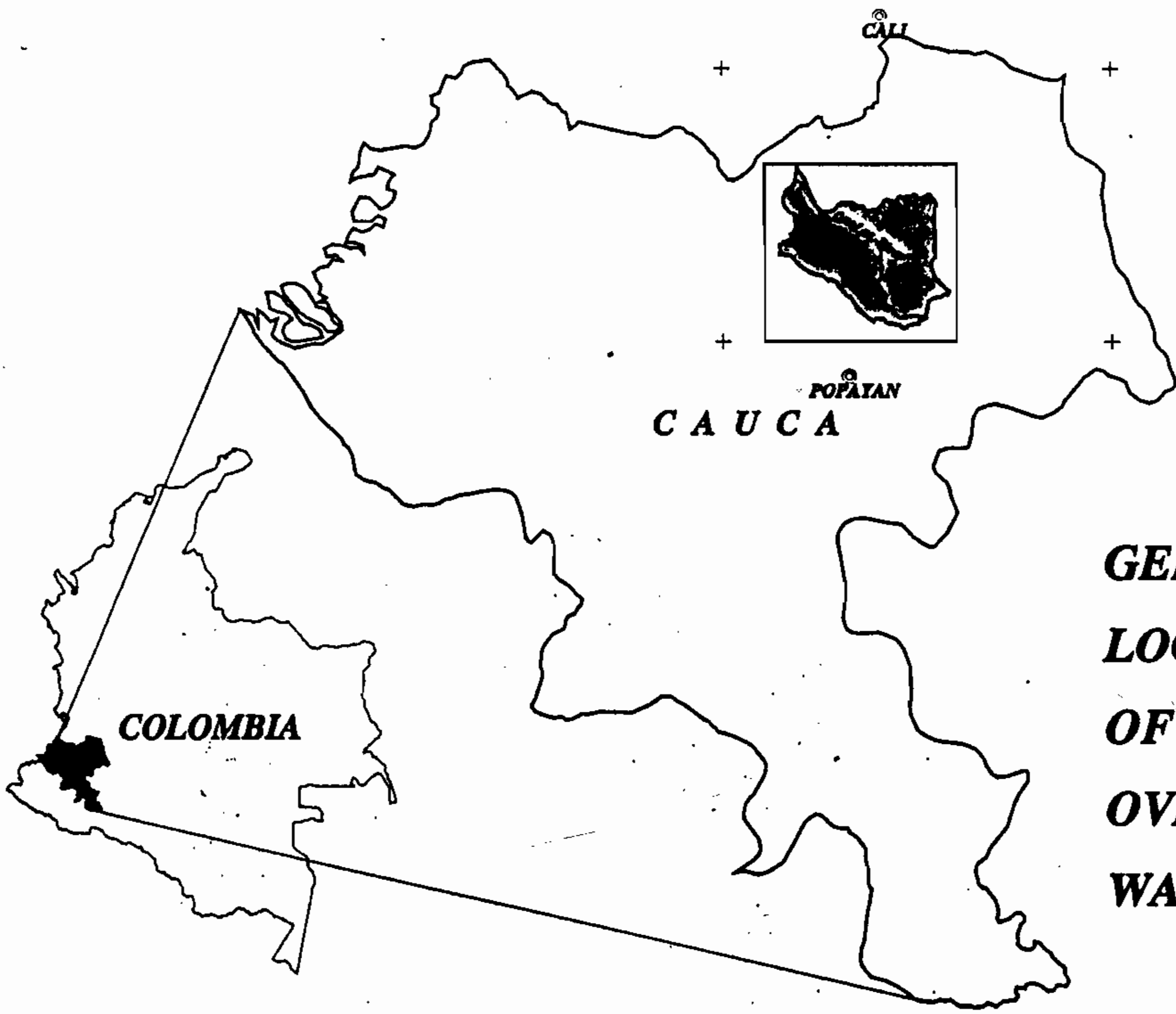

SCALE
1
2
3
4
5
6
CABUYAL CATCHMENT
Including the geographical and human organization and potential, e.g., land and river use.
CABUYAL RIVER SYSTEM
i.e., river use
MICRO-CATCHMENT 1
MICRO-CATCHMENT 2
....
MICRO-CATCHMENT N
L.U.T.-A
L.U.T.-B
...
L.U.T.-N
Farm 1
...
Farm n
field i
...
field n

FIG 4



MAP

GENERAL LOCATION OF THE OVEJAS RIVE[R] WATERSHED

C I A T

Land Use Program

August [illegible]