CIAT HILLSIDES PROGRAM

ANNUAL REPORT

(Draft)

1994-1995

FOREWORD

The CIAT Hillsides Agro-Ecoregional Program is an instrument for change which owes its existence primarily to the encouragement and support of the international donor community and the outstanding efforts of its contributors, visiting scientist and thesis students, who are recognized here:

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In the pages that follow, we present the Program strategy, structure and research highlights for 1995.

PROJECT AREA

ANDEAN HILLSIDES

PROGRESS REPORT

1995

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PART 1

PART 2

CIAT Hillsides AgroEcosystem Program

IN PERSPECTIVE: 1995

Goal, justification and objectives of the Program

The Goal of the Hillsides Program is "to improve the welfare of the hillside farming community by developing sustainable, commercially viable agricultural production systems." This goal is derived from CIAT's mission statement (CIAT, 1991) "to contribute to the alleviation of hunger and poverty in tropical developing countries by applying science to the generation of technology that will lead to lasting increases in agricultural output while preserving the natural resource base." The program's goal addresses the need identified in the mission to tackle problems of poverty and environmental degradation which go hand-in-hand in the hillsides of Tropical America.

The hillsides agroecosystem in Latin America is a major contributor to food supply and is the basis of the livelihood of a large proportion of the rural poor. The total area in hillsides in Tropical America is estimated at 95 million ha of which about 25 million ha are already highly degraded. This agroecosystem supports over 20 million people. Principal countries (followed by percent of area in steep-slope agriculture) include Bolivia, Colombia (40%), Ecuador (65%), Peru (50%), and Venezuela, Costa Rica (70%), El Salvador (75%), Guatemala (75%), Honduras (80%), Nicaragua, Panama (80%), Mexico, Haiti, Jamaica and the Dominican Republic. The CIAT natural resource management definition of "well-watered" hillsides amounts to 30.25 million hectares.

Other than in Colombia, Venezuela and Peru, a significant proportion of the population of the predominantly hillside countries was rural at the beginning of the 1990's. World Bank data show a high proportion of this rural population in poverty, ranging from 45% (Colombia) to 80% (Guatemala). In addition, a significant portion is indigent (i.e., without means to meet minimal nutritional needs): 23% of Colombian rural population is indigent; 46% in Peru and 57% in Guatemala (CEPAL, 1990). Female-headed households are a high proportion of the indigent rural population (CEPAL, 1992). Thus, in most of the countries with significant proportion of area in hillsides, the locus of poverty has yet to shift from rural to urban areas. Moreover, World Bank figures for the 1990's indicate that rural impoverishment has recently increased in some of these countries.

Causes of degradation in hillside agroecosystems include deforestation (24.9 million ha) overgrazing (24.7 million ha) and agricultural activities or domestic use of vegetation (42.6 million ha). It is estimated that approximately 53 million hectares are experiencing rapid rates of degradation.

Agriculture in mid-altitude hillsides is typically based on fallow-rotation systems in which forest or bush fallow is cleared for cropping with annuals (maize, beans, cassava, upland rice) and perennials, and returned to pasture or bush fallow once yields decline to a level that is non-economic for farmers to continue cultivation. In the more densely populated and drier areas, fallow periods have been shortened or replaced by organic or chemical fertilizers. When farmers cannot obtain or afford fertilizers, they work off farm, exacerbating the "feminization" of hillside farming, in which the real farmers are women managing subsistence or semi-commercial small farms.

Even in "well-watered" areas, erratic distribution of rainfall can lead to short but critical periods of drought stress. Pest, disease and weed control are major constraints in annual crops. Degraded fallows, largely synonymous with overgrazed pasture, occupy 40-60% of area. Large farms maintain low stocking rates and sharecrop arable land. This reflects a strategy of investing in land to protect capital. Improved production is frequently not a primary or even important objective of large landowners in the hillsides, who make up about 20% of farmers and own 80% of the land. Intensification of production on small farms is an important part of alleviating the poverty which drives migrants to colonize, deforest and degrade increasingly fragile environments.

Environmental degradation of hillsides has serious implications not only for viability of agricultural production in the agroecosystem itself, but also for "downstream" lowland agriculture and coastal ecosystems which can be affected by soil erosion and agrochemical pollution in uplands. Second, the welfare of urban populations which draw water supplies from water courses originating in hillsides is also intimately affected by soil erosion, sedimentation of dams, and major land slippage caused by deforestation or cropping without use of soil conservation practices. The third and potentially most irreversible damage due to hillside environmental degradation and that with major social cost is loss of biodiversity due to disappearance of montane forest. This amounts to between 15% of forest area in Bolivia to 57% in Guatemala. Rate of hillside deforestation is higher than in lowlands, causing a loss of 90 percent of montane forest by 1990. Montane forest has very high biodiversity, possibly higher than lowland forests, especially with respect to herbs and shrubs found between 600-3000m elevations, which are considered important for conserving wild crop genetic resources in-situ. A fourth feature of environmental degradation in hillsides is excessive use of agrochemicals which is characteristic of agricultural intensification, causing soil and groundwater pollution, ecological imbalance in pest and disease complexes, as well as chemically contaminated food.

The rapid rate of environmental degradation in hillsides is driven by the unfavorable structure of incentives for hillside farmers to invest in conservation. These incentives are shaped by specific agroecological conditions, available technologies, prices of inputs used and outputs produced, opportunities for off-farm employment and migration, as well as cultural and organisational norms of natural resource management. Income-generating activities that permit capital accumulation and agricultural intensification, and that involve the use of profitable conservation technologies are key to changing farmers' environmentally destructive management practices. This is the rationale for the objectives of the CIAT Hillsides AgroEcosystem Program, which are:

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

2. To generate agroecologically and economically viable components that are 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.

Each objective is discussed in CIAT's Strategic Plan (CIAT, 1991) and Midterm plan 1993-98 (CIAT, 1992).

Program Structure and Development

The Program's logical framework structure is shown in Table 1. Program research activities are organized under four highlighted outputs which reflect tight structural integration across projects. For example, participatory research methods appear as a separate output, when in fact, participatory methodologies are integrated, to a greater or lesser degree, into all program projects.

Figures 1, 2, 3, and 4 on pages 6, 7, 8 and 9 outline the work breakdown structure, which follows from the Program's logical framework.

Program staffing has varied significantly since 1992. Currently, principle research staff, as measured by full time equivalents (FTE), stands at 2.75 headquartered at Tegucigalpa, Honduras and 2.70 headquartered at Palmira, Colombia. An additional 0.6 FTEs are allocated from the Tropical Lowlands Program and are associated with the Interprogram Project (HA-3). Special restricted funding supports all but 2.45 FTEs.

The CIAT Hillsides Program enjoys a special working relationship with CIMMYT through the mechanism of a jointly funded research position for a soil fertility specialist working on mulch conservation systems. The specialist also acts as regional project coordinator for Central America.

Site Selection for Hillside Eco-regional Research.

A major challenge for researchers addressing issues in natural resource management (NRM) and agricultural sustainability is to fill knowledge gaps through innovative experimental methods that do not rely on large numbers of expensive, replicated observations across numerous sites. The most promising approach is to adopt a logical experimental framework that requires a minimum of sites to elucidate key principles and processes. This is preferable to relying on huge quantities of data and statistical relationships, as is common in traditional commodity research. In such research the typical experimental site is a single farmer's field. By making observations over numerous fields, researchers identify productivity constraints through conventional experimental design and statistical analysis. In Figure 5 this traditional commodity approach is shown as a series of comparisons across research sites at the field scale.

Table 1. Logical Framework Structure for the CIAT Hillsides Program

	INDICATORS	*VERIFICATION*	*ASSUMPTIONS*
GOAL To improve the welfare of the Hillside farming community through development of sustainable and commercially viable production systems.	Project farming communities experience increased individual and social benefit.	Locally relevant indicators show family well-being and sustainability of production systems improving.	Well-being indicators and sustainability indicators are available.
PURPOSE To develop and validate a strategy, including a methodological "toolkit" and delivery system, for generating and executing projects consistent with the program goal.	Projects are generated and executed by stakeholders.	Projects are funded and satisfactorily completed.	Development funds are available.
OUTPUTS ■ Soil quality assessment methods. ■ Prototype production systems development. ■ Participatory research methods and organizational models. ■ Community-based, watershed decision-support systems. ■ NARs capacity improved to use the models and methods.	■ Methods in use by NARs, and Consortia. ■ Publications. ■ Functioning stakeholder action groups. ■ Stakeholder adaptation of prototypes. ■ Stakeholders use decision-support systems to plan land use. ■ Training carried out.	■ Publications available. ■ Annual reports. ■ Planning workshops using systems applications. ■ Annual reports. ■ Consortia workplans.	■ Interprogram and interinstitutional cooperation. ■ Technologies and methods available. ■ Completion of Outputs 1,2,3 and interinstitutional cooperation. ■ Adequate funding.
INPUTS A) Staff B) Budget	FTE years of senior scientist and support staff. Operational budget.	Annual report of the Hillsides Program. Annual budget.	There is a Hillsides Program, and inter-program projects share staff. Ditto.

HILLSIDES PROGRAM WORK BREAKDOWN STRUCTURE

PROJECT 1. EFFECTS OF SOIL DEGRADATION

Program Goal

To improve the welfare of the hillside farming community through development of sustainable, commercially *viable* agricultural production systems

Project Purpose

To define and quantify causes and effects of accelerated soil quality degradation and regeneration and its true costs, both individual and social

Project outputs / *Activities*

1 Criteria to stratify and map experimental sites

- Statistical characterization of historical soils analysis
- Georeference and resample soils in fields with historical soil analysis
- Analyse changes in soil properties due to changes in land use
- Quantify soil change as function of land use history
- Publish journal article on soil quality assessment and land use change

2 Estimates of loss of yield potential

- Select field locations for cronosequence studies
- Conduct maximum yield trials (MYT)
- Define healthy and degraded soil systems through estimated crop response curves
- Publish journal article on loss of yield potential

3 Criteria to evaluate soil improvement practices

- Determine relevant environmental variables
- Establish on farm *practices trials (PT)* with indicator crops in different land use types
- Prioritize soil P response mechanisms
- Monitor soil properties vis-a-vis different types of practices
- Evaluate types of practices with respect to effects on productivity
- Derive implications for new soil improvement techniques
- Publish guidelines for determining practices to use in a given type of environment

4 Prioritized soil properties correlated with soil degradation and regeneration, and changes in productivity

- Parameterize process-level P component of IBSNAT crop models
- Prioritize organic matter effects in trials and identify indicators of effects of practices on soil properties
- Prioritize N-flux effects in trials; identify indicators related to changes in productivity and the effects of practices on soil properties
- Describe soil fauna communities
- Determine relationships between landuse, soil fauna and productivity
- Explore interrelationships between P, N-flux and soil biology and organic matter properties
- Identify relative importance among *them for soil* improvement
- Derive implications for design of new soil improvement techniques
- Publish joint articles on soil system properties

5 Acceptability and management requirements

- Identify farmers with known soil improvement practices
- Establish management costs with *farmers*
- Identify economic interactions between soil improvement practices and other activities
- Study labor demand and supply and implications for practice adoption
- Publish results

6 Estimates of private costs

- Collect data on inputs and outputs in practices
- Cost-benefit analysis
- Develop methods to value changes *in soil properties*
- Quantify economic value of loss of yield potential

HILLSIDES PROGRAM WORK BREAKDOWN STRUCTURE

PROJECT 2. COMMUNITY-BASED, WATERSHED DECISION SUPPORT SYSTEMS

Program Goal

To improve the welfare of the hillside farming community through development of sustainable, commercially viable agricultural production systems.

Project Purpose

To process information from strategic research in the form of decision-support systems

Project outputs

Activities

1 Priority areas in the Andean and Central American hillsides identified

- Multiple - scale analysis of land use change
- Characterize hillside watersheds by hierarchical organizational structure
- Value effects of sedimentation and agrochemical pollution from different land uses in selected watersheds
- Develop ex-ante economic impact assessment model for hillsides agroecoregion
- Workshops on impact assessment

2 Guidelines for defining minimum data needs

- Develop prototype user-friendly biophysical and socio-economic databases with NARI'S
- Test minimum data needs for modeling options
- Develop a step-wise procedure for refining precision and resolution of spatial data
- Conduct cost/benefit analysis of decision support models
- Publish a manual on the procedures

3 Methodology for incorportating stakeholders values into optional changes

- Conduct participatory resource mapping and correlate results with remote sensing and GIS micro zoning
- Identify indigenous environmental indicators and calibrate with scientific measurements
- Translate local stakeholder taxonomy into relevant categories to assist interactive modeling
- Develop field tools for local monitoring of indicators for different interest groups; assess knowledge - based (KB) decision support model
- Validate models interactively with stakeholders
- Compare results from process models built with "hard" data and from models built with subjective weights or decision rules
- Audit indicators with local monitoring and calibrate with GIS analysis
- Conduct AEAM workshops
- Publish manuals on consensus - building procedures

4 Prototype interactive, computer-based decision-support applications for hillsides stakeholders

- Analyse evolution of land use in case study sites
- Construct multi-objective analytical models with input from projects (1), (3), and (4)
- Develop knowledge-based (KB) models
- Evaluate and adapt software for presentation of scenarios in interaction with stakeholders
- Simulate environmental x production tradeoffs
- Estimate true value of production at plot, farm & landscape units of analysis including environmental costs
- Assess economic environmental x production tradeoffs in farm and landscape models
- Test the decision-support system with stakeholders
- Feedback needs for data to improve modeling

HILLSIDES PROGRAM (INTERPROGRAM PROJECT) WORK BREAKDOWN STRUCTURE

PROJECT 3. PROTOTYPE SYSTEMS FOR ECOLOGICALLY-SOUND INTENSIFICATION OF PRODUCTION IN THE HILLSIDES

Program Goal

To improve the welfare of the hillside farming community through development of sustainable, commercially viable agricultural production systems

Project Purpose

To contribute to sustained and improved total productivity and to enhance natural resource conservation in the hillsides, by developing a strategic understanding of how to incorporate new and different combinations of species into existing types of production systems

Project outputs / *Activities*

1 Potential system components identified and characterized

- Hypothesize "benchmark" cropping patterns and rotations from existing data, site appraisals
- Review available information on effect of potential components on environmental variables
- Review available information and survey livestock population, feed supply, animal productivity
- Establish "satellite trials" to identify germplasm for poor, acid soils
  - evaluate elite cassava germplam to expand cassava harvesting window from 12 to 18 months, increase starch yield 15% ha
  - evaluate bean germplasm with low P tolerance and higher N fixation
  - evaluate materials for live barriers
  - evaluate promising grasses and legumes to identify promising rotation and improved fallow components
- IPM subproject for pest/disease complexes in different crop regimes

2 Strategic principles for prototype multispecies combinations identified

- Review information on hillside systems to identify strategic entry points for *sustainable intensification*
- Determine theoretical principles for design of prototype combinations of species, and
- Hypothesize promising "blends" of introduced and traditional technology
- Select and characterize experimental sites (see Output 1 of HSProject #1)
- Design prototype species combinations with center-wide team to test crop, grass, tree, legume species within benchmark prototype systems and rotations
- Establish these treatments in long-term system trials in at least 2 different environments
- Determine mechanisms of *sustainable grass/legume* establishment
- Evaluate crop/tree associations
- Evaluate acceptability with farmers (Link to HSP #4)
- Model in qualitative and quantitative form (Link to HSP #2)

3 Strategic principles for interaction among plant and livestock species identified

- Review information on hillside crop-livestock systems to identify strategic entry points
- Determine theoretical principles of competition and synergy among species
- Introduce animal components to long-term system trials in at least 2 different environments
- Evaluate animal production in systems trials
- Determine forage quality and LWG in systems with trees
- Stabilize DM yield and botanical composition
- Determine optional niches for trees
- Evaluate acceptability with farmers (Link to HSP #4)
- Model in qualitative and quantitative form (Link to HSP #2)

4 Effect of prototype combinations of plant and animal species on system productivity and soil health evaluated

- Evaluate prototype combinations for biomass, yield, soil quality (Link to HSProject #1)
- Study dynamics of organic matter pools
- Construct nutrient budgets
- Study soil biology, conduct soil fauna surveys
- Conduct soil physics studies on soil quality indicators, erosion dynamics
- Develop indicators to monitor environmental impact to compare alternatives in the system trials
- Input to models (Link to HSProject #2)
- Publish results
- Construct database with published and indigenous knowledge about species and combinations in different environments

5 Economic value estimated of prototype combinations of plant and animal species for system productivity and environmental effects

- Review literature to identify scarce factors of production important for design of hillsides systems
- *Characterise* labor use in systems with high, low and medium management intensity; derive implications for prototype system design
- Study markets to identify product opportunity; prioritize high potential products for inclusion in system trials
- Model potential impact of markets on adoption of prototype systems
- Estimate management requirements of prototype combinations
- Model bioeconomic interactions
- Value environmental impact of incorporating prototype combinations into different types of hillside production systems
- Introduce economic values to models (Link to HS Project #2)
- Publish results

HILLSIDES PROGRAM WORK BREAKDOWN STRUCTURE

PROJECT 4. PARTICIPATORY RESEARCH

Program Goal

To improve the welfare of the hillside farming community through development of sustainable, commercially viable agricultural production systems

Project Purpose

To develop methodologies to support a community-based, participatory R&D approach for evaluating technologies with potential for improving land use in the hillsides of tropical America

Project outputs

1
Prototype technology assessed for acceptability to farmers

Activities

- Conduct regular innovator workshops with experimenting farmers
- Evaluate acceptability of component technology and systems with farmers
- Conduct participatory system trials designed with interprogram team and farmer participation
- Derive farmers'criteria for acceptability

2
Participatory methods adapted

- Select suitable methods for:
  - typologies of stakeholders
  - problem definition, goal setting by stakeholders
  - local level monitoring by stakeholders
  - organisational and management capacity
  - conflict resolution
- Incorporate methodological innovations
- Develop and publish training materials

3
Community-based organization developed for R&D

- Form consortium, watershed Steering committee, land use council of local beneficiaries and establish community fund
- Form local agricultural research committees (CIALs) for technology testing
- Monitor and evaluate process results into training materials
- Conduct pilot training and test materials
- Develop, test and evaluate strategy for multiplication
- Publication and dissemination of results

4
Trained people (IPRA project)

- Identify partner institutions in multiple sites
- Construct training capacity in partner institutions
- Conduct training in FPR methods for technology evaluation with CIALs
- Application and follow-up training in multiple sites
- Extend methods and approach in Central American and Andean countries

NRM research requires that the traditional definition of research sites be adjusted to include different spatial scales. This is essential for addressing sustainability issues. But so far "across-scale analysis" at NRM research sites has resulted in little more than independent characterization of ever larger geographical areas (from the plot to the landscape, as indicated in Figure 5) in less detail.

To characterize, categorize, and compare research sites at multiple scales is expensive and time-consuming. As a result, NRM researchers have little choice but to use fewer experimental sites than in commodity research. Documents on NRM research methods refer to "benchmark," "heritage," and "sentinel," sites, suggesting that these have unique properties, which permit tradeoffs between data quality and quantity.

CIAT's Hillsides Program has adopted an alternative strategy that radically redefines the purpose and function of research sites. One of our main activities is to analyze the *organizing principles or relationships which structure* multiple-scale systems. The outputs of this research are process-level analytical models that can define and categorize the biophysical and socioeconomic resources upon which agricultural systems depend. This information helps identify points of policy and management intervention, and provides ex-ante analysis of the trade-offs involved in choosing different interventions.

As suggested in Figure 5, the research of the Hillsides Program emphasizes the *linkages* that act as feedback and feed-forward control mechanisms across scales. A key advantage of this strategy, based on hierarchical systems theory, is that it does not depend on large numbers of sites, nor does it require that we identify representative sites exhibiting certain uniform characteristics.

In fact, with a research strategy that focuses on system processes, detailed descriptions of representative sites (whether fields, farms, watersheds, communities, regions, or countries) is of secondary importance. More important are examples of sites that illustrate the range of variation in hillside systems at different scales of analysis, whether biophysical, geographical, or social (e.g., noncontiguous farm fields, watersheds, and institutions), and that allow contrasting types of interventions and their likely impact to be tested.

Watersheds as an organizing unit of study

The CIAT Hillsides Program has adopted the "watershed" as a useful unit for organizing some, but by no means all, of its research activities. Reasons for this are that overland and through-flow of water draining through catchments integrates and concentrates the effects of many crop and land management activities; off-farm effects can be made explicit; catchment boundaries are specifically definable and reproducible permitting application of systems analysis; catchments are naturally organized into biophysical, and in some cases, socio-economic hierarchal systems. Although watersheds are a useful unit for organizing research, this does not imply that an objective of the Program is to identify a management plan that would optimize resource use at the watershed scale. Rather, the objective is to include analysis of water as well as soil and vegetation in the indicators which provide a "feedback mechanism" for stabilizing and sustaining hillside production systems (TAC, 1995 "Priorities and Strategies for Soil and Water Aspects of Natural Resources Management Research in the CGIAR).

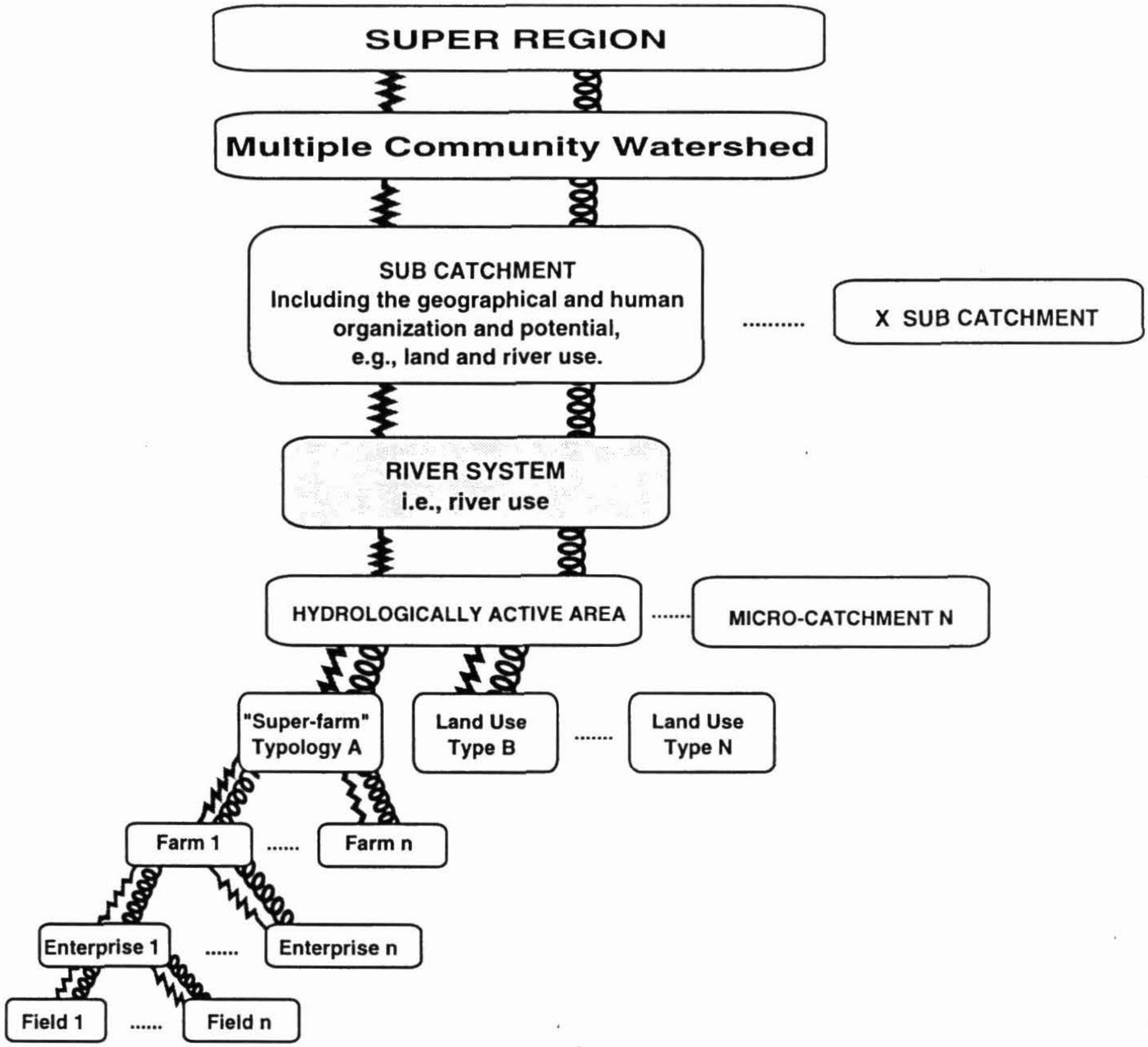


Figure 5. Schematic diagram illustrating a common physical and social organizational structure found throughout the Hillside agro-ecosystem. Program research emphasizes the role of the multi-scale linkages that act as control mechanisms for introducing change.

Current research sites

Using the strategy of selecting contrasting sites across a range of variation, the CIAT Hillsides Program is currently focusing its research efforts in two sites. The Andean region site is a 100,000 ha watershed in the Department of Cauca in southwestern Colombia (Fig. 6). In-depth descriptions of the Cauca study area can be found in many of the research papers presented in the annual report, particularly beginning on page 25.

In Central America, the Program works in five watersheds in Honduras and Nicaragua. Detailed site studies, consistent with the strategy detailed above, are beginning in the regions of La Ceiba, Yorito, and Danlí in Honduras and Matagalpa and Esteli in Nicaragua (Fig. 6). These sites were selected after consultations with partners in the Central American Hillsides Consortium.

Program Evaluation and Donor Relations

During 1995, the Hillsides Program took part in three formal reviews; an External Program and Management Review (EPMR), an Internally Commissioned External Review (ICER), and a review by the International Development Research Centre (IDRC-Canada). In addition, the Program hosted a week-long visit by the new Swiss Development Corporation (SDC) representative from Bern.

The two visits by Program donor representatives were particularly satisfying. In both cases, donor representatives strongly endorsed current efforts of the program and made significant suggestions on future areas of program-donor collaboration. Specific results of consultations with SDC representatives from Bern, together with local Central American representatives, was the submission of a request for an interim program phase in the Central America program to take full advantage of available resources and program momentum. Similarly, the visit by the IDRC representative was followed by strong endorsement and a suggestion to submit a request for continuing work in the Colombian study site.

In addition to formal visits by donor representatives, the Program is very grateful for significant continuing support from the W.K.Kellogg Foundation and the Royal Danish Ministry of Foreign Affairs (DANIDA). Over time, the W.K. Kellogg Foundation has consistently supported research and development of methods for improving and increasing the participation of rural stakeholders in promoting technology change for improving the livelihood of rural poor. During 1995, DANIDA supported Hillsides Program efforts with salary and operational funds for a post-doctoral rural sociologist, as well as for restricted core activities.

Additional support for the Hillsides Program came in the form of support for student research assistants from DANIDA, ETH-Switzerland, and Norway. The Hillsides Program gratefully acknowledges both donor financial support and the indispensable efforts of the visiting student researchers. Figure 7 outlines the financial structure of the CIAT Hillsides Program for 1995.

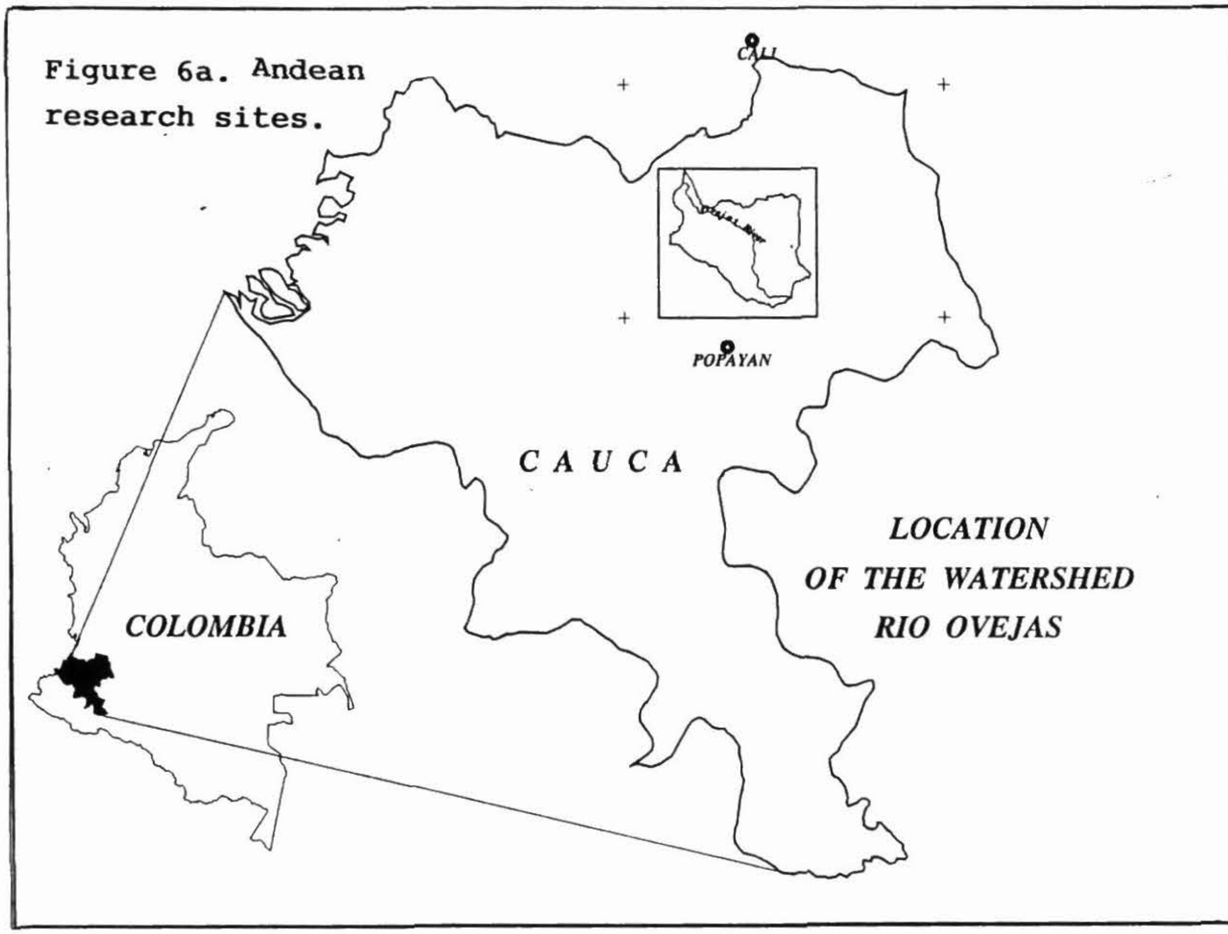
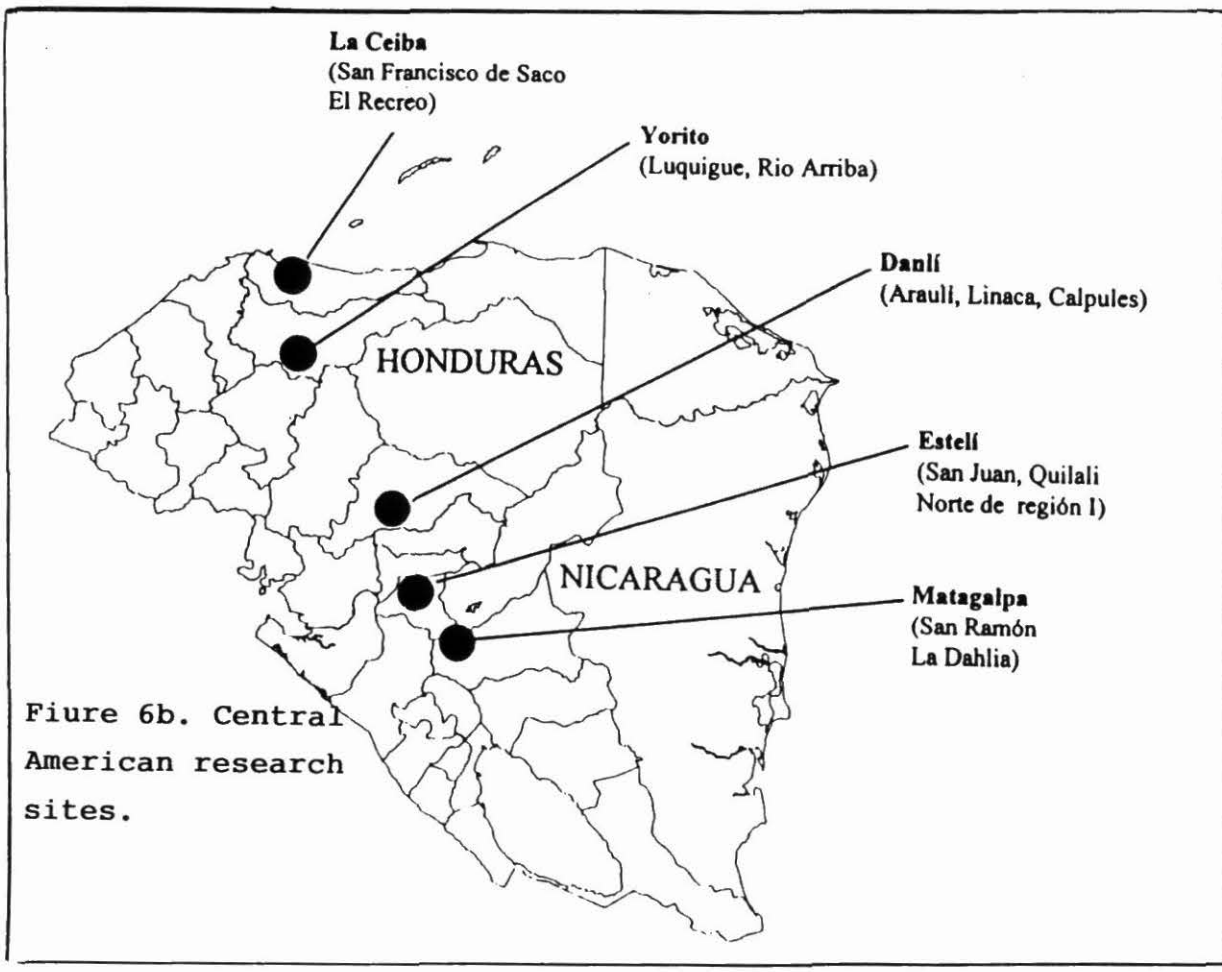


Figure 6a. Andean research sites.



Fiure 6b. Central American research sites.

Figure 7. Financial Structure of the CIAT Hillsides Research Program

	AREA	
PROJECT	**ANDEAN HILLSIDES**	**CENTRAL AMERICAN HILLSIDES**
Project 1. Effects of soil degradation	Core	SDC
Project 2. Decision support systems	Core IDRC	Core SDC
Project 3. Prototype agrosilvopastoral systems	Core IDRC	SDC
Project 4. Participatory research	IDRC DANIDA W.K.Kellogg	SDC W.K.Kellogg IDRC

Research Highlights for 1995

Project 1 (HA-1): Effects of Soil Degradation.

In Cauca, useful criteria for detailed characterization and stratification of contrasting site soil mapping units are being investigated. The treatments are historical land use types (LUT) ranging from undisturbed 40 year-old secondary regrowth forest to traditional cassava cultivation. Results show a range of 9 LUT can be categorized into 2 classes, which accounts for 67% of the total variance in four soil chemical indicators of nutrient retention. The two classes correspond to non-cultivated and cultivated LUT. Detailed spatial analysis of undisturbed forest and traditional cassava sites showed most, but not all, soil nutrient retention indicators were spatially autocorrelated with sample independence occurring at intervals of from 2.4 to 8.0 meters. (Beginning Part 2).

For the Cauca study site, a digital database was created from several hundreds of historical soil analysis records supplied by the Secretaria de Agricultura y Ganaderia (SAG). Descriptive statistical pattern analyses are being carried out with the intention of developing time series information for soil quality change analysis.

Also, a study appraising soil quality, using estimates of irreversible loss of attainable soil productivity, has completed four crop cycles. Bean, cassava and maize yields attained on farmers fields are quite variable but reach 2 to 10 times farmer yields. This amounts to 3 t/ha bean, 7 t/ha maize and 60 t/ha cassava root. There is not yet any indication that a soil productivity degradation threshold has been passed. Causal (path) analysis for bean and maize indicates the major source of yield variability is attributable to "cropping cycle", i.e., semester B versus semester A, followed distantly by previous historical land use. (Beginning Part 2)

A survey of soil macrofauna properties across diverse LUT is following the protocol supported by the CIAT Tropical Lowlands Program and the Tropical Soil Biology and Fertility (TSBF) Consortium. Quantification of macrofauna density, biomass and species diversity of earthworms vary considerably across LUT, both with respect to sampling depth and date. Initial factor analysis (principle components) resulted in 3 factors accounting for 88% of total variance in macrofauna density. Factor 1 accounts for 48% of the variance and can be interpreted as a termite/myriapod/aracnido factor, which is associated exclusively with the undisturbed secondary regrowth forest. Factor 2 accounts for an additional 25% of total variance and can be interpreted as an ant/beetle (coleoptera spp.) factor. The third factor accounts for an additional 15% of total variance and can be interpreted as an earthworm factor. (Beginning Part 2).

Project 2 (HA-2): Decision Support Systems.

A simulation modeling exercise was carried out in Cauca, to test the appropriateness of experimental crop modeling/GIS software developed at the University of Florida at Gainesville. The study explored *ex-ante* analysis of change in water balance in small watersheds as a result of development of small irrigation projects. The modeling tool proved appropriate for rapid *ex-ante* analysis using data generally accessible in lesser developed countries. (Beginning Part 2. (This work is in press as a co-authored book chapter, and was presented at three conferences).

Collaborative research with the Land Use SRG has made significant progress overcoming technical problems of precision in remote sensing interpretation and spatial mapping and analysis of very small, sloping, heterogeneous land use/land cover units. An initial study used traditional airphoto interpretation and GIS to quantify changes in land use/land cover for a sub-watershed in Cauca for three key dates beginning with 1946. Results show that aggregate estimates of land cover change need to be interpreted with caution, as specific land mapping units show much greater dynamic shifts into and out of land cover classes. (Beginning Part 2. This work has been presented at two international conferences.)

Another Cauca study is exploring minimizing aggregation bias and maximizing stakeholder acceptance in regional scale systems analysis. Research is progressing on the development of a farmer-derived, locally-relevant social index of family "well-being". The index was synthesized from responses to a survey of local residents. It has five parameters related to land and cattle ownership, labor sources and housing characteristics. The utility of the indigenous index is being tested for aggregating households for possible analyses of regional systems. This was done by assessing the within-and across-class variability of index-derived classes. Predictions of household wealth, financial risk and farm viability were simulated by a process-level, whole-farm economic model driven by stochastic economic and weather variables. The farm model is based on the DSSAT suite of models. The goal of this research is to improve precision of regional scale analyses and to make the analyses more participatory and relevant to stakeholders. (This work is being presented as a co-authored poster at an international conference, Los Baños, Philippines.)

In Central America, significant time and resources have been spent gathering and evaluating digitized biophysical and socio-economic data from a variety of sources with two main objectives in mind. First, the data will be processed and analyzed as part of the Program's strategic research addressing the issue of improved targeting of research and development activities. Second, in exchange for much of the data, the Hillsides and Land Use Programs will create user-friendly accessible GIS databases for collaborators in the region. During 1995, satellite imagery for multiple dates covering most of Honduras and Nicaragua has been obtained. A supervised classification of land cover has begun for Honduras. In addition, for local study sites, detailed digital orthographic mapping has begun. This is required for resource modeling analysis, using spatially distributed landscape parameters. Significant progress has also been made in linking population and agricultural census data to spatial coordinates. A digital database of the IV National Agricultural Census for Honduras at the municipio level has been developed by the Tegucigalpa office. Work by the CIAT Land Use SRG is well advanced disaggregating census data to the village level. Results of this work will permit direct analysis of the relationships between poverty, land management and resource degradation. Finally, in collaboration with the Land Use SRG, a detailed climate grid database which surpasses any previous attempts has been created. (see CIAT Land Use Program's annual report for more information.)

Project 3 (HA-3): Prototype Systems for Ecologically Sound Intensification in the Hillsides.

The Interprogram Project in Cauca is a long-term project that is less than two years old, and therefore data interpretation would be premature. Nevertheless, early indications are that, contrary to common belief, land fallowed for several years is not necessarily more productive than continuously cropped land. Soil productivity depends on past managementm and continuously cropped land that has received applications of organic manure over time is highly productive. (These results are consistent with results observed in Project 1 above.) An additional aspect of organic manuring uncovered in this study is that common application rates of 6 t/ha manure far exceed the total nutrient uptake and exports from the harvest. This raises the issue of potential accelerated soil acidification due to leaching. (Beginning Part 2)

In Cauca, research on a methodology for quantifying relationships between resource sustainability and current and potential product marketing systems is well advanced. As a step in the methodology, a market survey, centering on Cali and its area of influence, was completed in 1995. Information was obtained for a portfolio of products from supermarket chains, milk and food processing companies and flower shops. Eight reports were prepared and presented to groups of stakeholders. (Beginning Part 2).

Project 4 : Participatory Research

Research is progressing on developing a methodology for producing rural poverty (or well-being) profiles to improve the targeting of research to different types of beneficiary groups. (Beginning Part 2). Based on enquiries among local informants into what constitutes well-being, a well-being index was developed. In Cauca, this index has seven parameters related to dependency/independency on day-laboring as a source of income, ability to employ day laborers, access to non-agricultural sources of income, land and cattle ownership, crop diversity, and housing quality. The well-being index will improve targeting of research and development activities and will provide indicators against which to assess the impact of such activities.

In Cauca, research is underway to identify critical issues, including organizational principles, for local-level watershed management. (Beginning Part 2). The research follows a participatory action research approach and uses FEBESURCA, the río Cabuyal watershed beneficiary federation which forms part of CIPASLA, as a case. A description of the work to date has been submitted to an international journal for publication.

During this research, burning as a common means of land preparation was identified as a critical - and controversial - issue, as it has detrimental effects on local watershed management. Burning was therefore used as a case study to test with methodology based on a stakeholder approach to the identification, analysis and negotiation of conflicting interests involved in watershed management. (Beginning Part 2).

A strategy is now in place for developing in-country capacity for training professionals and farmer-paraprofessionals in the CIAL methodology. The concept of focus sites as permanent training ground is essential. In order to establish such sites, it was found necessary to (1) establish relationships with potential partner institutions and inform them of the project's objectives, and (2) develop the terms of the interinstitutional agreement. The search for partners is organized around two vital institutional functions: research capacity (e.g., national or regional agricultural research institutes and agriculturally oriented universities) and development work with small farmers.

Opportunities for 1996

The CIAT Hillsides Program looks forward to 1996 with great anticipation. In addition to finishing certain research activities and continuing others, new opportunities have presented themselves. The Program is continuously being approached by potential research partners including PROCIANDINO, CORPOICA, the Wageningen Agricultural University, CIP, IFPRI and IIMI to mention a few. During 1996, collaborative research with CIMMYT, CIP and IFPRI are likely to be formalized through funding of the Latin American Agroecoregional Initiative. There also appears to be opportunities for a jointly funded CIAT-CIP economic systems staff position similar to the CIAT-CIMMYT position in Central America. Another highly probable collaborative effort will likely be catalyzed by the Inter-Center Initiative on Water Management. This will result in the CIAT-hosted IIMI representative working in the Cauca, Colombia, research site.

Other opportunities for 1996 include continuing linkages with other CIAT Programs, as well as non-CIAT institutions, through the organizing, managing and delivering training courses by Hillsides Program staff in Farmer Participatory Research.

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Part 2

RESEARCH IN PROGRESS

1995

PROJECT 1: Effects of soil degradation and of practices for soil conservation or regeneration on the potential productivity of cultivated hillsides

Purpose: **To define and quantify effects of accelerated soil quality degradation and of practices for soil regeneration or conservation on soil properties, and their true costs, both social and private.**

I. ASSESSING THE EFFECTS OF SMALL FARMER CROPPING SYSTEMS ON SOIL NUTRIENT RETENTION IN A COLOMBIAN ANDEAN WATERSHED

Prepared by: *E. Bronson Knapp*[1] *and Claudia M. Buitrago*[2]

Introduction:

Environmental lobbyists and and policy-makers are putting pressure on farmers, ranchers and foresters to manage their soil resource in a way that addresses social needs as well as their individual interests. Unfortunately, soil quality indicators and thresholds are contentious issues which can lead to erroneous and possibly costly policy decisions. A case in point relates to the 1990 update of the U.S. Soil and Water Conservation Act of 1977 (RCA) that mandates the implementation of soil conservation plans based upon predicted assessments of soil erosion. Some U.S. farmers contend that the models do not assess the true quality of their soils under minimum-tillage management, and therefore they should not be required to implement costly remedial conservation measures (Science, 1994). If assessments do not accurately depict soil quality, unreasonable and costly demands may be placed on farmers which will sooner or later be felt in the marketplace.

In tropical agricultural systems where small farmers predominate, a lack of consensus about soil quality assessment and the desirability of remedial measures is common. The result is the very low rates of adoption of soil conservation practices typical of resource-poor farmers in the tropics. Traditional commodity constraints agronomy research in developing countries has focused on improving cropping productivity by measuring the efficiency of practices such as fertilizer levels which are evaluated in terms of economic marginal rates of return. This approach is an undeniably important element in predicting the acceptance or rejection of new technologies by individual decision-makers or groups of decision-makers with similar economic circumstances. A more important gap in

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our understanding of natural resource management and agricultural sustainability however, is the degree of resilience of the resource base and whether irreversible loss of productivity is occurring under current land and crop management practices across a wide spectrum of land users. In our study, understanding the factors that put the soil resource at risk of exceeding a threshold of irreversible loss of crop productivity requires treatments that are the land management strategies used by farmers to exploit the soil resource.

Management practices may considerably alter, not only absolute values of soil properties, but the inherent spatial structure as well. Trangmar (1984, as discussed in Trangmar et al., 1985) found that topsoil removal and residue burning during conversion of forested land to arable farmland considerably increased the short-range spatial variability of topsoil acidity, ion exchange characteristics and subsequent crop growth.

Lal (1994) and Acton (1994) have identified insufficient precision and quantification, and a confusing range of spatial and temporal scales of measurement as two important reasons for the slow progress in achieving goals of sustaining the productivity potential of the natural resource base. The goal of this research is to assess soil quality change over time and space; to provide some indication of soil quality suseptibility to change resulting from soil-modifying process promoted by selected land management choices; and to improve the precision of inventory mapping of landscape units at risk of serious environmental degradation. Specifically, the objectives of this study were, in the Río Ovejas watershed in the central western Colombian Andes, given a single, dominant soil association mapping unit stratified by elevation, to define the underlying distributions for a number of soil chemical properties that define nutrient retention; to test the respective properties for spatial autocorrelation; and to compare and contrast the effect of land use type on the soil "quality" indicator: nutrient retention.

Some concept of nutrient retention is universally accepted as an important element of soil quality not only for its relevance for assessing soil productivity (Riquier, 1970; Lal, 1994), but also for assessing the critical function of environmental filtering or buffering, i.e., reduced leaching (MacDonald et al., 1994). The Canadian Centre for Land and Biological Resources Research (CLBRR) has proposed a hierarchical framework for soil quality assessment (Acton and Padbury, 1994) that identifies nutrient retention as one of four critical elements in assessing the function of soil productivity (MacDonald et al., 1994). As a sustainability indicator, nutrient availability is more narrowly defined than soil productivity, but more broadly defined than *in situ* measurements, e.g., aluminum and base saturation, exchangeable acidity or soil organic carbon. As a compound index that integrates several commonly measured soil chemical properties, nutrient retention can potentially be defined by a few class intervals, thereby making aggregation and disaggregation of mapping units across scales more interpretable than for a large set of continuous distributions of individual plant nutrients like Ca, Mg, K, etc.

Uncertainty is an important element of the decision when assigning observations to classes. Wilding (1988, as discussed in Lal, 1994) considered the magnitude of variability of several soil properties sampled within mapping units of soil series and proposed three classes based upon their coefficients of variation: (i) least variable properties have CV's less than 15%, (ii) moderately variable have CV's of 16 to 35%, and (iii) highly variable have CV's of 36 to 70%. Soil pH, for example, had a mean CV of 10 and a range of 5-15, while soil organic matter content had a mean CV of 39 and a range of 20-61. What is apparent is that the precision and size of the class interval varies considerably due to differences in underlying frequency distributions of the measured soil properties.

In addition to non-normal probability distributions, spatial autocorrelation violates the critical assumption of sample independence (Trangmar et al., 1985) thus confounding the issue of measurement, classification, extrapolation, and mapping of relevant but heterogeneous soil properties. Assigning confidence limits to field observations and derived compound soil quality indexes can lead to objective, automated, and eventually interactive, consensus-building agricultural resource decision support systems for predictive mapping such as that described by Dean (1994) for forest management.

Methods:

The research study area is defined by the geographic limits of the 106000 ha Río Ovejas watershed in the west central part of Colombia. Within this watershed, a GIS analysis defined a sub-catchment representative of the most widespread soil association (Typic Dystrandept) and superimposed elevation classes in the Río Ovejas (Fig. 1). After several reconnaissance surveys, six land use types were selected for detail study. Until recently, the dominant land use type in the study area has been perennial coffee and rainfed annual cropping of semi-commercial cassava, bean and maize by smallholders with low capital resources using simple animal drawn metal plows; with high labor intensity on freehold farms of 5-15ha. Limited capital is used for soil management and improvement, i.e., chicken manure is applied sparingly. Vegetation is burned and land is "abandoned" to fallow when yields decline markedly. Within this context the land types were subdivided into 1) secondary natural succession woodlots greater than 40 years old and managed for wood products, 2) secondary natural succession forest greater than 40 years old, 3) one year of commercial drybean (*Phaseolus vulgais*) following perennial grass pasture, 4) long term perennial coffee-banana, 5) bean-maize-cassava-fallow as a long term annual cropping system, and 6) a long term cassava-fallow system that is traditionally associated with soils with greatly depleted fertility. Also included as part of the study were a second cassava field and two sites which are a LUT representing intensively managed irrigated horticultural crops, in this case tomato. Farmers' indigenous knowledge holds that crop requirements that land/soil resource must satisfy decrease from tomato, coffee, bean-maize, cassava, to unimproved pasture. Unimproved pasture is virtually equivalent to unmanaged fallow which is used by farmers, historically, in a fallow rotation system that leaves fallow to regenerate to secondary forest which is then cut and burned to begin a new cropping cycle.

Soil sampling for each of the six sites (LUT) was carried out on a basic 4m x 4m grid with subsamples at 2m and for the two extreme land use types #1 and #6, subsamples were taken at 1m intervals at a sampling depth of 0-25. This was chosen following evidence that only the organic-C in the topsoil (A horizon) is in direct steady state with the present day vegetative cover (Volkoff and Cerri, 1988). It was this steady state that we wished to assess.

Soil chemical analises were carried out using standard accepted techniques. The properties determined were organic C (C), exchangeable acidity (ExAc), base saturation (BS), total exchangeable bases (TEB) and effective cation exchange capacity (CECe) which is just the sum of ExAc plus TEB.

Results and Discussion:

This study does not assume nor propose a nutrient retention index for defining soil quality standards or thresholds in tropical soils. A large number of across site comparisons will have to be carried out before such an index becomes a reality. At this stage, the status of individual soil properties that are associated with assessing soil nutrient retention will be examined to provide some indication of soil quality susceptibility to change resulting from soil-modifying process promoted by selected land management choices.

Figs. 2 and 3 present box plots showing the median, 25 and 75 percentiles, and minimum and maximum values for ExAc and organic-C across six sites (LUT). For comparison, the frequency distributions for a large database of historical soil analyses covering a period of 15 years are also included. These data form part of a database of soil analyses of the Secretaria de Agricultura y Ganaderia de Cauca (SAG) and cover nearly 400km2 of the surrounding area in the watershed. It is clear from the descriptive statistics that differences in important soil chemical properties exist across sites and LUTs.

All nine sites were analyzed using Ward's minimum variance cluster analysis using organic-C, ExAc, TEB (Table 1; CECe is shown but was not a variable in the analysis as it is the sum of ExAc+TEB). The analysis shows that the nine sites can be categorized into two classes which explain 67% of the variance, i.e., sites 1, 2, and 3 versus sites 4-9 (r^2=0.67). Sites 1 and 2 are the two forested sites recently cleared for cultivation and site 3 is the site that was recently cultivated after being in unimproved perennial pasture. All of the other sites are intensively cultivated to a wide range of crops. Following a second iteration, the analysis shows that forming three categories, sites 1-2, 3, and 4-9, reduces the variance by another 13% (r^2=0.80). The trend suggested by the analysis is that cropping practices in the area following deforestation, are leading to significant changes in the soil resource base.

Nutrient retention, by all definitions is now and always has been very low in the soils examined. Table 1 describes some soil properties associated with nutrient retention and soil quality for the first two classes identified by the Ward's cluster analysis (r^2=0.67). The intensively cultivated sites have, on the average, 208% higher levels of organic-C, 77% lower levels of exchangeable acidity and 58% lower CECe. The magnitude of differences found in the above soil properties, however, is not reflected in differences in the TEB's which means that base saturation (BS) is much higher in the intensively cultivated sites.

Table 2 presents the results for two contrasting land use types for the soil properties organic-C, ExAc, BS, TEB and CECe. The underlying distributions for C, ExAc, BS, TEB and CECe were a mix of normal and ln-normal (P.0.01). However, as it is difficult to compare statistics of unlike probability distributions, for the sake of interpretation, all statistics are presented assuming the distributions were normal.

Soil organic-C, ExAc and BS showed spatial dependence at both sites while TEB showed no spatial autocorrelation and the case for CECe is doubtful. The best-fit spatial models were a mix of exponential and spherical. The semivariogram parameters of sill, nugget and range shed light on the nature of the spatial dependence of sampling and suggests future soil sampling strategies. To facilitate comparisons, the semivariogram parameters "sill" (an estimate of maximum population variance) and "nugget" (an estimation of random error) are standardized. A potentially important observation is that the range means are dissimilar for the different soil properties and two sites presented. Particularly evident is the nearly 100% difference in the range for ExAc. The interpretation is similar to Trangmar's observations cited above: the cultivated site has greater short-range spatial variability compared to the forested site. The significantly lower absolute levels of ExAc (0.51 versus 3.02meq/100g) in the cultivated site are consistent with the one unit difference in Ph; 4.5 versus 5.5 for the forested and cropped site respectively and are validated by analysis of the other sites.

Generally the soils in the watershed, including the specific soil association studied, are derived from volcanic materials (Andosols) that are known to have relatively much higher carbon contents than soils from other parent materials (Sombroek et al, 1993). This has been attributed to strong bonding between the carbon and the amorphous mineral phase resulting in much reduced decomposition rates. Applications of fertilizers, including organic fertilizers, as is the custom in the watershed, enhances biomass production. In fact, agronomy trials carried out in the watershed have shown that annual cropping without P applications is virtually impossible. The long term effects of the additions of organic manures and the concomitant increases in biomass production are consistant with the observed results even considering the generally high decomposition rates that exist in the tropical and sub-tropical soils.

During field sampling, the surface horizon at the forested site was observed to be much darker than the equivalent horizon at the cropped site; Munsell 10YR 3/2 versus 10YR 4/4. Generally, other soil characteristics being equal, such observations suggest higher levels of soil organic matter although the opposite was measured. In addition, the lower effective cation exchange capacity (CECe), as defined by the sum of exchangeable acidity plus TEB's, and the higher organic C of the cropped sites appear in contrast with conventional wisdom which says CEC and organic-C are positively correlated (Sombroek, 1988, as discussed in Sombroek et al., 1993). These issues raise questions about the reliability of conventional visual indicators and the quality versus quantity of soil organic matter under conditions found in the watershed and similar watersheds throughout the Andean Region.

Conclusions

It is well established that increasing humification of soil organic carbon results in increasing organic-C cation exchange capacity (CEC). Future research should address the likely senario that the less disturbed sites have lower organic inputs than the cultivated sites; that the organic fraction in the less disturbed sites is more humified resulting in higher exchange capacities than the cultivated sites; that the natural acidity of the soils causes the exchange sites of the humified organic-C to be preferably blocked with H and Al complexes according to accepted CEC theory, resulting in the symptom of increased exchangeable acidity for the class of less disturbed sites.

One final consideration is that sites were selected based on existing soil survey maps and assumptions that within stratified landscape configurations, the sites were comparable at some time in the past and that observed changes in soil properties are dominated by human intervention and to a significantly lesser degree by natural soil forming factors, i.e., climate, topography, parent material, and natural soil biotic activity. The possibility that the sites were never comparable, and that farmers with their indigenous knowledge, purposely selected better sites for cultivation has to be examined. The difference in measured soil quality may, in fact, be confirmation of indigenous land evaluation knowledge. Even in such a case, the intensive scientific soil sampling carried out for this project would permit the objective definition of a compound index thereby making aggregation and disaggregation of mapping units across scales more interpretable.

Table 1. **Clustering of soil organic-C (C), exchangeable acidity (ExAc), total exchangeable bases (TEB), effective cation exchange capacity (CECe), and base saturation (BS) into two classes with resultant means and standard deviations.**

Land use class	No. farms	Org. C	ExAcid	TEB	CEC_e	BS
		(%)	----------	meq/100g	--------	(%)
1	6	7.7 (1.47)	0.72 (0.27)	1.25(0.31)	1.97 (0.41)	63
2	3	3.7 (0.72)	3.18 (0.77)	1.51(0.53)	4.69 (0.40)	32

Table 2.

	Organic C (%)		Exchangeable Acidity (meq/100g)		Base Saturation(%)		TEB (Total Exch. Bases: meq/100g)		CECe (Effective Cation Exchange)	
	Forest (n=87)	Crop (n=75)	Forest	Crop	Forest	Crop	Forest	Crop	Forest	Crop
Mean [1]	4.10	6.72	3.02	0.51	38	73	1.89	1.58	4.91	2.08
Standard Error	0.68	1.61	0.77	0.20	13	12	0.75	0.89	0.68	0.87
CV	16	24	25	39	34	16	40	56	14	42
Spatial Auto-correlation model (r^2)	exp. (0.92)	sph. (0.59)	exp. (0.96)	exp. (0.84)	sph. (0.87)	sph. (0.87)	NS	NS	sph. (0.91)	NS
Lag/Step (m)	15/1.1	15/1.0	15/1.1	10/1.1	8/1.0	15/1.2	NS	NS	15/1.1	NS
Sill[2]	1.07	0.94	1.02	1.22	0.85	1.04	NS	NS	0.78	NS
Nugget	0.24	0.30	0.10	0.00	0.17	0.10	NS	NS	0.29	NS
Range (m)	5.1	8.0	4.5	2.4	3.2	6.6	NS	NS	4.1	NS
Jackknife r^2	0.31	0.36	0.38	0.32	0.19	0.46	NS	NS	0.18	NS

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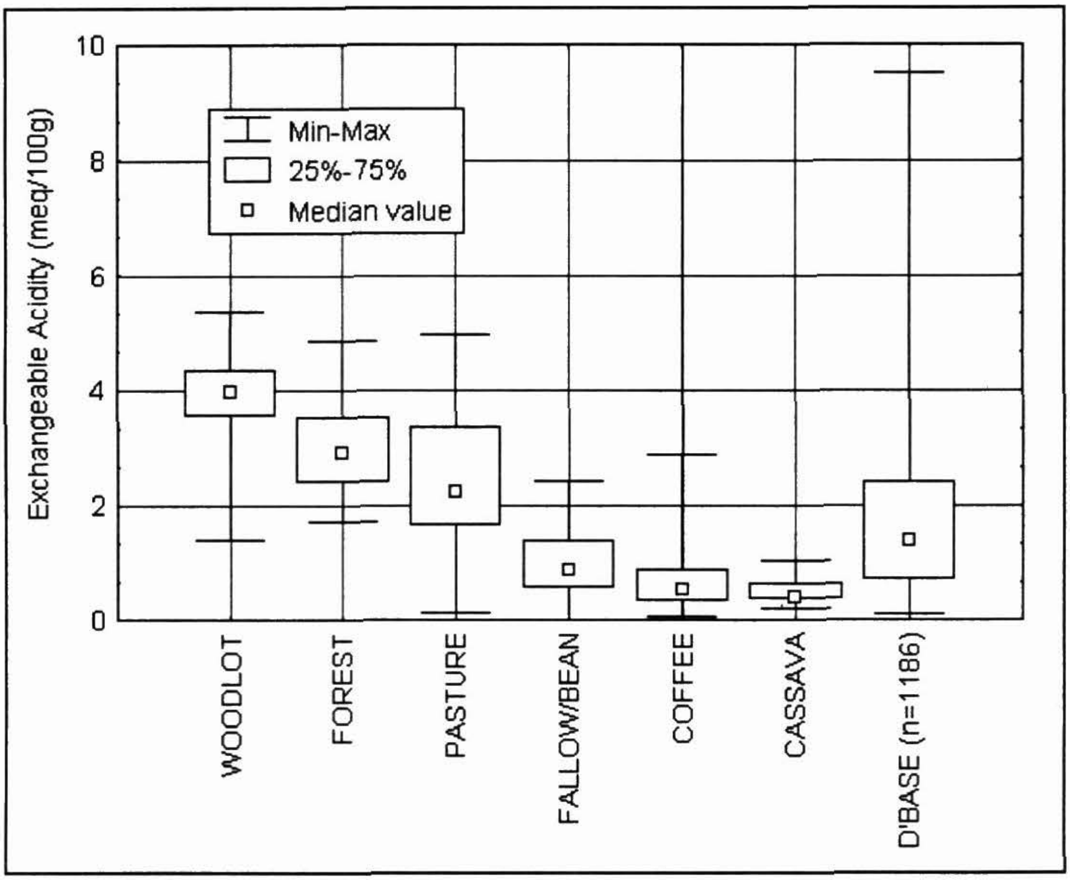
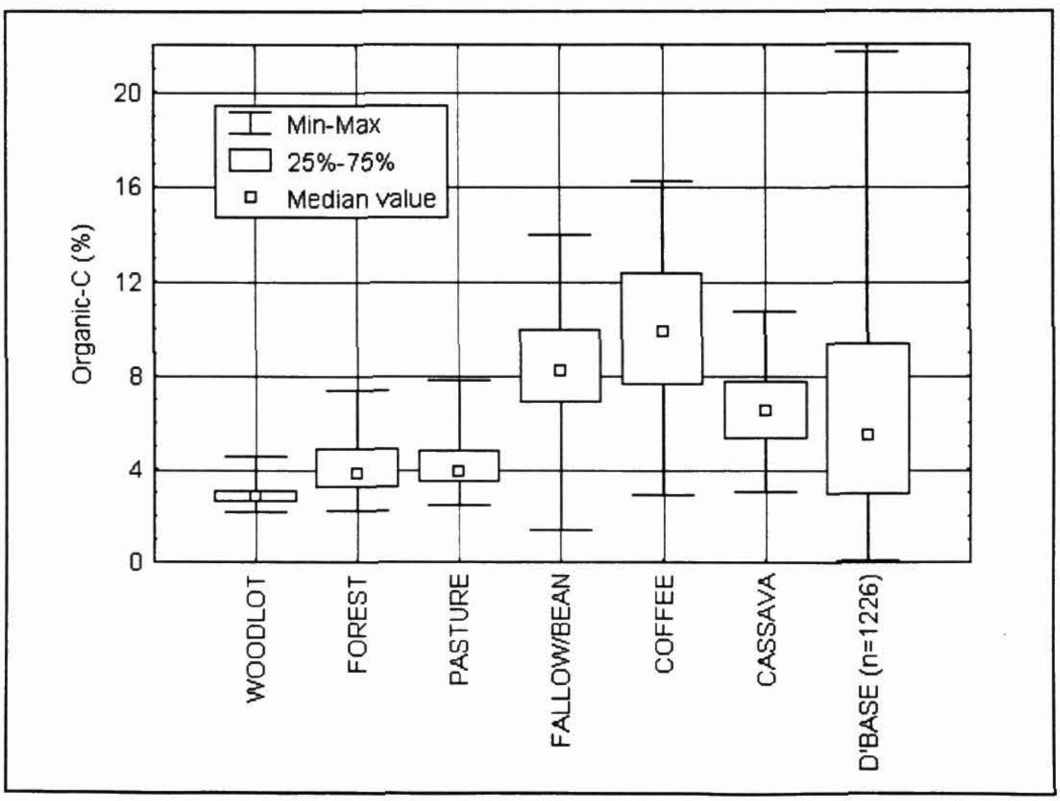
[1] It should be noted that the underlying frequency distributions for the specific soil chemical properties analyzed were not always normal. Since comparisons between the two sites would be difficult if the statistics were presented using a mix of distributions, the table presents statistics assuming the properties are normally distributed.

[2] To facilitate comparisons between the two sites and different soil chemical properties, the spatial statistics - sill and nugget effect - have been standardized to the chemical properties' sample variances.

Fig. 2 and 3. Frequency distributions of soil exchangable acidity and organic-C across a range of 6 sites.





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II. SOIL QUALITY APPRAISAL USING ESTIMATES OF THE IRREVERSIBLE LOSS OF ATTAINABLE SOIL PRODUCTIVITY

Prepared by: *E. Bronson Knapp and Jorge Alonso Beltrán*[1]

Introduction:

Soil degradation, or loss of soil quality, is widely perceived as the central problem of the hillside agroecosystem in tropical America.

The capability to assess the quality of soil at a specific time and place has always been an important part of an overall appraisal of the natural resource base and land management. Twenty-five years ago, agricultural development organizations considered soil quality in terms of the critical function of providing a medium for crop growth (Riquier et al. 1970). Since then, the concept of soil quality has expanded to include sustainable future production (FAO 1976; Lal, 1994), and more recently, to include other functions like regulating and partitioning water flow through the environment, and soil as an effective environmental filter (Larson and Pierce 1992). Even so, providing a medium for plant growth is still arguably the most critical function of all.

Traditionally, agronomic commodity-constraints research has focused on improving cropping productivity by, for example, measuring fertilization efficiency which is evaluated in terms of economic marginal rates of return for various fertilizer levels. This approach is an undeniably important element in predicting the acceptance and rejection of new technologies by individual decision makers as well as groups of decision makers with similar economic circumstances.

An arguably more urgent gap in our understanding of agricultural sustainability, however, is the identification of current land and crop management practices across a wide spectrum of land users that put the soil resource at risk of exceeding a threshold of irreversible loss of crop productivity. The issue for resource management research is to investigate the level of resilience of the soil resource base. Thus, the treatments for such a study are not levels of applied fertilizer, but rather land use types which represent different management regimes in the hillsides.

Soil Productivity Assessment Strategy:

Fig. 2.1 is an abridged schematic of the quantitative land evaluation approach developed by the Dutch group at Wageningen (van Keulen et al 1986). The rectangles in the second row represent the factors that ultimately determine the agricultural potential

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[1] CIAT Hillsides Program

yield. Climate and soil are fixed factors for a given location and, in combination with the level of land "reclamation", characterize the 'land quality level'. There is importance assigned to quantifying reclamation activities required to bring land to a higher level of quality. The Dutch approach does not specifically address the antithesis of reclamation, i.e, degradation, defined here as all unsustainable uses of land for agricultural production.

As indicated in Fig. 2.1, land quality is determined by intrinsic climate and soil properties, and reclamation or degradation level. Crop breeding may change crop characteristics and yield potential, but as van Keulen (1986) states, "For a given land quality level, the yield potential is ... more or less fixed for the relevant period of time". This framework is quantitative and linked to crop simulation modeling.[2] "YIELD LEVELS", as identified in Fig. 2.1, are calculated for four hierarchically ordered situations (van Keulen and Wolf 1986). The highest level assumes water, nutrients including nitrogen, are in optimum supply, and that crop protection against weeds, pests and disease is sufficient to eliminate any effects. Crop yield under this circumstance is referred to as potential yield. The second hierarchial level again assumes mineral nutrients including nitrogen are optimal but now the influence of the availability of water is taken into account. The third level deals with less than optimum crop nutrition, predicted from empirical rather than mechanistic functions, and the fourth level takes into account the effects of non-optimum crop protection.

It is clear from van Keulen's description that the principle aspects of the Dutch land assessment scheme encompass soil quality status or current condition. Soil quality can change due to reclamation, or degradation as we have added, and thus potential crop yield is an important concept in evaluating soil and land quality. These concepts are still a mainstay in the Wageningen approach to land quality assessment and have recently formed the framework for a study by the Netherlands Scientific Council for Government Policy analyzing the consequences of different agricultural policy options on land use in the European community (WRR 42, 1992).

Similar to the Wageningen approach, Riquier et al. (1970) defined theoretical soil productivity as "optimum soil yields, not taking into consideration damage caused by insects or other pests, or choice of seed, unsound husbandry, and the rest." He states: " The concept is very close to that of 'soil quality'". Riquier goes on to define a concept he calls "potentiality" that is the "productivity of a soil when all possible improvements have been made, even the most difficult and costly". This appears similar to the Dutch concept of 'reclamation'. Riquier also proposed that his soil appraisal scheme could be used to map **potential** soil productivity, and he gives an example where the application of fertilizers in

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[2] Systems analysis, including crop simulation modeling, is an important element in the overall goal of the Hillsides Program's Andean Project as it is in the Wageningen evaluation framework. The trials of this study are also supplying field validation for crop model parameterization and system analysis studies described in Section V. For this reason, many crop phenology and soil measurements are being taken in these trials which are not actually critical to this study. Examples of measurements are biomass development, leaf area index development, photo-thermal time analysis of crop development, etc. Geostatistical analysis of soil chemical properties were taken as part of Section I and will be used to link the interpretations of Sections I, II, III, and IV.

suitable quantities could change soil base saturation (an index parameter) thereby increasing the quality level ranking.[3] An important aspect of Riquier's approach is that it stresses productivity, or known yields, rather than limitations.

This approach avoids economic and sociological considerations. Like the Dutch approach, aspects of Riquier's framework include current soil condition, soil quality status improvement, and the concept of potential yields as an indicator of resource quality.

The concept of 'irreversibility' appears in many definitions of sustainability beginning with Conway (1988). Dumanski (FAO:FESLM 1994) suggests that "a form of land use may be regarded as 'sustainable' if no *permanent* or progressive deterioration of its 'fitness' (i.e., 'suitability') to the land in question is foreseen over a reasonably lengthy period of future time. In other words, sustainability can be considered to be an extension in time of the concept of suitability". It should be mentioned that in contrast to Riquier, the FAO concept of 'suitability' includes the 'attractiveness' of economic return.

For this study, 'irreversibility' is defined as a change of state of the soil which cannot readily be overcome by the application of fertilizers, i.e., a normal human response to market forces responding to product shortages, and a definition consistent with evaluation frameworks reviewed above. Irreversibility is related to the concept of 'thresholds', which is a special form of assessment criteria or standard against which a judgement can be made (Acton et al., 1994). Although this study does not assume or propose soil quality standards or thresholds, the concepts are implicitly recognized in the sense that, if there is irreversible loss of productivity, then an implicit threshold has been exceeded. The next step would be to identify the causes and set standards for evaluation and possibly compliance monitoring taking into consideration the specific land use, e.g., crops grown, rotations, etc.

From the above review, four aspects of soil quality assessment are obvious; macro-environmental stratification, current soil quality status or inherent quality, the issue of soil quality change, and the use of potential crop yields as an environmental indicator.

Methods:

In many Andean hillside watersheds, like the 100000ha Río Ovejas watershed in South Colombia where this study was carried out, soil maps at scales of 1:50000 are generally available. At such scales, soil maps differentiate soils by association or "cadena" which generally means the mapping unit aggregates soils formed under conditions of similar climate, parent material, native vegetation, and topographic sequence (USDA Soil

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[3] As explained in the preliminary results in Section I, significant differences in soil properties, e.g., base saturation, related to nutrient retention and hence soil quality, have been measured for a forested and intensively cropped site. Whether the difference in base saturation is actually due to management strategies, and whether it signifies an increase in soil quality needs more corroborating evidence. Nutrient retention is a compound index and base saturation is only one parameter determining that index. The increase in base saturation may have occurred at the expense of overall root zone or soil profile nutrient retention.

Survey Manual, 1951). For this study, we used site elevation and topographic classes as proxies for climate to impose additional stratification within small to medium size watersheds. Found within similar land mapping units, however, are a wide range of human induced land use pressures, either degrading or reclaiming. The key resource management issue is whether such land use intensification has irreversibly changed, for better or for worse, the productivity potential of the defined soil mapping units.

After several reconnaissance surveys, six land utilization types (LUT) were selected for study.[4] The dominant LUT in the study area is perennial coffee and rainfed annual cropping of semi-commercial cassava, bean and maize by smallholders with low capital resources using simple animal drawn metal plows, with high labor intensity on freehold farms of 5-15ha. Limited capital is used for soil management and improvement, i.e., chicken manure is applied sparingly. Vegetation is cleared by burning and land is "abandoned" to fallow when yields decline markedly. Within this context, the LUT's were subdivided into 1) secondary natural succession forest greater than 40 years old, 2) secondary natural succession woodlots greater than 40 years old and managed for wood products, 3) perennial grass pasture, 4) long term traditional perennial coffee-banana, 5) bean-cassava-maize-fallow as a long term annual cropping system, and 6) a long term cassava-fallow system that is traditionally associated with soils with greatly depleted fertility.

To test the hypothesis that, over time, the six LUT's described above have resulted in changes in soil quality in the study area, indicator crops of bean, cassava and maize were seeded at the corresponding sites. The trials are planned to cover two seasons per year for three years for bean and maize, and two harvests over three years for cassava.

The plot dimensions were 5mx5m and managed to express potential yields. The bean variety seeded was ICA Caucaya at a row spacing of 0.6m x 0.1m giving a seeding density of 166667pha-1. For the first season, soil amendments were applied at the rate of 1 tha-1 of dolomitic lime, 1500 kgha-1 of 10-30-10 compound chemical fertilizer and 20000 kgha-1 of organic (chicken) manure which had an analysis of 2-4-2. For the second season, soil amendments were applied at the rate of 1 tha-1 of dolomitic lime, 1000 kgha-1 of 10-30-10 compound chemical fertilizer and 10000 kgha-1 of organic (chicken) manure which had an analysis of 2-4-2. Weeds and pest were controlled as needed.

For cassava, the variety CG 402-11 was seeded at a row/plant spacing of 0.8m x 0.8m giving a density of 15625 pha-1. Soil amendments were applied at the same rate as the first season of bean.

For maize, the experimental variety CIMCALI SA-3 was seeded 3 seeds per hill at a row/hill spacing of 0.8 x 0.5m. The maize was thinned at 15d to 2 plants per hill and a final population of approximately 50000pha-1. Soil amendments were applied at the same rates as for bean. Weeds and pest were controlled as needed.

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[4] LUT is a type of land use defined in greater detail than that of a major type 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.

At harvest, subplots were harvested to minimize border effects. Grain yields were adjusted for moisture effects. Total above ground dry matter was determined and is reported as kgha-1.

Results of research in progress:

Four seasons of bean and maize and one crop of cassava have been harvested. It is premature to draw firm conclusions until the trial is completed, nevertheless, certain patterns are being revealed. Fig. 2.2, 2.3 and 2.4 show preliminary results for maize, bean and cassava across environments for the cropping cycles completed so far. Descriptive results indicate consistently lower yield during semester A versus B. Another apparent trend is lower yields across time, e.g., cycle !993B versus 1994B and cycle 1994A versus 1995a. Contrary to popular opinion, the trend is for the more intensively cultivated land use types (LUTs) to out yield the non-cultivated LUTs given non-limiting levels of fertility. Finally, it should be noted that although fertility was non-limiting, significant yield loss did occur in some repetitions; in maize from Helmenthesporium spp., in bean from nematodes, and in cassava from root rots.

To illustrate the experimental analysis being proposed, data have been presented in the form of path coefficient analysis. Path analysis uses *a priori* knowledge of causal relationships which are than numerically estimated using linear regression techniques (Asher, 1976). Fig. 2.5 and 2.6 show the model with resulting path coefficients.

As explained above, the sites at which the trials are being carried out have been categorized according to historical land use. "LUT", a categorical variable, can be changed to an "ordinal" variable by ranking the sites according to observed crop yield. In simple terms, when entering the data into a computer, the sites, i.e., LUT's, are converted to numbers. The question of how readily one can and should treat ordinal data as interval data, as "required" in causal analysis, has sparked a major controversy. It is probably true, however, that the greater number of categories in the ordinal variable, the less critical the interval data requirement. At this early stage in the research, the most obvious violation in treating ordinal data as interval is not the LUT variable but rather the "year/cycle", identified as "semester" variable, which to date is made up of two "categories".

Due to the early stage of this research, interpretation of the analysis presented in Figs. 2.5 and 2.6 should be limited to the sign and general magnitude of the coefficients rather than the traditional interpretation of ranking direct and indirect effects of the independent variables. Nevertheless, as an example of the analytical method and interpretation, refer to Table 2.1. The strengths of the direct, indirect and total causal relationships of the *a priori* defined "causal variables", e.g., land use type, on the dependent variable, e.g., economic yield and biomass, is defined by the magnitude of the "path" coefficients. For the case of maize and bean, land use type clearly "causes" significant variability in potential economic yield. The "R" values are the residuals which mathematically are equivalent to 1-the coefficient of determination (r^2), i.e., the variance not explained by the linear models.

As was apparent from Fig. 2.2 and 2.3, season variablity, as represented by the variable *semester*, is consistently the most important source of variability in yield. *LUT* is a significantly less important source of variability.

Land Use Type is obvious a "black box" when used to describe a *cause* of the variability in soil productivity. Future research will shed light on the biochemical or physical reasons for the observed differences.

Future Research:

This activity will continue for one more year during which time it will continue to supply data for the decision support project (Project 2 below).

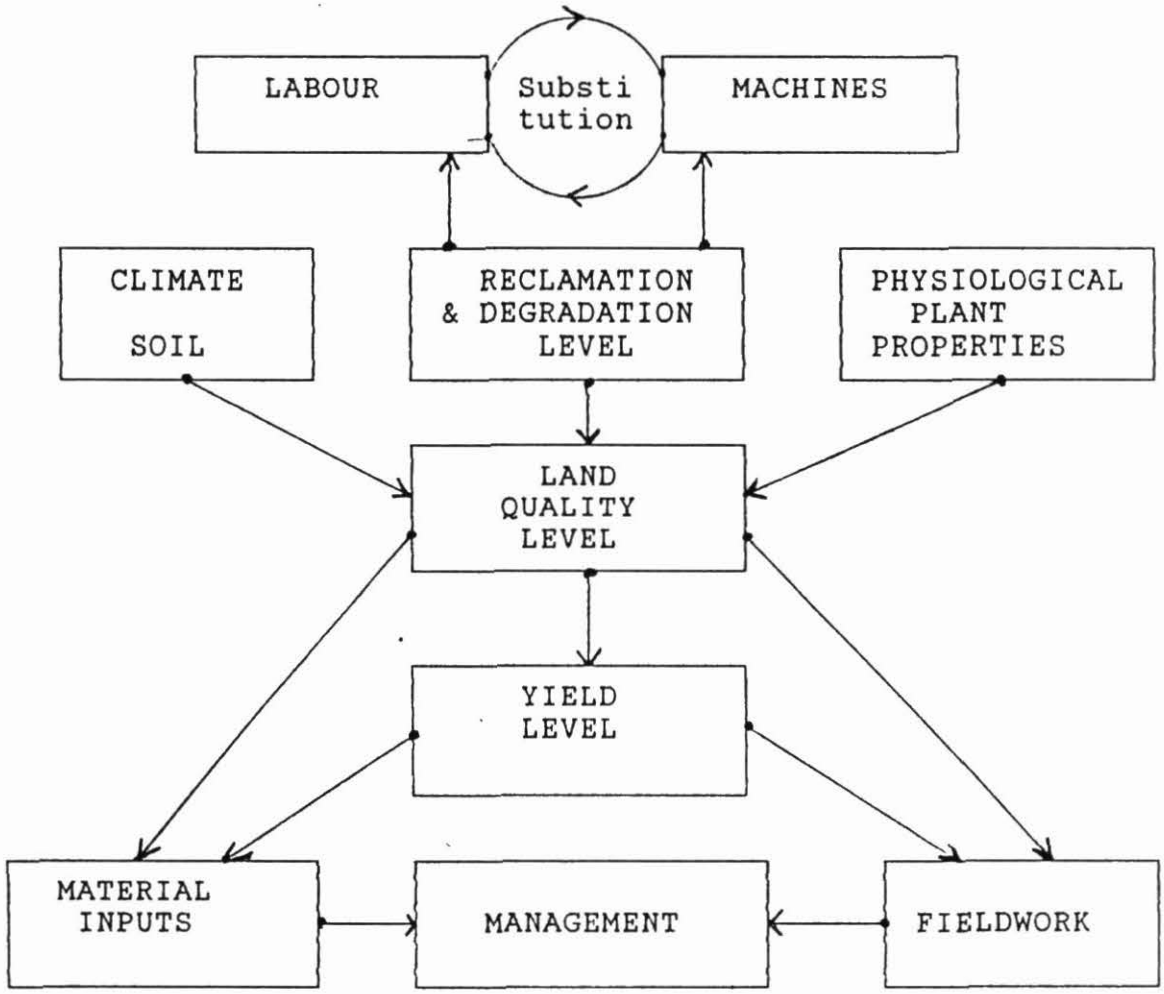


Fig. 2.1 Schematic presentation of the framework for quantitative evaluation of land quality and sustainable land management proposed by the University of Wageningen.

Figure 2.2

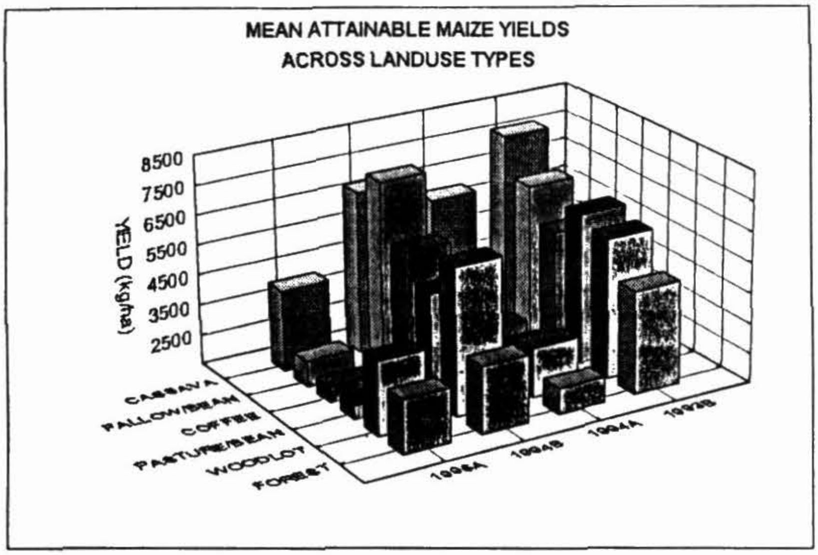
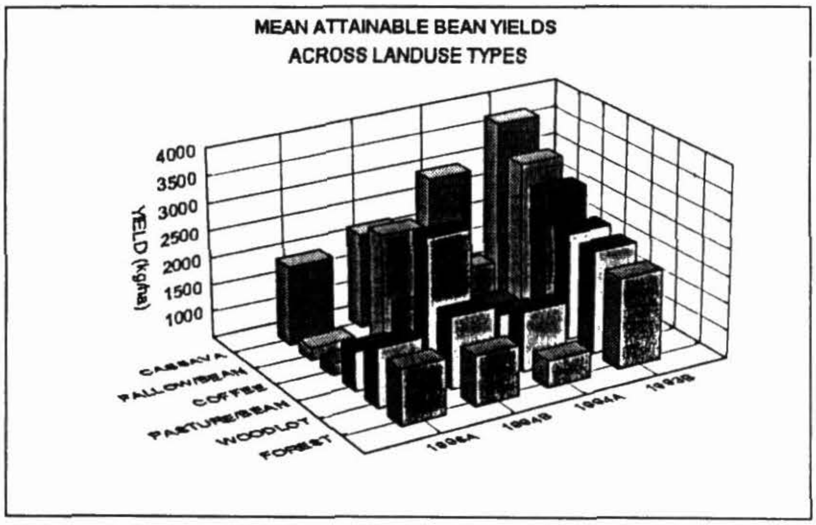


Figure 2.3



MEAN ATTAINABLE CASSAVA YIELDS
ACROSS LANDUSE TYPES

Figure 2.4

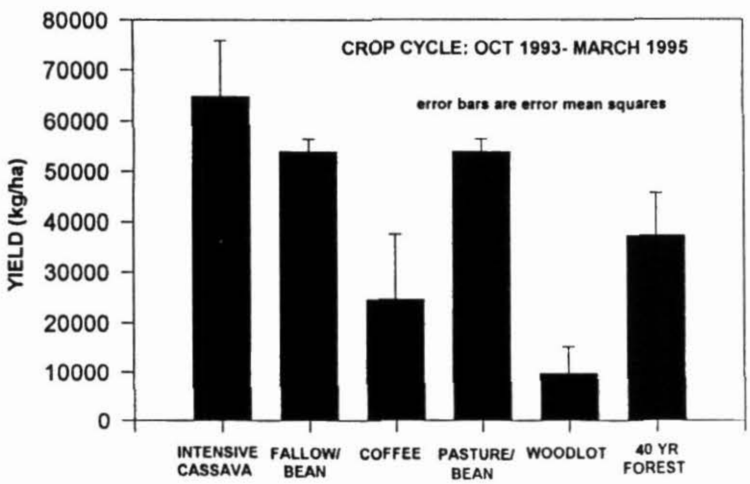


Fig. 2. 5 Directed graph showing "Path" coefficients (normalized partial regression coifficients) for variables to be analyzed for their effects on attainable yields of maize.

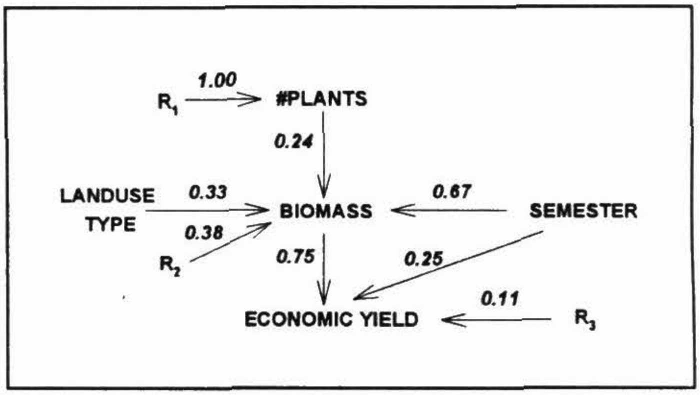


Fig. 2. 6 Directed graph showing "Path" coefficients (normalized partial regression coifficients) for variables to be analyzed for their effects on attainable yields of bean.

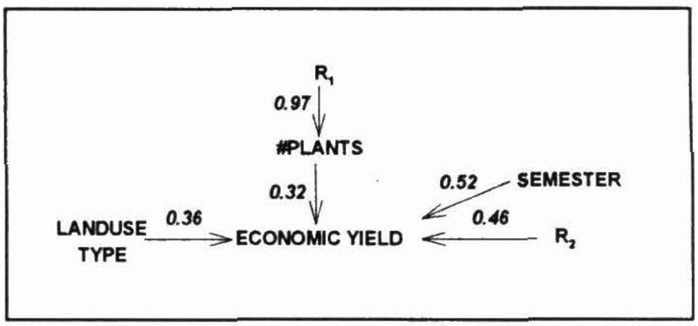


Table 2.1 Path analysis for direct, indirect and total effect of model source variables on maize and bean yields.

Dependent	Variable Source	Direct Effect	Indirect Effect	Total Effect
Maize Grain Yield:				
	Crop Cycle	.25	.50	.75
	Biomass	.75	-	.75
	L.U.T.	-	.25	.25
	# Plants	-	.18	.18
Maize Biomass:				
	Crop Cycle	.67	-	.67
	L.U.T.	.33	-	.33
	# Plants	.24	-	.24
Bean Seed Yield:				
	Crop Cycle	.52	.07	.52
	L.U.T.	.36	-	.36
	# Plants	.22	-	.22

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III. CUANTIFICACION DE LA MACROFAUNA DE SUELOS DE LADERAS DE LA SUBCUENCA DEL RIO CABUYAL, DEPARTAMENTO DEL CAUCA, COLOMBIA

Prepared by: *E. Bronson Knapp and Alexander Feijoo M.*[1]

Summary

I. Introduction

Species diversity and activity of soil fauna have been identified as making important contributions to the functioning of tropical agro-ecosystems through diverse processes including the protection of large particle size organic fractions, increases in mycorrhizal infection, improvement of soil macroaggregation with concomitant changes in porosity, the release of significant amounts of N and P, and finally, significant effects on crop production (Lal, 1994; Lavelle et al, 1993). Earthworm activity has been associated with ameliorating the pejorative effects of tillage operations thereby affecting the resilience of intensively cultivated cropping systems. A survey of farmers in the study site showed that farmers believe that the presence of earthworms in a field indicate a higher level of soil quality. Consistent with this belief is the initiative of a local NGO for promoting earthworm culture and compost as an alternative soil amendment to chicken manure and inorganic fertilizers.

A survey of macrofauna populations carried out by the CIAT Lowlands Program in the ICA-CIAT CNI-Carimagua, Colombia research station has shown a remarkable effect of different land management systems on the soil fauna, with crops of rice and cassava virtually eliminating earthworms, termites, and ants. On the contrary, sown grass pasture maintained the degree of biodiversity of the gallery forest and native savanna, and when a legume was sown with the grass, a significant increases in earthworm biomass was measured (M.Fisher, personal communication).

This activity aims to compare and contrast macrofauna density, total biomass and the species diversity of earthworms across a range of land use types in a typical Andean Hillside watershed. If significant differences are observed for individual or categories of land use types, we will pursue a line of research into the use of ratios of soil macrofauna biomass carbon to soil organic carbon as an indicator of quantitative and qualitative changes in soil organic matter. Studies by Sparling (1992) and others have shown correlations between soil microbial biomass and soil organic matter ratios may be sensitive predictive indicators of changes in SOM.

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[1] CIAT Hillsides Program

2. Methods

The protocol of the methodologies have been formalized by Prof. Patrick Lavelle in the Handbook of methods of the Tropical Soil Biology and Fertility Network (TSBF, 1989). The standardization of methods makes this study complementary with the study being carried out in the Colombian savannas by the CIAT Lowlands Program as well as other studies of Prof. Lavelle's in Mexico and Peru.

For this study, a range of ten Land Use Types were sampled biweekly during both the wet and dry seasons. Of the ten, six are the same as described in Activities I and II above. The additional Land Use Types include a pure pine forest, a fallow dominated by *Brachen* fern, a fallow of mixed species, a kikuyo (*Pennisetum clandestinum*) pasture, and an improved *Brachiaria* pasture (similar to the perennial pasture site of Activities I and II).

3. Results

The complete analysis of the survey is not yet available. Nevertheless, early results indicate macrofauna density, biomass and species diversity of earthworms vary considerably across LUT both with respect to sampling depth and date. This is an important finding because variable sampling periods will add variability to survey results in the event a soil quality indicator based on macrofauna index is a possibility. Initial factor analysis (principle components) resulted in 3 factors accounting for 88% of the total variance in macrofauna density. Factor 1 accounts for 48% of the variance and can be interpreted as a termite/myriapod/aracnid factor which is associated exclusively with the undisturbed secondary regrowth forest. Factor 2 accounts for an additional 25% of the total variance and can be interpreted as an ant/beetle (coleoptera spp.) factor. The third factor accounts for an additional 15% of the total variance and can be interpreted as an earthworm factor. In contrast to the savanna study, termites seem to have a much reduced importance, only being significant in the undisturbed secondary regrowth forest which also showed the greatest macrofauna density. (Table 1)

4. Future research

Work is continuing to define trophic earthworm groups and correlate these to organic mater states across LUT. In addition, results of this survey will be related to the results of Sections I and II above to draw inferences about the validity of macrofauna biodiversity, and perhaps derived indices like macrofauna biomass and soil organic carbon ratios as sensitive predictive indicators of irreversible soil degradation or agents for soil regeneration.

In instances where NO significant differences in existence of particular species across diverse land use is found, research will look at those widely adapted species as agents for hastening ***in situ*** regeneration of degraded soil.

III. CUANTIFICACION DE LA MACROFAUNA DE SUELOS DE LADERAS DE LA SUBCUENCA DEL RIO CABUYAL, DEPARTAMENTO DEL CAUCA, COLOMBIA

Prepared by: *Alexander Feijoo M.*[2]

La diversidad y actividad de la fauna del suelo se ha determinado para sitios de latitudes tropicales y se ha mostrado su importacia acerca del papel que cumplen. Son recientes los trabajos sobre cuantificación de macroinvertebrados del suelo que relacionan su importancia en ambientes tropicales y el impacto que ocasiona sobre ellos la perturbación del ambiente (Collins, 1979, 1980; Lavelle y Kohlmann, 1984; Lavelle y Pashanasi, 1989; Decaens, 1993).

Los macroinvertebrados del suelo como lombrices, coleopteros, hormigas, termitas y otros artropodos del mantillo juegan papel importante en la regulación de los procesos del suelo puesto que ingieren una mezcla de partículas orgánicas y minerales, que al excretar son de gran tamaño y contienen mayor cantidad de materia orgánica; además, han desarrollado un sistema eficiente de digestión mutualístico en asociación con la microflora, que es ingerida con el alimento consumido, el cual permite digerir los sustratos más complejos, y crear diversas y abundantes estructuras en el suelo que tienen efecto sobre las propiedades físicas y en la pedobiocenosis. La abundancia y textura de estos materiales son determinados por las tasas de consumo y la ingestión de partículas minerales y orgánicas (Lavelle, 1994). Las excretas son componentes de macroagregados y estructuras estables que regulan la porosidad, agregación, densidad aparente y otras características superficiales (Bal, 1982). El objetivo de este trabajo es comparar la diversidad, abundancia y biomasa de la macrofauna de suelos de laderas con diferente uso de la tierra de la Subcuenca del Río Cabuyal.

Area de estudio:

El trabajo se realizó en la subcuenca del Río Cabuyal, con 7.000 ha y aproximadamente a 120 km de Cali, entre 76° 33' - 76° 30' longitud oeste de Greenwich y, 2° 42'- 2° 52' latitud norte; con alturas que van desde 1250 a 2300 metros. Los sitios de muestreo se situaron en la parte media (1450 - 1550 m.s.n.m.) y alta (2000 - 2200 m.s.n.m.) de la subcuenca.

Sitos seleccionados para el estudio:

El estudio se llevó a cabo durante la temporada seca de 1994 entre los meses de abril y septiembre, en diez sitios seleccionados por el equipo de trabajo del "Programa de Laderas", CIAT, de acuerdo con el tipo y frecuencia de uso de la tierra:

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[2] CIAT Hillsides Program

a. **Selva Secundaria (S.S.)**

La vegetación de este sitio aun conserva las características de la selva Subandina, es estratificada y de distribución horizontal y vertical con gruesas lianas y árboles con protuberantes bases de sosten, columnarios y lisos, con "copas y subcopas en forma de cúpula" tipo **Quercus sp,** conforman el dosel, mientras que en el sotobosque se destacan arbustos acompañados de helechos, heliconias y el complejo epibiofítico (anexo 1).

b. **Sucesión de 40 años (S. 40)**

Sitio donde se taló la vegetación original para introducción de pastizales (**Panicum maximun** y **Melinis minutiflora**), posteriormente se abandonó y permitió durante aproximadamente 40 años, el recrecimiento de vegetación de tipo secundario. Los árboles no son de gran tamaño y se destacan algunos arbustos de miconias, Cecropia, Philodendrum, Tectaria (anexo 1).

c. **Sucesión de más de 40 años (SU+40)**

Sitio caracterizado por la extracción y quema de madera para venta de carbon. Los árboles para quema se seleccionan, se talan y posteriormente son colocados en un sitio (zanja o hueco) donde se amontona la madera para luego quemarla. Aquí no se practican quemas generales, lo que permite que sobrevivan grandes árboles, que no son aptos para extracción de carbón. La vegetacion es estratificada y predomina entre otras la especie **Quercus humbolti.**

d. **Matorral Helecho (M.H.)**

Los agricultores permiten el descanso de los lotes cultivados durante uno a tres años, luego de dos o tres cosechas. En este tiempo germinan las semillas de las especies vegetales que se favorecen con la perturbación y éstas mejoran las condiciones para que proliferen otras que benefician el suelo por su aporte y cobertura.

e. **Cultivo Tradicional de Café (C.E)**

Cultivo con presencia de diversos estratos conformados por café, platano, banano, cítricos, guayaba, piña y leguminosas (**Inga sordida** y acacia), además de otras especies de porte arbustivo, dosel y arvenses (anexo 1). Este cultivo se caracteriza además por las bajas aplicaciones de insumos (fertilizantes, hebicidas, fungicidas) y la no ruptura del suelo (anexo 1).

f. **Cultivo de Pino**

Predomina en monocultivo la especie **Pinus patula**

g. **Cultivo Asociado de Yuca, Fríjol y Maíz**

Antes de la temporada de lluvias el suelo se prepara con tracción animal y se aplica abono orgánico (gallinaza), se siembra y después de tres meses se cosechan el fríjol y maíz; la yuca permanecerá sin riego 14 a 16 meses hsta la cosecha. Los muestreos se realizaron recien ocurrida la cosecha de fríjol y maíz y con tiempo de siembra de la yuca entre 3 a 8 meses.

h. Pradera de kikuyo

Pastizal que predomina después de los 1800 m.s.n.m en la región Andina colombiana. Al igual que las otras praderas no se le aplican insumos y solo se garrotea el helecho (Pteridium sp) para evitar la competencia con el pasto. Asociados con el se encuentran **Cuphea racemosa, Clidemia sp, Paspalum costaricensis, Hypochaeris rabicata**.

i. Pradera de Yaragua (Melinis minutiflora)

Cultivo introducido en las laderas colombianas después de 1920; los agricultores de la región no utilizan insumos de origen químico para controlar "malezas", sino que garrotean las especies indeseables.

j. Pradera de Brachiaria

La Brachiaria aparece acompañada por vegetación arvense y en ocasiones arbustos. Se introdujo en la subcuenca a finales de la década de los 80. (Anexo 1).

Método de muestreo de la fauna del suelo:

Los muestreos se realizarOn siguiendo la metodología del Programa T.S.B.F. (Lavelle, 1988a; Anderson e Ingram, 1989), en cada sitio se tomaron 10 muestreos al azar en un volumen de suelo de 25 x 25 x 30 cm de profundidad, con un mínimo intervalo de 50 m entre muestreo; para la separación de éste monolito se abre una zanja alrededor para evitar que la fauna se escape; luego, se separa el monolito manualmente en cuatro estratos (mantillo, 0-10, 10-20, 20-30), posteriormente se conservaron las lombrices de tierra en formaldehido al 5% y los invertebrados restantes en alcohol al 70%.

La fauna se agrupó de acuerdo con la mayor frecuencia de ocurrencia en lombrices, hormigas, termitas, coleopteros, miriápodos, arácnidos y otros. Se determinaron las unidades taxonómicas (Orden, Familia, Especie) y midió densidad y biomasa de los organismos recien coleccionados. Para medir la biomasa se toman los organismos de cada taxón encontrados por capa y se pesan, posteriormente los datos son extrapolados de 0.062 a 1 m^2

Resultados:

Cuatro situaciones se presentan con relación al uso de la tierra, Selva Secundaria, Sucesiones, Cultivos y Praderas.

La Selva Secundaria (Figuras 1 y 2) tiene alta riqueza taxonómica (57 unidades), alta densidad de población (6790 ind/m^2) y biomasa (98.62 g. m^2) (Cuadro 1). El 32 y 35 % de la población se encuentra en las capas 0 - 10 y 10 - 20 cm, sin embargo, otra proporción se halló en hojarasca (12.6%) y 20 - 30 cm (19%) (fig. 3). Las comunidades de coleopteros son el mayor componente de la biomasa (52.2%), seguido por termitas (13.2%) y lombrices (12.5%) (fig 3). La diversidad de lombrices fue alta (9 especies) con una mayor proporción en las capas 0 - 10 (58%) y 10 -20 cm (26%) (Fig. 4, Anexo 2).

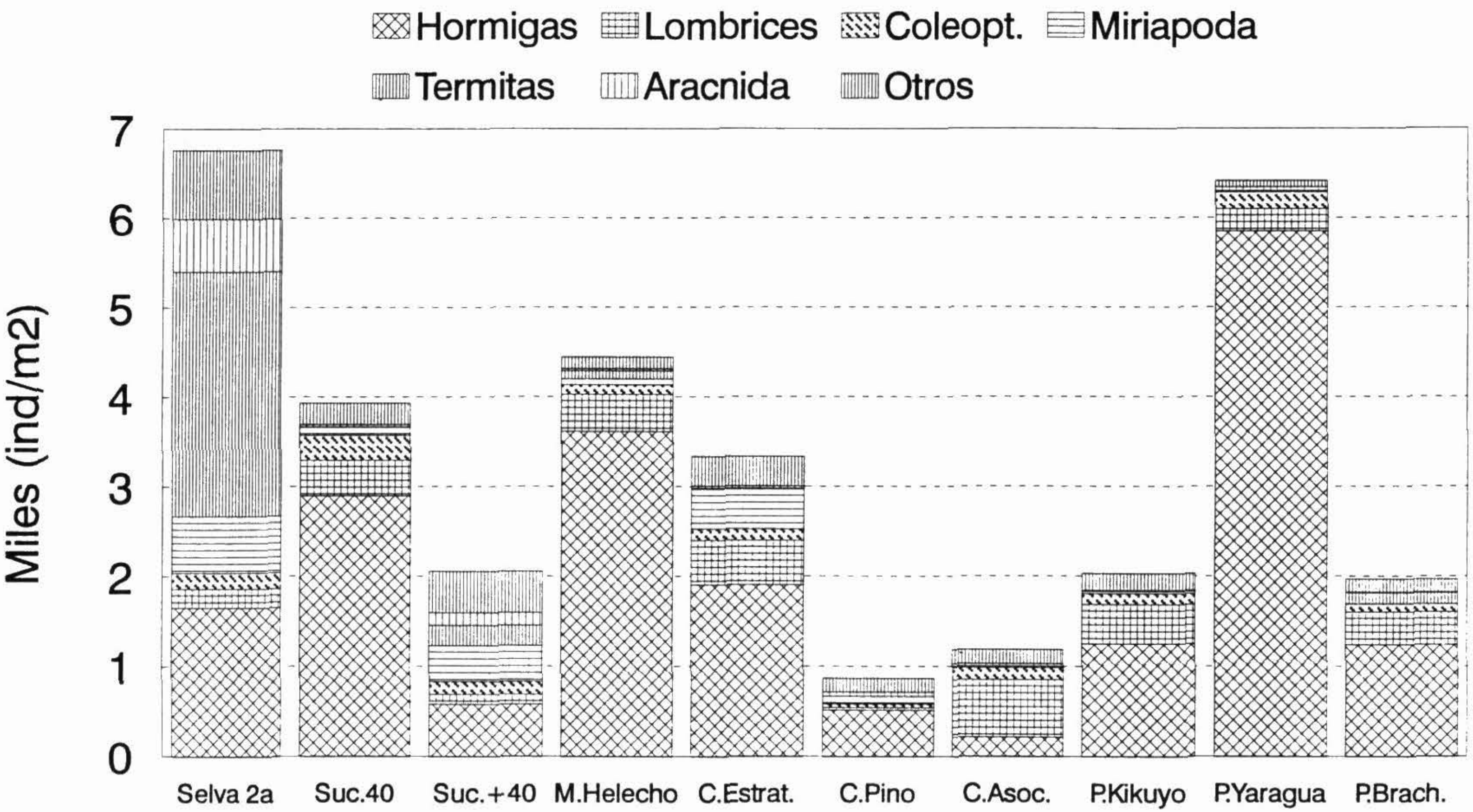
Las Sucesiones de 40 y más de 40 años presentaron valores para diversidad cercanos (26 y 29 respectivamente), aunque diferentes en densidad de población (2056 y 3932 ind/m^2) y en biomasa (27.04 y 91.42 g.m^2). La distribución vertical porcentual para los dos sitios está más concentrada en el mantillo (15. 8 y 19.8%) y en 0 - 10 cm (66.8 y 44%) que en la Selva Secundaria. Las lombrices (81 y 26.6%) y coleopteros (10.4 y 20.6%) son el mayor componente de la biomasa. La diversidad de lombrices es alta para los dos sitios (7 y 5 especies) mientras que la distribución vertical está regida por aquellas que se encuentran en la capa 0 - 10 cm (57.7 y 50.8%).

Los cultivos Estratificado, Asociado y Pino presentan diferencias en densidad (3352, 1187 y 870 ind/m^2) y alta biomasa para el primero y segundo (115.78 y 78.97 g.m^2 respectivamente) y la más baja de los sitios en el tercero (3.19 g.m^2); la diversidad es baja comparada con la selva (22, 16 y 13 respectivamente). La fauna se encontró en mayor proporción en las capas 0 - 10 y 10 - 20 cm . En C.E y C.A la biomasa está dominada ampliamente por las lombrices (79.45 y 80.8%), con 4 especies cada uno concentradas en la capa 0 - 10 cm (62.1 y 40.9% repectivamente), seguido por coleopteros (8.9 y 17.1%); mientras que en C.P. las poblaciones son bajas y prevalecen los coleopteros con 73.98%; sólo se colectó una especie de lombriz con predominio (40.9%) en la capa 0 - 10 cm del suelo.

En las praderas de Kikuyo, Yaraguá y Brachiaria la fauna está restringida a la capa 0 - 10 cm (78.4, 62.9 y 52.1%) del suelo y la diversidad disminuye drásticamente (14, 19, 11 unidades taxonómicas). La densidad oscila entre 2038, 6443 y 1965 ind/m^2, con el dominio de hormigas, especialmente en la pradera de yaraguá, mientras que la biomasa osciló en 67.9, 33.9 y 73.4 g.m^2, con mayor aporte de biomasa de lombrices y coleopteros para kikuyo (83.4, 13.8%) y Brachiaria (77.9, 16%) y, coleopteros (64%) y homigas (21.5%) en Yaraguá. Se hallaron 6, 4 y 1 especies de lombrices respectivamente con mayor ocurrencia en la capa 0 - 10 del suelo (53.1, 63.3 y 73.8%).

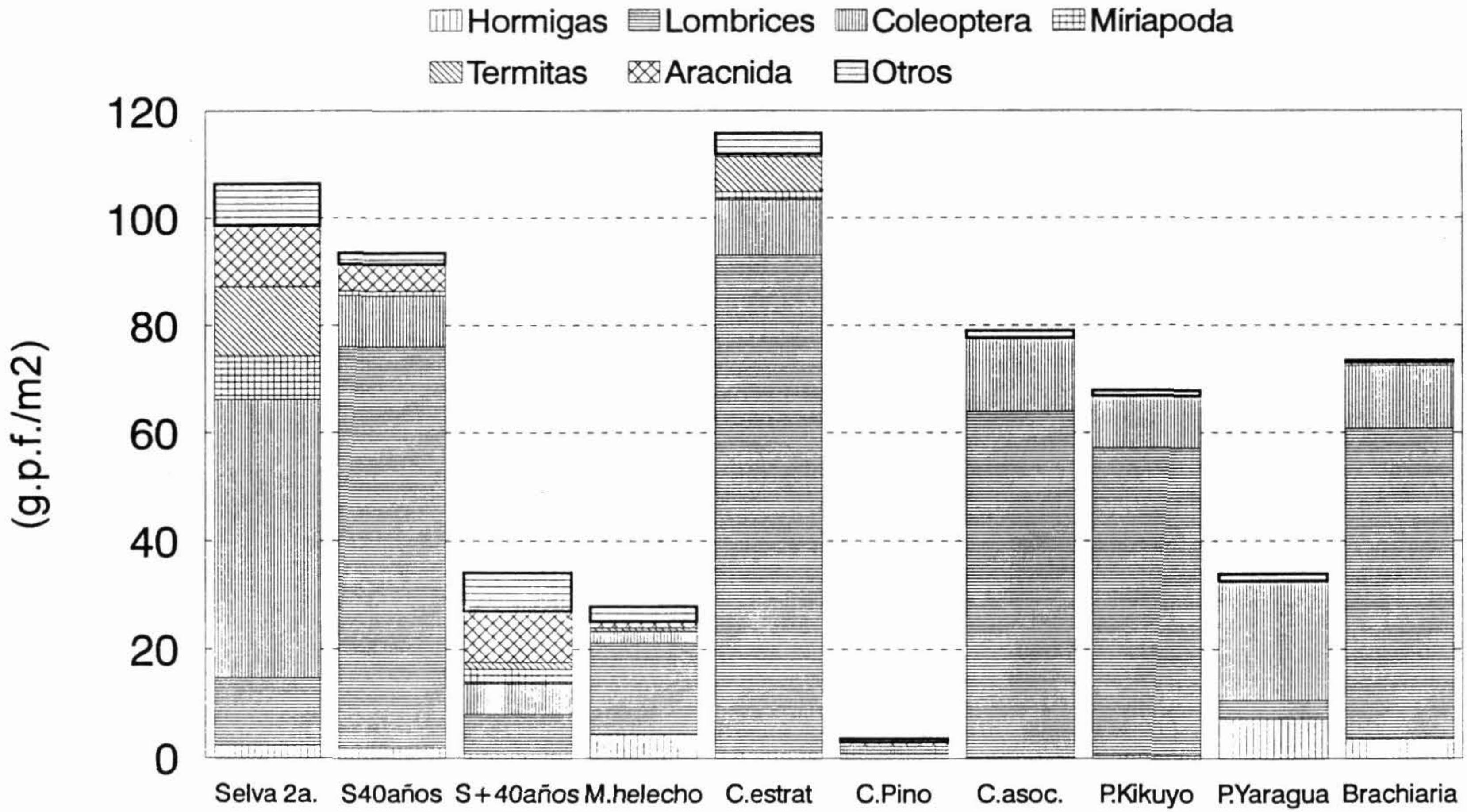
El Matorral Helecho considerado como el estado intermediario entre los anteriores presentó baja diversidad (19 unidades) alta densidadd de población (4464 ind/m^2) y baja biomasa (26.28 g/m^2). El mayor aporte en biomasa lo hacen lombrices (64%) y hormigas (17%). La fauna se encontró en mayor proporción en las capas 0 - 10, 10 - 20 cm del suelo (44.6 y 37.9%). Se encontraron 5 especies de lombrices con mayor distribución vertical en la capa 0 - 10 cm del suelo (66.7%) (fig. 4, anexo 2).

Fig. 1. DENSIDAD MACROFAUNA SUELOS LADERA



Suc.40=Sucesion de 40 anos; +40=de mas de 40 anos; M.=Matorral; C.=Cultivo; P=Pradera

Fig. 2. BIOMASA MACROFAUNA SUELOS LADERAS



S=Sucesión; S=de más de 40; M=Matorral; C=Cultivo;Asoc.=Asociado; P=Pradera

Figure 3. Vertical distribution of macrofauna in hillsides soils.

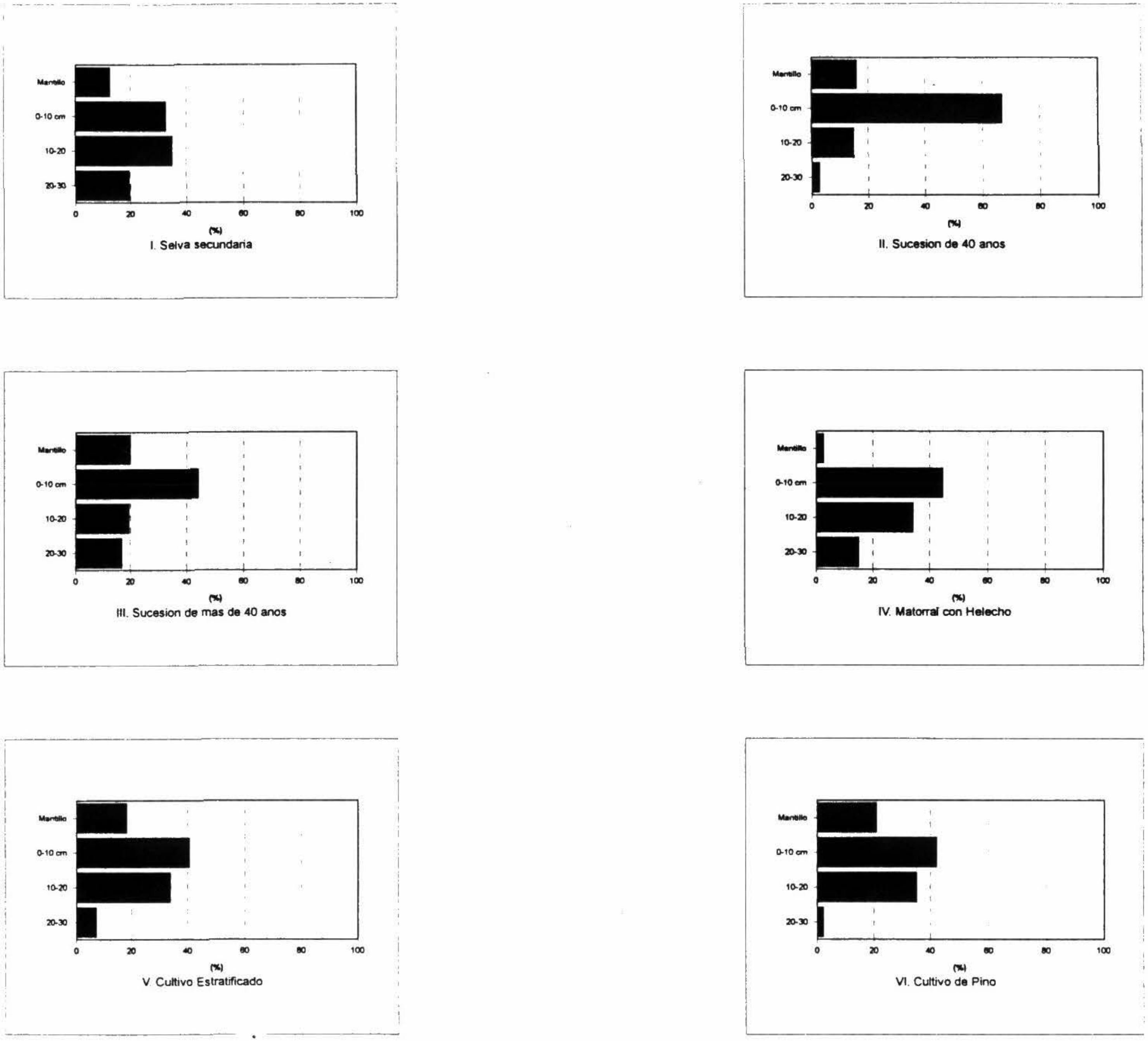


Figure 3. (Cont.)

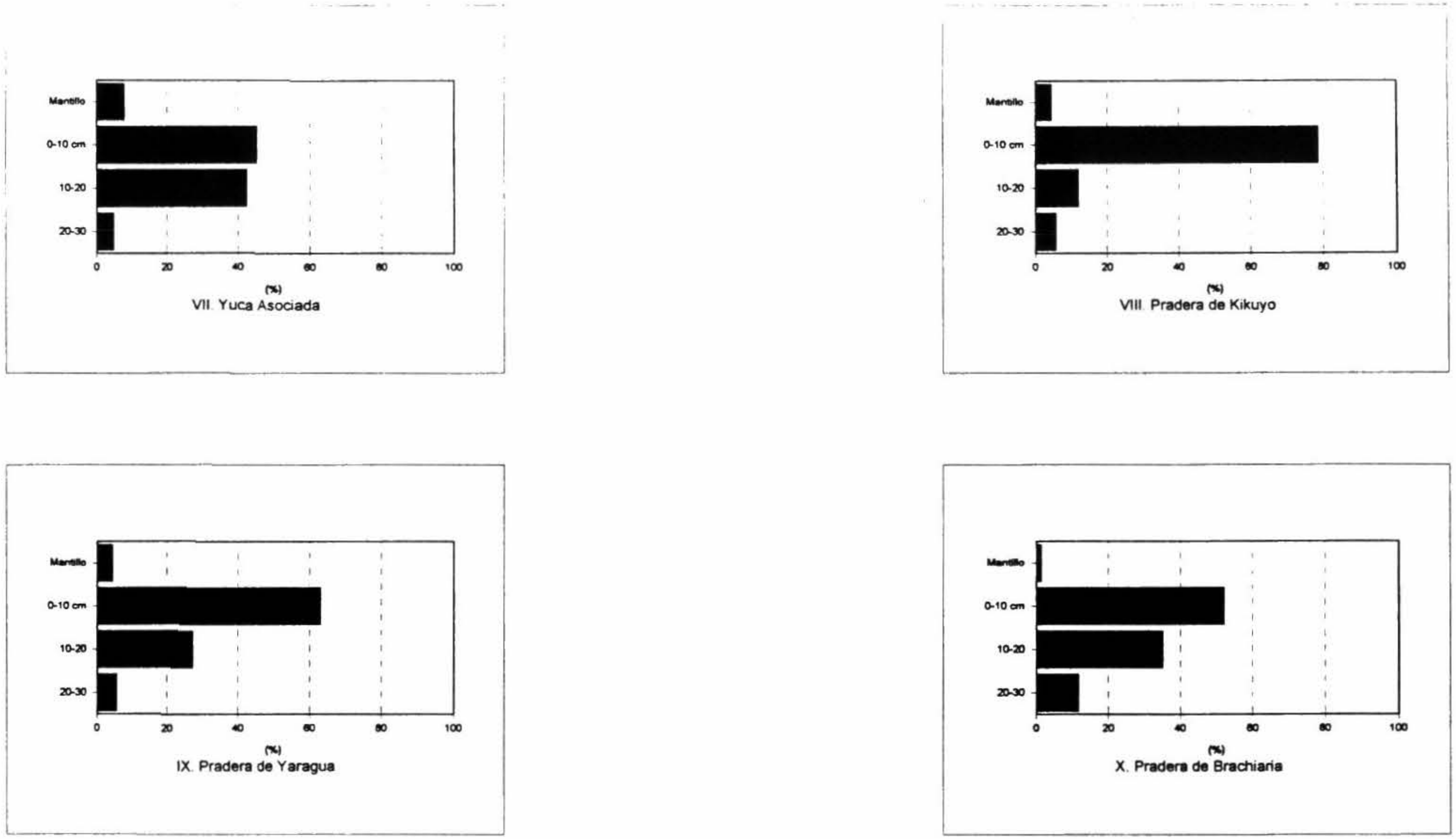
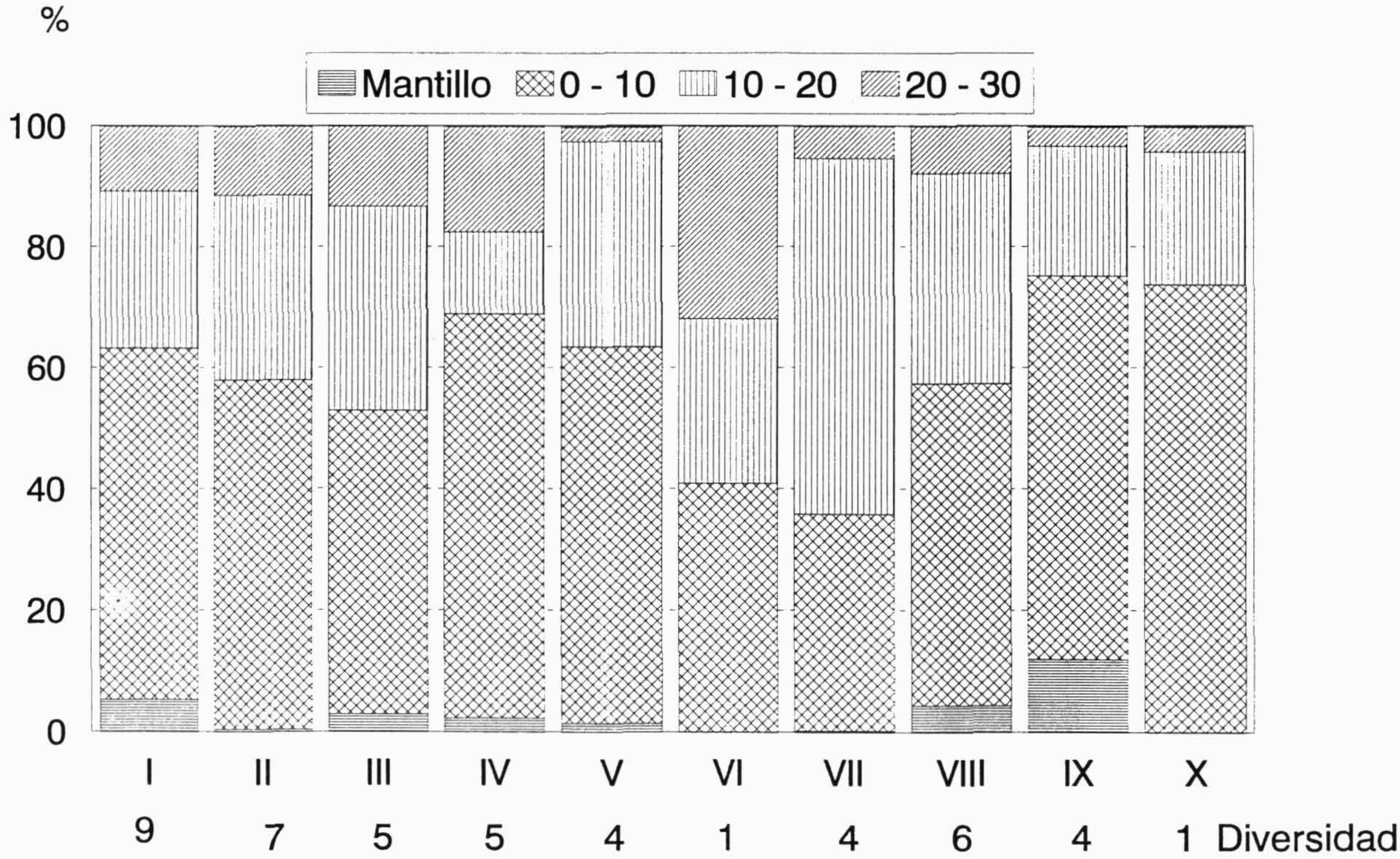


Fig.4. PROPORCION ESPACIAL Y ESPECIES DE LOMBRICES EN LOS USOS DE TIERRA

Ind./m2 SUBCUENCA RIO CABUYAL



Cuadro 1. Diversidad, Densidad y Biomasa promedio de la macrofauna en 10 sitios

USO DE LA TIERRA	No. Unidades Taxonómicas	Densidad Ind/m	Desviación Estandar	Biomasa x̄ g.m.f/m²	Desviación Estandar
Selva 2a.	57	6790	7019	98.62	150.3
SUCESIONES					
S. 40 años	26	2056	5542	27.04	42.8
S. +40 años	29	3932	1560	91.42	13.98
M. Helecho	19	4464	6254	26.28	35.6
CULTIVOS					
Café Tradicional	22	3352	3020	115.78	132.2
Pino	14	870	1076	3.19	2.1
Yuca Asociada	16	1187	951	78.97	46.2
PRADERAS					
Kikuyo	14	2038	1426	67.9	52.4
Yaraguá	19	6443	3133	33.9	23.1
Brachiaria	11	1964	2176	73.41	16.1

Anexo 1. Vegetación que tipifica los sitios muestreados

a. Selva Secundaria (S.S.)

Algunas de las especies dominantes son las siguientes: **Clidemia hyrta, Miconia minutiflora, M. rubiginosa, Acalifa diversifolia, Calea glomerata, Vismia baccifera, Chamaerodea brebifons, Laciacis sorghoidea, Crotom sp, Centropogon sp, Adianthum sp, Maratia sp, Pilea sp, Cacedalia silvestris, Dyapteris sp, Piper aduncum, Anthurium cordatum, Hediosmun sp, Palicourea coerulea, Palicourea sp 1, Palicourea sp 2, Palicourea sp 3, P. obesiflora, P. congespa, Solanoidas sp, Hyptis paniculata, Calea glomerata, Pteridium sp, Filodendrum sp, Rhynchospora sp, Clavya lancifolia, Miconia minutiflora, M. lepidota, Callaponia sp, Piper crassinervium, Chamaerodea sp, Cecropia eximia, Eugenia sp, Myrcinae ferruginea, Dioscorea sp, Sauraia sp, Stigmaphilum, Ciperus sp, Anthurium sp, A. caucanum, A. giganteum, Clarisia caucana, Mimosiopsis quitensis, Gonzalagia cornifolia, Myrica popayanensis, Clibadium surinanensis, Besleria solanoides, Duranta sp, Cococicelum sp, Fitonia sp, Urera baccifera, Vismia baccifera, Maripa sp, Elaegia sp**; en los márgenes donde la vegetación recrece se encuentran ejemplares de **Cecropia sp.**

b. Sucesión de 40 años

Miconia lepidota, M. stenostachia, Miconia sp, Ocotea sp, Koheleria sp, Cavendishia sp, Palicourea sp, Aegiphila sp, Philodendrum sp, Tectaria sp, Monozia sp, Myrcinae sp, Chamaerodea brebifons, Hediosmun sp, Serjania paniculata, Paulinea sp, Anthurium myceouroides, Melochia lupulina (Paspalum sacharoides, Ditassa cauScleria floribunda, Vernonia brasiliensis, Licaria sp, Croton junckianus, Hyptis conjerta, Cocosipselum hirsutums, Myrsinia guianensis, Sobralia sp, Rinchospora sp, Anaemia bellosa, Eupatoprium amigdalinum, Baccharis sp, Muehlenbergia emerskeyi, Palicourea augustifolia, Lacistema purpurea, Rhynchospora aristata, Quercus humboltii (Roble), Laciacis sorghoides, Miconia rubiginosa, M. cana, Rebulium sp, Piper aduncum, Eupathorium gracile, sobralia sp, Blechnum occidentale, Andropogon bicornis, Cordia occidentalis, Clethra faginaa, Calea glomerata, Verninia brasiliense, Catasetum ochraceum, Tococa guianensis, Sheflera monototoni, Chromolaena odoratha, Cecropia sp, Myrcinae guianensis, Stylosantes guianensis, Rebulnium hipocarpum, Irlbachia alata, Lantana rugulosa, Mikania banisteriae, Licaria sp, Styrax sp.

c. Sucesión de más de 40 años

Polipodium percusu, Danaea grandifolia, Dicanopteris sp., Cavendishia quereme, Rhynchospora aristata, Palicourea sp, P. augustifolia, P. obesiflora P. congesta, Myrcinia ferruginea, Lacistema purpurea, Quercus humboltii, Laciacis sorghoides, Hediosmun sp, Solanoides sp, Miconia sp, M. minutiflora, M. lepidota, Callaponia sp, Piper crassinervium, Chamaerodea sp, Acotea sp, Cavendishia sp, Palicourea sp, Aegiphila sp, Philodendrum sp, Tectaria sp, Monozia sp, Myrcinae sp, Sauraia sp, Ciperus sp, Chamaerodea brebifons, Myrica popayanensis, Hediosmum sp, Serjania paniculata, Paulinea sp, Anthurium myceouroides, Besleria solanoides.

d. Matorral Helecho

Se encontraron las especies **Pteridium sp, Myrica pubescens, Mimosiasis quitensis, Eupatorium odoratum, E. inulaefolium, Hipochaeris radicata, Delostoma roseum, Hyptis brachiata, Polpogon elongatus, Sida acuta, Axonopus affinis, Pectis bonplandiana, Aegopogon cenchroides, Cuphea racemosa, Miconia versicolor, M. micrantha, Miconia sp 1, Naphalium spicatum, Richordia seabra, Rubus urticaefolius, Marcipiantes chamaedris, Hyptis sp, H. artroruberis, Austroeupatorium inulaefolium, Hyptis sp 2, Sporobolus purpuracens, Clidemia sp, Ayapana migdalina, Budleia sp, Pteridium sp, Befaria sp, Panicum sp, P. purchelum, Rinchospora blefarofora, Pectis graveoleus.**

d. Cultivo Tradicional de Café

Spermacoce assurgens, Pseudochinolaena polystachia, Nectandra sp., Maytenus novogranatensis, Erechtites valerianaefolia, Melochia lupulina, Paspalum pictum, Pteridium sp., Eugenia fambos, Monina sp., Hypoxis decumbens, Rivina humilis, Panicum viscedellum, Sida rhombifolia, Sida linnifolia, S. spinosa, S. acuta, Merremia umbelliata, Salvia splandes, Phillantum niruri, Spermacoce capitata.

i. Pradera de Yaragua

La vegetación acompañante es de porte rastrero, entre ellas se destacan **Desmodium barbatum, Pteridium, Hyptis capitata, Melochia colombiana, Stachitargeta jamaicences, Homolepis atoresis, Conisa bonariensis, Stylosantes guyanensis**

j. Pradera de Brachiaria

Neobarletia paezense, Soralia sp, Eupatorium sp, Hyptis capitata, Polygala paniculata, Miconia stenotachia, Turnera ulmifolia, Mèlochia pyramidata, Conyza bonariensis, Hyrbachia sp, Miconia sp, M. rubiginosa, Pteridium sp, Clidemia hirta, Bochoca prismatica, Aechinomene virginica, Bocopa sp, Anemia vellosa, Cuphea racemosa, Baccharis tricuneata, Paspalum pilosum, Rhynchospora barbata, Eleocharis filicumis, Polygala paniculata, Spermacoce assurgens, Andropogon bicornis, Emilia sonchifonia, Agerathum conyzoides, Hemidiodia acymifolia, Seudoelephantopus spiralis, Waltheria americana, Atrorubens, Cuphea micrantha.

Anexo 2. Lista de Unidades taxonómicas

Lombrices de tierra

Glossoscolecidae

Martiodrilus heterostichon II
Martiodrilus sp 2 I, II, III, IV, VII
Martiodrilus agricola I, III, IV, VIII
Martiodrilus savanicola I, II,III, VIII
Glossodrilus sp 1 I, II, III, IV, V, VI, VII, VIII, IX
Desconocida I
Onoreodrilus sp I
Periscolex sp I, II, V, IX
Thamnodrilus sp I, III, IV
Pontoscolex corethrurus II, V, VII, VIII, IX, X

Megascolecidae

Amynthas corticis IV, VIII
Amynthas gracilis II, VII

Octochaetidae

Dichogaster sp 1 I
Dichogaster sp 2 VII, IX

Lumbricidae

Dendrobaena octaedra IV, VIII

ISOPTERA I, II, III, IV, V, IX, X

HYMENOPTERA
Formicidae I, II, III, IV, V, VI, VII, VIII, IX, X
Bethylidae I

COLEOPTERA
Melolonthidae I, II, III, IV, V, VI, X
Rutelinae I
Cyclocephala sp X
C. aff. amazonal X
Dichotomius aff. septentrionalis I
Veturius sp I, VIII
Heterogomphus chevrolati I, II, IV, IX

Melotinae I
Macraspis sp I

COLEOPTERA (cont.)

Carabidae II
- Celenophorus sp I, X

Tenebrionidae I, VII

Staphylinidae I, II, III, VIII, IX, X

Lampyridae I

Elateridae III, V

Scarabidae I, II, IX
- Oxisternom conspicillatum I, II, III, IV, IX

Scaphidiidae (micófago) I

Curculionidae I, II, VI

Ptilodactylidae (depredador) III

Nitidulidae I, III

Tenebrionidae VII

Crisomelidae
- Casidinae I

Passalidae
- Passalus sp I, X

ARACHNIDA
- Opilionida I, II, III, V, VI, VII, VIII
- Pseudoescorpionida I, II, III, IV, V, VI
- Escorpionida I, III

MYRIAPODA
- Chilopoda I
  - Scolopendromorpha I, II, III
- Diplopoda
  - Polydesmidae I, II, III
  - Sporobolidae I, II, III, IV, VI

PROJECT 2: Decision support systems for land use planning and technology design

Purpose: **To process information from strategic research in the form of decision-support systems to assist consensus-building among stakeholders, about plans for agricultural land use and for protection of ecologically gragile areas in the hillsides.**

I. EX-ANTE IMPACT ANALYSIS USING SIMULATION AS A TOOL FOR DECISION-SUPPORT SYSTEMS

Prepared by: *E. Bronson Knapp*, *P.* Urbano[1], *W.B. Bell*[2], *and J. E. Rubiano*[3]

Introduction:

ABSTRACT: "Changes in Land Cover/Land Use as a Possible Indicator of Sustainable Development in a Hillside Environment of Rio Cabuyal in Cauca, Colombia"

This research activity supports efforts for developing prototype interactive, computer-based decision-support systems to enhance community-scale participatory research and development. The objectives of this study were to quantify the evolution of land cover/land use (LC/LU) across 5392 ha in the case study site using using micro-computer based Geographic Information System (GIS) technology and advanced technology geographical databases. The changes in LC/LU were quantified in the traditional manner using airphoto interpretation for the years 1945/46, 1970 and 1991 at a working scale of 1:30000. The resolution of interpretation is approxamately 3 ha. Soil taxonomic units were digitalized from 1:50000 government soils maps. Topogaphic data was derived from digital-ortho photographic interpretation and a digital terraine model. Control points were developed from extensive fieldwork. Quality of infrastructure and accessability were defined as the euclidean distance from the principle settlement on the highway that divides the study area nearly in half.

Seven LC/LU types were studied; Natural forest (BN), pine plantation forest (BP), mature bush fallow (CD), improved pasture/fallow, multiple-cycle crops (CS), e.g., coffee, sisal, sugarcane, monocropped and intercropped cassava, intensive cropping (CL), e.g, horticultural crops, drybean, maize, burned/prepared land, overgrazed pasture/new fallow (RA), degraded land (SE), e.g., landslides, eroded pasture.

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Results indicate that 77% of the area has slopes between 12 and 70%. Sixty-six percent of the area has poor access which is also where more than 90% of the forest is found. Even in 1946, only 9% of the area was forested, by 1970 the total area was 6% but by 1991 the area in natural secondary regrowth had climbed slightly to 7% with an additional 1% in pine plantation (Fig 1). Analysis across the three time periods shows land mapping units have been rotated into and out of different LC/LU types across time. Fig 3 shows changes in land use suitability for four periods using a government index which includes soil and slope data. On balance, the suitability proportions of LC/LU aggregated at the three dates seem to have changed little over the past 50 years.

Antecedentes:

El estudio de los cambios de uso de la tierra en la zona del Río Cabuyal forma parte del proyecto 'Desarrollo de Sistemas de Apoyo a las Decisiones' desarrollado actualmente por los programas de Laderas y Manejo de la Tierra en el Centro Internacional de Agricultura Tropical (CIAT).

En la definición o selección de un uso de la tierra por parte de los agricultores, intervienen un conjunto de factores biofísicos y socioeconómicos que interactúan indistintamente según el peso o influencia que cada uno de ellos posea en cada circunstancia y momento del tiempo en particular. Es una consecuencia lógica, que el uso que se le de a la tierra tiene un impacto sobre los recursos naturales. Este impacto es el resultado de la acción de un uso determinado y de las prácticas de manejo y/o tecnología utilizadas y puede ser mayor o menor en la medida que corresponda o no con el potencial natural. La tecnología depende a la vez de otros factores entre los que se destacan la tenencia de la tierra (Blisborrow, et.al.), y rasgos de la población (Mwalyosi, R.) como la cultura, economía y aspectos demográficos. Así, un tipo de tecnología, de propiedad de la tierra, puede indirecta-mente inducir la pérdida de materia orgánica en el suelo, fluctuaciones en los caudales o en el balance hídrico así como el despoblamiento humano.

Cuando se estudian los cambios en el uso de la tierra, interesa conocer los factores asociados a dichos cambios. Las causas y posibles consecuencias del uso que se le da a la tierra es una información clave a la hora de tomar decisiones sobre el futuro de una región (Turner II, B.L., et.al.).

El análisis de los cambios de uso de la tierra puede ayudarnos a reconocer causas y efectos de alguno de los problemas de desequilibrio físico o social detectados en ecosistemas de ladera. El uso de los sistemas de información geográfica para este tipo de estudios es una herramienta básica para manejar la cantidad y complejidad de la información involucrada (Tan, Y.R. and Shih, S.F.).

2. Objetivos

A. Identificar y analizar los cambios de la cobertura del suelo ocurridos en la subcuenca del río Cabuyal a partir de fotografías aéreas de las series 1946, 1970 y 1991.
B. Determinar la relación existente entre la pendiente y la accesibilidad con la cobertura del uso de la tierra de 1991.

3. Metodología

El método seguido se fundamenta en el análisis de sistemas. Se han definido unos límites de un sistema (la subcuenca del rio Cabuyal), en el que se encuentran unos subsistemas (fincas) que a su vez poseen unidades en su interior definidas como usos de la tierra.

Tanto los subsistemas fincas como los usos de la tierra interactúan entre sí y con el exterior y poseen una dinámica definida por la función que cumplen cada uno de ellos: producción de alimentos para el consumo y/o para el comercio, entre otras. Esta función también depende de componentes biofísicos como los tipos de suelos, geomorfología, clima, etc.

Desde el punto de vista socioeconómico, la densidad de población, tipo de propiedad, localización, la acción de las instituciones agrícolas, las políticas micro y macroeconómicas hacia el sector, etc, inciden notoriamente en la orientación o función de estos subsistemas. Este componente es parte de los objetivos pero no se desarrolla en el presente documento.

De igual modo la subcuenca en su conjunto cumple una función en relación con la cuenca mayor en que se encuentra: aporte de agua y sedimentos, y en general en el balance hídrico de la cuenca.

4. Procedimiento:

4.1 Delimitación del área de la cuenca.

En el presente estudio, los límites del sistema lo constituyen las 22 veredas que comprenden la cuenca hidrográfica del Río cabuyal en el municipio de Caldono en el departamento del Cauca. Son 3200 has al interior de la divisoria de aguas y 7366 has considerando los límites administrativos locales (veredas).

Las alturas mínima y máxima son de 1200 y 2200 metros sobre el nivel del mar respectivamente. Según la clasificación de zonas de vida de Holdridge, en la subcuenca se encuentran las zonas de vida Bosque húmedo premontano y Bosque muy húmedo premontano. El área es atravesada por la vía Panamericana que comunica Cali con Popayán a la altura del corregimiento de Pescador.

4.2 Colecta y preparación de la información básica biofísica:

- *Selección de las fotografías aéreas de la zona.*

Previa revisión de las líneas de vuelo disponibles para la zona, se seleccionaron las series de fotografías que cubrían un mayor porcentaje de la subcuenca. Se seleccionaron las series de los años 1945/46, 1970 y 1991 para la fotointerpretación. La serie de 1991 se utilizó como herramienta de trabajo para el levantamiento del uso actual en 1994, contando al final con las series de 1946, 1970, 1991 y 1994. En el presente estudio no se ha considerado el uso de 1994 dadas las diferencias metodológicas al momento de definir los usos de la tierra, sin embargo, es utilizado para identificar la relación de éste con la accesibilidad y la pendiente. El área seleccionada para los análisis es de 5392 has. dado que el área útil de las fotografías no corresponde entre las diferentes series de tiempo.

- *Fotointerpretación y transferencia del uso de la tierra para las series de tiempo seleccionadas.*

La fotointerpretación fue llevada a cabo por un fotointerprete de la Corporación autónoma regional para el manejo de Recursos Naturales en el Valle del Cauca (CVC), con más de 20 años de experiencia en la zona. La transferencia se realizó sobre la cartografía 1:25.000 del Instituto Geográfico Agustín Codazzi (IGAC), con el uso de sketchmaster también por técnicos de la CVC. La escala de trabajo fue de 1:25.000. Existen zonas que carecen de información por inexistencia de fotografías. Por otro lado, la escala y calidad de las mismas fue un limitante para la fotointerpretación, lo que incidió en el detalle y resolución de la información; 3 has. para cada polígono de uso del suelo.

- *Definición de tipos de uso de la tierra.*

De las bases de datos de cobertura del suelo de cada serie de tiempo se elaboró la estadística y variación porcentual. Los usos del suelo producto de la clasificación de campo y consignados en la fotointerpretación se agruparon por tipos, según la cobertura que ejerce sobre el suelo, con el fin de reducir el número de clases y facilitar su análisis. Las agrupaciones conformadas se presentan en la tabla 1.

- *Conversión a formato digital.*

Los mapas con las delineaciones de los usos de la tierra fueron digitalizados en el CIAT usando el módulo de digitalización de ARC/INFO y ATLAS/DRAW. Los archivos de datos de cada una de las series se transfirieron a ARC/INFO, donde se completaron los procesos de corrección y asignación de datos alfanuméricos.

- *Digitalización de la cartografía básica.*

Paralelamente, las líneas de contorno, ríos, vías y puntos geodésicos fueron digitalizados en el CIAT con base en la cartografía a escala 1:10.000 del área de trabajo. Vale la pena resaltar que esta cartografía no corresponde a restitución 1:10.000, sino a ampliaciones de la restitución 1:25.000.

El estudio de suelos llevado a cabo por la CVC y el IGAC con mapa fuente a escala 1:50.000 también fue digitalizado. En él se encuentran las diferentes asociaciones de suelos de la región definidas por criterios geomorfológicos y de características físicas y químicas de los sitios de muestreo. De los perfiles característicos de las asociaciones de cada unidad de suelos, se identificó la profundidad promedio de la capa arable así como la textura.

5. Manejo y análisis de la información:

Los resultados derivados del presente estudio hasta la fecha se relacionan en los siguientes cinco puntos:

5.1 La información del medio físico (cartografía básica del IGAC) se utilizó en un primer momento para la generación del modelo de elevación digital con el fin de generar las coberturas de pendientes del suelo. El modelo de elevación digital es la estructura física digital del terreno necesario para la realización de simulaciones de procesos físicos que suceden sobre la superficie.

Del modelo se obtuvo un mapa de pendientes que se agruparon en 4 rangos y los cuales se distribuyen así:

PENDIENTE	AREA en has.	%
. <=6%	396	5
. >6 =<12%	737	10
. >12 =<30%	2728	36
. >30 =<70%	3117	41
. >70%	584	8
Total	7560	100

El total del área aquí es levemente más alto, debido a requerimientos técnicos para la construcción del modelo de elevación. Las pendientes en esta región tienen la particularidad que se acrecientan en las partes bajas mientras que en las altas predominan pendientes suaves y onduladas.

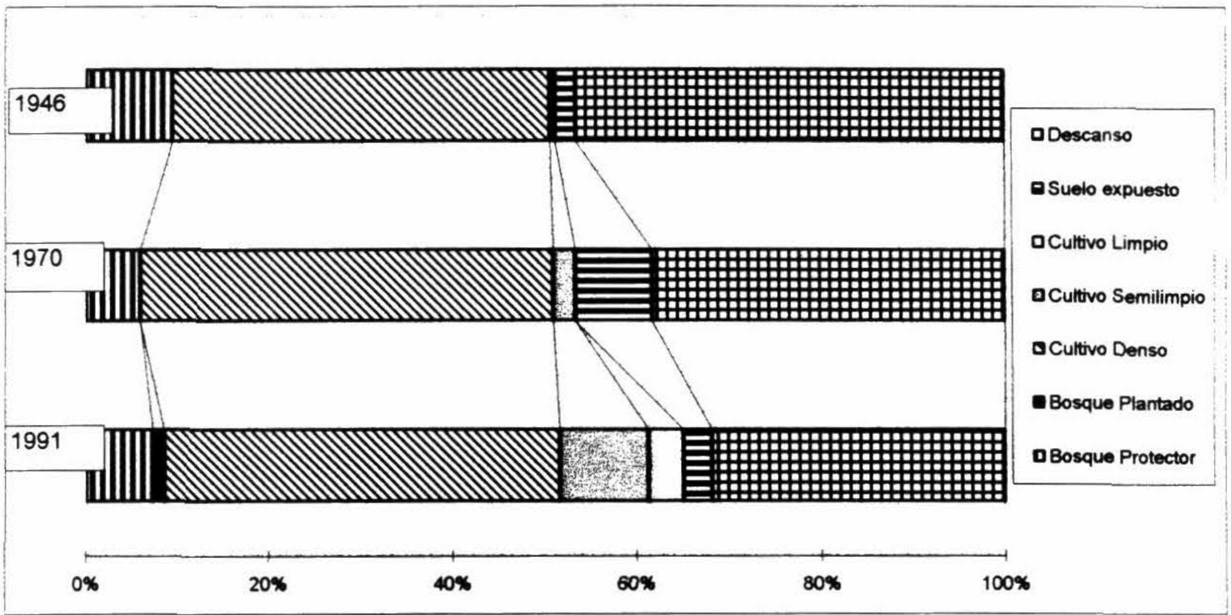
En la Figura 1 se resume esta información y en ella se puede apreciar que a lo largo de los 45 años que comprende el estudio no ha habido cambios muy significativos.

- El área dedicada al Bosque protector o Natural no ha variado en más del 2%. El Bosque plantado aparece en la última serie con un 1%, en razón de la introducción de plantaciones de Pino Kessia por parte de la Corporación Regional CVC a mediados de los años 80.
- Los cultivos Densos se han mantenido en el orden del 43 +/- 2%.
- Los cultivos semilimpios han aumentado un 8% desde 1970. En esta agrupación el café es el cultivo más representativo, muy en coherencia con la presencia que ha tenido el Comité de Cafeteros del Departamento promoviendo este cultivo en los últimos 20 años.

Fig 1. CAMBIOS EN EL USO DEL SUELO - SUBCUENCA DE CABUYAL CAUCA - COLOMBIA

USO DEL SUELO	1991	1970	1946
Bosque Protector	394	318	510
Bosque Plantado	67	0	0
Cultivo Denso	2324	2429	2219
Cultivo Semilimpio	521	129	28
Cultivo Limpio	202	0	0
Suelo expuesto	170	452	124
Descanso	1714	2063	2510
TOTAL(has)	5392	5392	5392

USO DEL SUELO	1991	1970	1946
Bosque Protector	7	6	9
Bosque Plantado	1	0	0
Cultivo Denso	43	45	41
Cultivo Semilimpio	10	2	1
Cultivo Limpio	4	0	0
Suelo expuesto	3	8	2
Descanso	32	38	47
TOTAL(%)	100	100	100



- Los cultivos limpios entre los que se cuenta el fríjol, la Yuca, el Tomate, etc., aparecen en la última serie con 4% del área. La ampliación y mejora de las vías de comunicación han permitido conectar esta región con los principales centros de comercio como Piendamó y Santander de Quilichao.

- En el caso del suelo expuesto, el área se incrementó hacia 1970 y volvió a iguales proporciones en 1991. Para este año el área en descanso se redujo en un 15% con relación a 1946.

5.2 De otro lado, se establecieron comparaciones entre duplas de series de tiempo así: 1946 - 1970, 1970 - 1994 para identificar el cambio de cada uno de las coberturas precedentes. Las diferentes coberturas del suelo para 1946 no cambian en más de la mitad al pasar a 1970. La excepción se presenta en los Bosques protectores que se ven reducidos en 1970 a la quinta parte de lo que eran en 1946.

- Sólo el 2% del área que en 1946 estaba en Cultivos Densos y en Descanso paso a ser Bosque protector en 1970.
- Una tercera parte de lo que estaba en Cultivos Densos y en Bosque protector pasó a Descanso en 1970.
- Todas las coberturas del suelo de 1946 tuvieron cambios hacia Cultivos Densos, especialmente aquellos que estaban en Bosque Protector y Descanso.
- Sólo en el caso de las áreas en descanso de 1946 se presentaron cambios hacia Suelo Expuesto en 1970.
- El suelo con Cultivos Semilimpios se mantiene en más del 90% pero áreas en Descanso y en Cultivos Densos fueron convertidas hacia este uso en 1970.
- Una pequeña parte del Suelo Expuesto de 1946 pasó a Cultivo Denso en 1970.

En el caso de la dupla 1970-1991 (Figura 2), los Bosques se reducen nuevamente en poco más de la tercera parte y las otras dos terceras partes pasan a ser ocupadas por Descanso y Cultivos Densos en forma similar a lo observado en la dupla 1946-1970.

- El área que se encontraba en Cultivo Denso da paso a áreas en Descanso y Cultivos Semilimpios y Limpios.
- Una cuarta parte del anterior área en Cultivos Semilimpios pasó a Cultivo Denso.
- Más de la mitad del área que estuvo en suelo expuesto pasó a ser ocupada por Cultivos Densos y Descanso. Un 5% como caso particular pasó a ser Bosque Protector.
- Los Cultivos Limpios sólo se generaron a partir de áreas diferentes a Suelo Expuesto y a Cultivos Semilimpios.
- De otro lado, Suelo Expuesto sólo aparece en áreas que estuvieron en Cultivo Denso.

Por otra parte, se identificaron los ciclos más comunes de las coberturas (por área) para el conjunto de las series de tiempo. En la Tabla 2 se presentan los ciclos o rotaciones más característicos. Los ciclos escogidos fueron aquellos que tenían la información para las tres series y aquellos que sumaban un área mayor de 60 Has. Los que sumaban menos de este valor se agruparon en el grupo "Otros", donde se presentan numerosas combinaciones pero en áreas en promedio no mayores de 1 Ha. La mayoría de las rotaciones tienen asociado el cambio de Cultivo Denso a Descanso o viceversa. Suelo Expuesto sólo aparece después de Descanso. A pesar de estar agrupados los usos del suelo, es notoria la diversidad de combinaciones que ocurren.

Con base en reconocimientos de campo se confirma el dinamismo en la rotación de cultivos y coberturas en tiempos no superiores a dos años, así como la tendencia general en el incremento de cultivos comerciales que conforman los grupos de cultivos limpios y densos.

5.3 La serie de tiempo de cobertura del suelo de 1994 se analizó en función de su correlación con la pendiente y la accesibilidad.

La Tabla 3 presenta los porcentajes de usos de la tierra en los diferentes rangos de pendiente. En todas las pendientes predominan los usos de la tierra Cultivos Densos y Descanso. Las áreas en bosque predominan en las pendientes por encima del 30%. Tanto los cultivos limpios como los semilimpios disminuyen en razón de la pendiente. El área en descanso aumenta proporcional a ésta. Suelo expuesto se encuentra en proporciones similares en todas las pendientes.

De otro lado, se generaron zonas de accesibilidad con base en la distancia euclidiana de cada punto (pixel) del interior de la subcuenca, a los centros de mercadeo y caminos más importantes. La pendiente se utilizó como criterio que limita la comunicación en línea recta. Todos los puntos adquirieron así un valor que luego de una reclasificación pasaron a formar parte de una de cuatro zonas de accesibilidad. Los porcentajes del área en cada una de las zonas se presentan a continuación:

NIVELES DE ACCESIBILIDAD	PORCENTAJE DEL AREA
BAJA	66
BAJA-MEDIA	17
MEDIA-ALTA	12
ALTA	6

Las coberturas con cultivos orientados al mercado, como son los cultivos limpios y semilimpios son las predominantes en las zonas de altas o media-alta según accesibilidad. Más del 90% del bosque total (Protector y Plantado) se encuentra en zonas de baja accesibilidad.

Las carreteras están ubicadas en las crestas de las laderas y los reductos de bosque que aún se conservan estan en las hondonadas de las vertientes.

6. Conclusiones

Sobre la cobertura de la tierra:

- Existe una intensa dinámica de cambios en la cobertura de la tierra. La excepción la representa el área con Cultivos Densos que varía muy poco; sin embargo, en términos generales, las proporciones no cambian en forma notoria, lo que sugiere la existencia de estabilidad en el conjunto del sistema.
- El área con suelo expuesto no ha variado considerablemente, hubo un pequeño aumento en 1970 proveniente de áreas anteriormente en Descanso y Cultivo Denso.
- De igual manera, los Bosques Protectores no han variado proporcionalmente debido a la regeneración de áreas con una cobertura previa diferente (especialmente Descanso).
- Los cultivos limpios sólo aparecen en áreas que se encontraban en Descanso, Cultivo Denso o Bosque Protector.
- Existe una estrecha relación entre el uso de la tierra y los factores pendientes y accesibilidad.

Sobre la metodología:

Se identificaron puntos críticos para la realización de estudios de cambios de uso de la tierra con base en procedimientos convencionales (fotointerpretación con estereoscopio y transferencia a cartografía con Sketchmaster). Estos puntos, posibles fuentes de error o que limitan las inferencias que puedan establecerse son:

- La resolución de la fotointerpretación de fotografías a escala 1:30.000 no fue mayor a 3 has. Lo que dejó por fuera del estudio pequeñas parcelas de cultivos muy características de esta región. - El grosor en la delineación de las unidades de uso de la tierra es de una banda de 8 a 15 mts. que incide en la precisión del proceso de transferencia a la cartografía.
- Los tipos de unidades de cobertura de la tierra definidos en la fotointerpretación comprendieron un rango de tipos que incluyó desde cultivos específicos a sistemas de uso de la tierra lo que restringió la realización de comparaciones.
- Las coberturas definidas por la fotointerpretación reflejan únicamente la situación del instante en que fue tomada la fotografía y no propiamente el uso de la tierra para el año en mención, pues la cobertura vegetal a lo largo del año y para esta región cambia considerablemente.
- No todas las fotografías de cada serie de tiempo fueron tomadas el mismo año, para la parte norte de la serie de 1946, se recurrió a fotografías de 1945 lo que seguramente incidió en el tipo de cobertura identificado en la fotointerpretación.
- El uso de Sistemas de Información Geográfica es una herramienta clave para estudios de cambios de cobertura dada la versatilidad con que es posible manejar la información, realizar correcciones y ajustes, actualización y sobreposición de capas de datos.
- Para el manejo de las estadísticas extractadas de los datos, se recurrió a programas comerciales como Excel y SAS. Aunque el movimiento de archivos no es muy complejo, se hace necesario contar con este tipo de manejadores de datos en forma más cercana a las bases de datos geográficos.

Tabla 1. Agrupaciones de usos por cobertura y usos de la tierra según fotointerpretación.

USO AGREGADO	USOS EN FOTOGRAFIA
BN - Bosque protector	BN - Bosque Natural
BP - Bosque Protector - Productor	BP - Bosque Plantado
CD - Cultivos Densos	PNB (pasto natural con parcelas de árboles) PND (pasto enmalezado con parcelas de bosque) PC(pasto de corte) PN(pasto natural limpio)
CS - Cultivos Semilimpios	MS(cultivos en parcelas intercaladas de yuca, frijol, tomate, habichuela), CC(cafe), CT(citricos), FQ(fique), CN(caña de azucar)
CL - Cultivos Limpios	CL (cultivos limpios en parcelas intercaladas de yuca, tomate, habicuela, fríjol..) YU (yuca), PR (tierras en preparación) y Q (zonas quemadas)
SE - Areas de suelo expuesto	PNC(pasto natural con zona erosionada) y MR (miscelaneo rocoso), MC (misceláneo con cárcava)
RA - Descanso	RA (rastrojo), PNE (Pasto natural enmalezado)

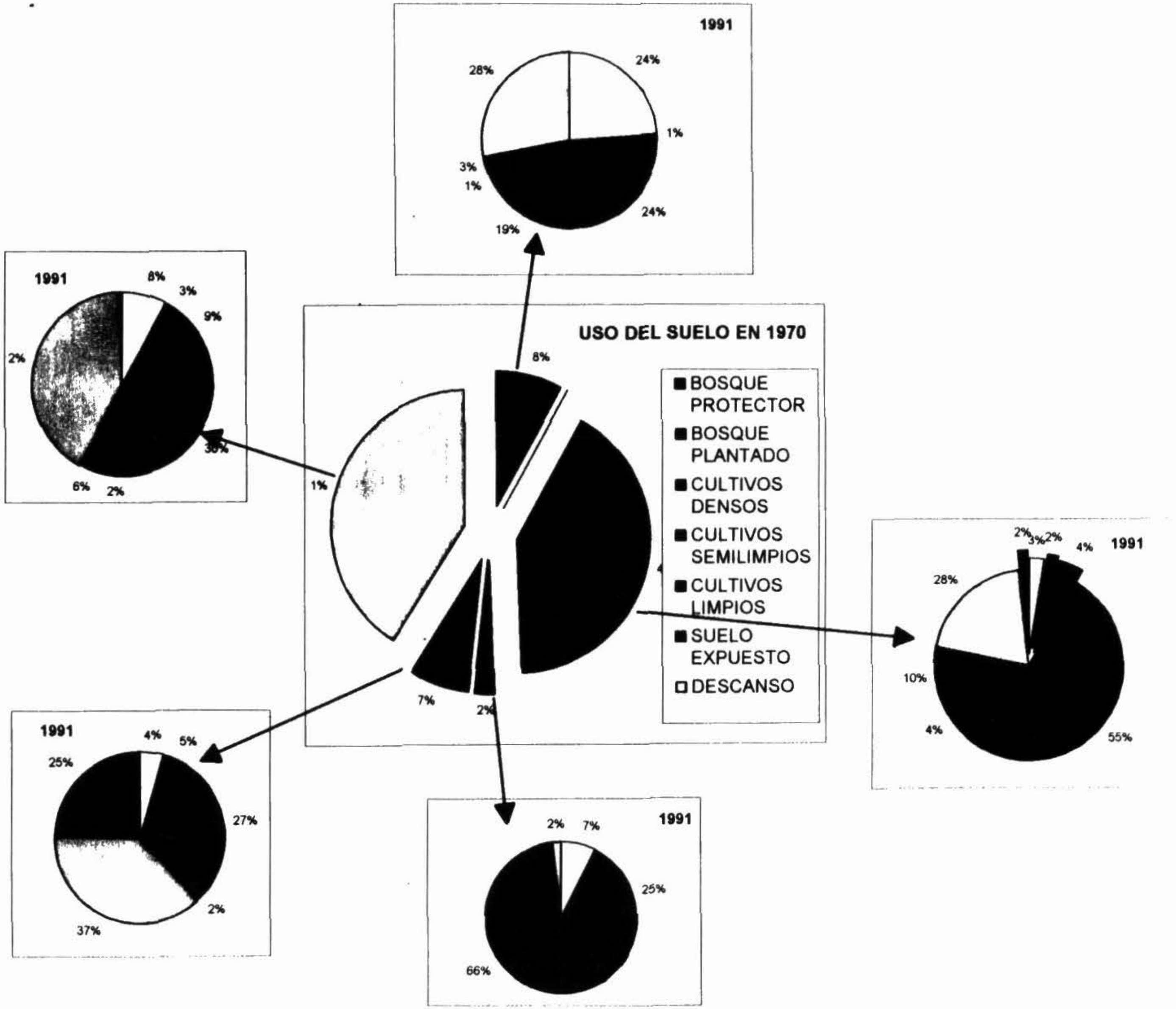
Tabla 2. Ciclos de cambio en el uso de la tierra al interior de la subcuenca del río Cabuyal

TIPO DE USO	AREA HAS.	FRECUENCIA
OTROS	962	976
CD/CD/CD	788	191
D/D/D	640	191
D/CD/CD	446	195
D/D/CD	385	189
CD/CD/D	243	131
CD/D/CD	238	164
CD/D/D	229	105
CD/CD/CS	1910	99
D/CD/D	190	138
D/SE/D	157	44
BP/CD/CD	150	73
D/D/BP	132	86
D/SE/CD	94	12
SE/SE/SE	89	3
CD/CD/CL	76	33
CD/D/CS	73	41
D/D/CS	71	42
D/CD/CS	71	70
BP/D/D	64	57
BP/D/CD	63	48

Tabla 3. **Porcentajes de Uso de la Tierra en rangos de pendiente**

Uso/ Pendiente	BOSQUE PROTECTOR	BOSQUE PLANTADO	CULTIVO DENSO	CULTIVO SEMILIMPIO	CULTIVO LIMPIO	SUELO EXPUESTO	DESCANSO
<6%	2.6	1.1	53.5	16.7	3.7	3.2	18.9
>6%- <12%	4.2	1.6	53.5	12.0	3.5	4.3	20.6
>12%- <30%	7.2	2.0	47.9	8.9	2.8	3.6	27.5
>30%- <70%	8.8	2.2	36.1	5.1	2.3	3.3	42.0
>70%	9.5	1.3	27.3	3.2	1.5	2.6	54.5

FIG. 2 CAMBIOS DE USO DE LA TIERRA ENTRE 1970 Y 1991
SUBCUENCA DEL RIO CABUYAL - CAUCA - COLOMBIA



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PROJECT 3 Prototype systems for ecologically sound intensification of production in the hillsides ("INTERPROGRAM PROJECT")

Purpose: **to develop sustainable agrosilvopastoral systems that improve soil quality, water management, and efficiency and productivity of labor.**

I. PROTOTYPE AGROSILVOPASTORAL SYSTEMS FOR ECOLOGICALLY SOUND INTENSIFICATION OF PRODUCTION IN THE HILLSIDES

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Introduction

This project aims to contribute to the Hillsides Program's objective of generating "win-win" technologies that meet conservation and production needs. The purpose of the project is to develop principles for the design of sustainable agrosilvopastoral systems that improve soil quality, water management, and the efficiency and productivity of labor.

Consultations with researchers and hillside farmers involved in the Andean project site, together with broad local and international literature search showed that the available research on hillside production systems consists mainly of site or single problem specific experimental work (eg. Magolis et. al. 1991; García and Marcano, 1990; Raros, 1985). Systems research includes socio-economic studies normally not acted upon to solve the related problems, or featuring misconceived strategies as reported by Browman (1987, 1984). There is a general deficiency of principles with strategic validity either at the site level, or at a comparable international macrolevel (eg. Andean hillsides) within a range of predefined site characteristics.

It is important for CIAT's Hillsides Program to fill this existing gap at an international level. For this purpose, the IARC can bring together and disseminate data and experiences from system experiments being conducted by partners across the region. This would facilitate extrapolation across similar environments, aiming for a large scale impact.

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[1] CIAT Lowlands and Hillsides Program

Specifically, research on integrated crop-livestock systems, including studies on nutrient cycling and nutrient-use efficiency is weak in the region. Also research involving trees is almost all concentrated on agroforestry but not on agro-pastoral or agro-silvo-pastoral systems.

This project aims to develop a strategy for transition production systems, which over time increase the use of perennial plants (grass and legume pastures as well as trees) in cropping systems and in varying landscapes. In doing so, it aims to develop principles for management of hillside landscapes or multifarm systems, to improve the efficiency of the use of the land both in time and space, while increasing the ability to preserve the environment.

The project in the first three years will focus in the watershed of the Río Ovejas in Cauca, Colombia. Experimental sites will be chosen with the help of national institutions, local organizations as well as with GIS and secondary information on soils, climate, vegetation, actual land use, etc., available for the area. Extrapolability to other hillside areas in Latin America of the derived principles from this project in its first few years is expected to be determined with the help of GIS as well as modelling tools.

The río Ovejas watershed covers an area of 106000 hectares ranging between 1100 and 3000 masl. with 67% of farmers with less than 3 ha of land. The population is 85000 with 41% illiterate. The natural forest vegetation cover is 4% average for the watershed.

These figures illustrate that the Río Ovejas watershed represents a type of hillside situation in Latin America today characterised by high population density with little education, depletion of forests with the implication of soil losses particularly if intensively used, in order to feed the high population. The consequences of this erosion go beyond the site, affecting water quality and producing sedimentation of rivers and dams downstream. At the same time, low income implies limited access to inputs, leading to depletion of the soil for local food production as well as for cash crops for urban consumption.

Many organizations both government and non-government have been trying to implement sustainable land use practices in our study area and in general in the Latin American Hillsides. Unfortunately, successful widespread adoption of practices is not common due to several reasons such as: lack of vigorous research on the ecological processes that the induced practices aim to sustain, a very fragmented process of trial and error focused on productivity, ignoring long term development and conservation needs, weak research capability to extrapolate results from one site to another.

Problem solving strategy and expected outputs

The Center-wide group of collaborating CIAT scientists in the project took part in a "Planning by Objectives" process, and identified a set of major problems to be dealt with. These problems are:

1. Deterioration of soil quality: soil erosion, fertility decrease, decreased nutrient regeneration (shorter fallows).
2. Unrealized production potential of existing farming systems: lack of complementarity of farm activities, increased pesticide use, poor linkage between farming systems and markets.
3. Poor water management: limited irrigation for small farmers, water pollution, limitation of water management due to topography.
4. Low labor productivity.
5. Poor information.
6. Deficient infrastructure.

Based on the above problems and in order to comply with the stated purpose of the project, the expected outputs are:

1. Sustainable agrosilvopastoral systems

2. Stable or improved soil quality

3. Improved water management

4. Improved labor productivity and efficiency

In this manuscript, only the first three outputs are dealt with. Socioeconomic aspects, specifically market opportunities related to production system design are dealt with separately by J. Smith in the following section.

Recent survey research carried out by the Program show that important monocrops in the area in order of decreasing importance in terms of cultivated area are: cassava (16-18 months cycle, labor intensive), coffee, sugar cane, beans (becoming more important), maize, tomato, sisal, plantain, fruits. Intercropping is common in the area, eg. cassava-beans and cassava-maize-beans in the low altitude, cassava-maize and plantain-coffee-sisal in mid-altitude.

The project strategy consists of developing alternative ways or paths to make the transition from existing production systems, based on short-cycle shallow-rooted monocrops, to a new agrosilvopastoral system incorporating more diverse deep rooted, perennial species. Treatments will be derived from existing or proposed systems, drawing on ideas of farmers, national institutions and CIAT's scientists.

The site selection for the initial phase will be in the range of 1400 masl. to about 1800 masl. to ensure adaptation of CIAT's germplasm. The number of farms involved will depend on the availability of land to fit few or several systems. Ideally, at least directly comparable systems will be planted on the same farm with as similar conditions as possible.

In the initial phase, the experiments will be simple and as large as possible including areas for cattle grazing in some instances. They are planned for long term evaluation and in this way (large and simple) they will allow for future additions and modifications, as progress is made in the evaluations, and contributions from the collaborators (national institutions, farmers and CIAT scientists) come into the experiments.

Selected systems and hypotheses

The "transition system" is a strategic concept which recognises that hillside farmers need to improve production over time while increasing the long-run stability of their farming systems. The treatments for long-term evaluation in the experiment involve a range (or menu) of "generic" options that incorporate this idea of transition from the typical hillside system (monocrops rotated with native pasture for grazing). These transition options involve the progressive introduction over time of diverse, perennial, deep rooted species into the crop (for example, grasses with legumes), to increase system sustainability. "Transition" options need to be compared with intensive monocrop rotations. In addition, improving landscape management is an objective, addressed by including treatments aimed specifically at steep slopes; and the identification of appropriate niches in the landscape for trees, in a way that these add value to the system without competing with crops.

The crops and pastures are viewed within the systems as plant types:
- beans: short term, shallow rooted
- maize: medium term, medium rooted
- cassava: long term, deep rooted
- pastures: perennial, deep rooted, herbaceous
- trees: perennial, deep rooted, woody

In the selected farms various alternatives from the following systems will be evaluated:

1. Monocrops: cassava, maize, beans.
2. Maize + legumes cocktail (green manure or forage) in two contrasting fallows (cropped land and 2 years old fallow).
3. Maize + *Brachiaria dictyoneura* + legumes cocktail (for grazing) (to compare with 1 above, and 4 and 8 below).
4. Naturalized grass (*Melinis minutiflora*) for grazing (to compare with 3 above and 8 below).
5. Cassava + legumes cocktail (green manure or forage) in two contrasting fallows (as in 2 above).
6. Triple crop association: beans + cassava + maize.
7. Barriers and field(s) perimeter(s) with: grasses, grasses + legumes, and grasses + legumes + trees.
8. Cut and carry species on steep slopes: grasses, and legumes trees (to compare with 3 and 4 above).
9. Uncropped plots: subdivided in bare and mulch cover for soil physics studies.

Systems 2 and 5 above are in two sites with varying conditions and all systems with three replications, except systems 3 and 4 which are respectively 1 and 0.7 ha for grazing.

System 1 is traditional monocropping without conservation practices and System 4 is for traditional grazing of naturalized pastures.

Systems 2 and 5 are the same as System 1 but they already include a cover crop (legumes) for soil protection/fertility enhancement.

System 6 includes the three crops from System 1 but all together in the field, aiming for continuity of production/income.

System 3 has only one season with a crop and is continued without further tillage under improved grass/legumes cover for grazing.

System 8 on steep slopes aims to have perennial species for cut and carry without further tillage after the initial one.

System 7 aims soil protection while being productive.

In these systems there is a gradient from shallow rooted short cycle systems to perennial both herbaceous and woody, deep rooted systems. System 9, uncropped plots with bare and mulch covered plots represent the two extremes of the gradient.

The general hypotheses for the project are: through perennial deep rooted systems it is possible to:

1. Improve quantity and quality of soil organic matter.
2. Hold soil in place against erosion.
3. Improve microbial activity.
4. Stabilize/increase soil fertility.
5. Have less variability, more security of income, cash flow.

The germplasm has so far been selected as follows:

- Crops: the most common in the area and in CIAT and CIMMYT commodities: cassava (Algodona), beans (Caucayá), maize (Sikuani 1).

- Grasses and legumes: the outstanding materials in both CIAT's trials and farmers evaluation. Grasses: *Brachiaria dictyoneura, Pennisetum purpureum (*elefante enano), *Axonopus scoparius* (imperial 60), and *Melinis minutiflora.* Legumes: *Centrosema acutifolium, Arachis pintoi, Stylosanthes capitata, Chamaecrista rotundifolia,* and *Desmodium macrocarpum.*

- Barriers: German project results and farmers opinion. Elefante enano, Imperial 60, sugar-cane, pineapple (local variety), and several species of legume trees.

- Trees: CIAT's farmers' and CVC's recommendations until now. There is a need to keep looking for adapted, useful species and systems in this area of research. *Calliandra calothyrsus* CIPAV-2, *Cajanus cajan* CIAT-18700, *Codaryocalix gyroides* CIAT-3001 and 23748, *Cratylia argentea* CIAT-18516, *Sesbania sesban* CIAT-21250, *Indigofera* sp, *Leucaena leucocephala* CIAT-17474, *Desmodium velutinum* CIAT-134218, *Erythrina edulis*, *Dendrolobium* sp, *Desmodium cajanifolium* CIAT-3124, *Tadehagi triquetrum* CIAT-13276, *Leucaena diversifolia*.

Satellite experiments

These are for testing a number of lines of the selected crops, in order to evaluate their behavior, in comparison to the varieties used in the systems trials. 1) Beans: 11 lines (3 reps.), 2) Cassava: 5 lines (4 reps.), 3) Rice: 2 lines (1 rep.), 4) Legume trees: several species (3 reps.)

Results during Initiation Phase of Project

The Interprogram Project on Hillsides is a long-term project and therefore at this point in time, one year after its initiation, it is only possible to refer to some interesting happenings in these early stages of work.

Contrary to the common belief, a land fallowed for several years is not necessarily in better shape than a continuously cropped one. It all depends on the management of the cropped land and on the quality of the biomass cycling nutrients in the fallow. For our situation (Table 1) the continuously cropped land was fertilized with chicken manure for several years previous to our trials and we did it again in the form recommended by the farmers in the region, i.e. 6 t/ha. The fallowed land had a plant cover fully dominated by *Melinis minutiflora* for several years, and received the same manure as the non-fallowed land for our trial. The initial soil analysis shows a much better chemical quality of the non-fallow land.

It is clear from our results that 6 t/ha of chicken manure commonly used in the region exceed by far the total amounts of nutrients taken up by the full above ground biomass and even much more, those nutrients exported from the field in produce. This added to the abundance of available nutrients in the non-fallow land before fertilizing, results in tremendous waste of nutrients and farmers capital. Even in the fallow land there are still nutrients in acceptable amounts before fertilizing, particularly calcium.

Specifically, in both the non-fallow and the fallow, the wasted P not used by the crop becomes fixed in the soil and is not available as shown by the soil analysis after the harvest. The available cations K, Ca, Mg, particularly in the no-fallow, are being lost in big amounts from the system, either by leaching or by erosion with eroded soil or both.

In the fallow, the cations are approximately found in the final soil analysis. It is surprising that the uptake of nutrients by the maize crop in the fallow is lower than in the non-fallow when their availability is not actually a limiting factor. Perhaps the 4.1% difference in quantity of organic matter and probably with a difference also in its quality is what accounts for the yield difference in the maize crop between the two fallows.

Table 1. Nutrient balances in the first season of prototype systems on Hillsides. Pescador, Cauca, Colombia. 1995

	FERTILIZATION	AFTER NO FALLOW							AFTER FALLOW			
		MAIZE-LEGUMES (yield = 2.7 t/ha)				MAIZE (3.3 t/ha)			MAIZE-LEGUMES (1.7 t/ha)			
	Chicken manure (6 t/ha)	Initial soil	Nutrient uptake[1/]		Final soil	Nutrient uptake		Final soil	Initial soil	Nutrient uptake		Final soil
			Total	% export[2/]		Total	% export			Total	% export	
OM (%)	-	12.1	-	-	-	-	-	-	8.0	-	-	-
N (kg/ha)	297.6	-	101.3	(46.6)	-	116.0	(50.6)	-	-	50.5	(45.1)	-
P (kg/ha)	117.0	13.7	19.9	(68.9)	9.8	21.9	(74.1)	10.1	5.6	14.4	(70.8)	14.5
K (kg/ha)	136.2	393.5	117.7	(19.9)	163.0	131.1	(19.2)	154.8	66.6	76.3	(22.1)	141.4
Ca (kg/ha)	272.2	565.0	22.0	(7.3)	514.1	18.9	(7.5)	543.1	343.8	14.9	(5.2)	531.1
Mg (kg/ha)	28.8	333.6	17.2	(31.9)	186.1	21.4	(43.8)	183.0	113.5	10.4	(33.0)	173.6
Zn (kg/ha)	1.3	5.20	0.26	(46.1)	4.70	0.24	(50.0)	4.36	8.70	0.19	(42.1)	4.59
B (kg/ha)	0.2	0.59	0.05	(20.0)	0.48	0.04	(25.0)	0.47	0.34	0.03	(0.0)	0.57

1/ Nutrient uptake by total above ground biomass

2/ Percentage of taken up nutrients exported from the field in grain + cob + shuck

The presence of legumes as a cover crop for maize seems to compete for nutrients and depresses their uptake and grain yields, compared to maize monocrop in the non-fallow area. Six t/ha of chicken manure at present cost Col$240.000 per hectare. Big savings should be implemented here, of course taking into account the need for further studies on the organic matter contribution of this form of fertilizer.

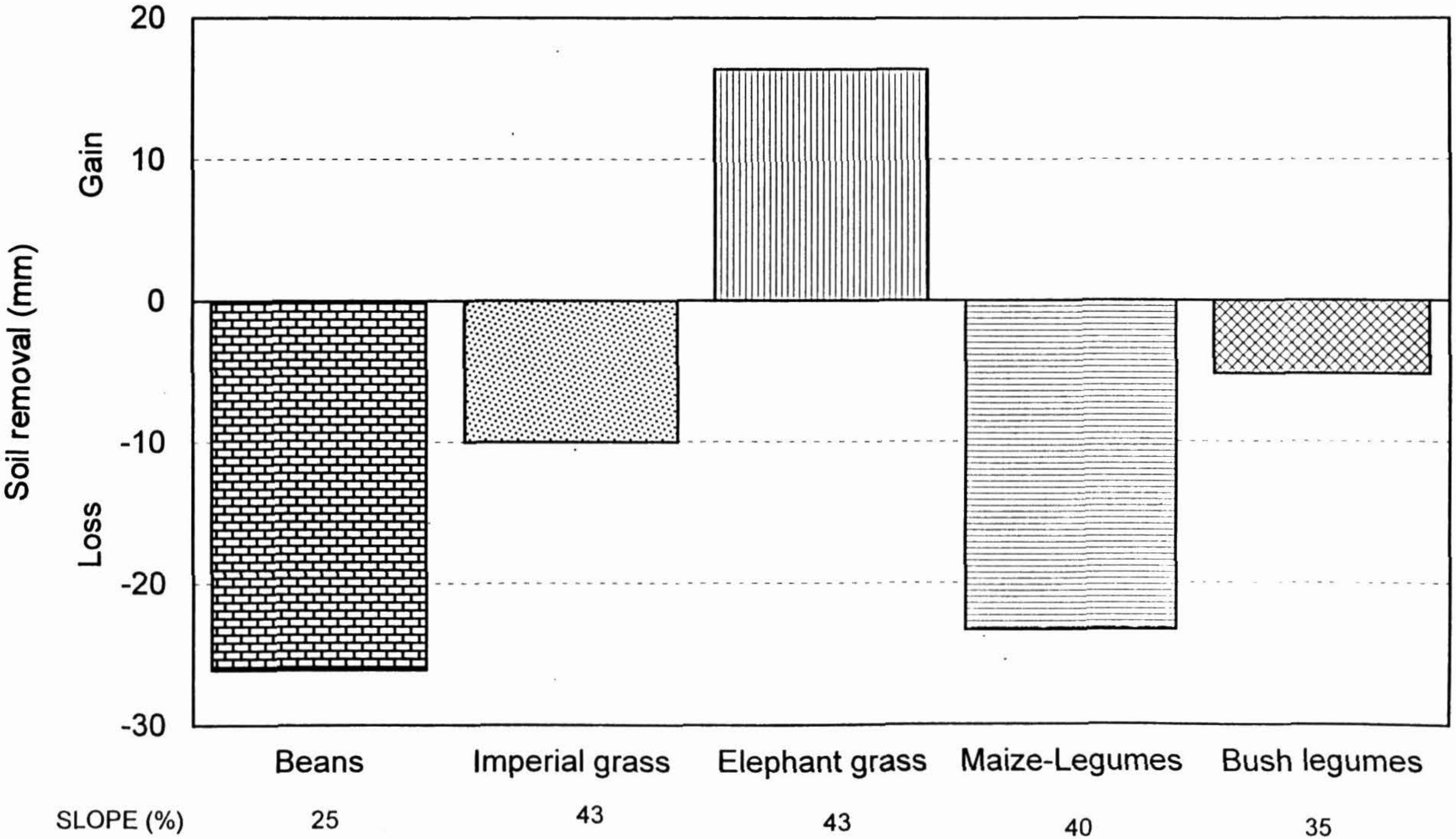
Figure 1 shows the soil removed from various systems in the project, measured between March and September, 1995, with a relief meter apparatus.

The aim of the project is to promote the transition from short cycle shallow rooted to perennial deep rooted crops or the integration in systems of these plant types. In the figure it can be seen that the greatest soil removal is for the short cycle shallow rooted monocrop of beans in contrast to the soil gain by the perennial deep rooted and fast growing Elephant dwarf grass (*Pennisetum purpureum* cv. Mott). Imperial grass (*Axonopus scoparius*) is slower at establishment and does not close the rows as well as *Pennisetum* in the early stages of development. Initial fast growth of the barriers or the cover legumes seems to be key at preventing soil erosion. The cover legumes in the maize-legumes system had an initial slow growth and the soil removal is almost the same as for the bean monocrop. Some of the bush legumes grow fast from the beginning and probably produce a superficial root system that holds the soil in place. This is still to be proved.

The bulk density of the first 5 cm of the soil in the area of this work is 0.53 g/cm^3. The removal of 25 mm of top soil in the bean monocrop means a removal of 132.5 t/ha of top soil.

Investment in prevention of erosion with fast growing barriers or cover legumes is a must, and could be made at the expense of saving in the volume of chicken manure utilized. Definitely, it is important to take into account the apparent big effect of the increased quantity and probably quality of the soil organic matter with the application of chicken manure. On the other hand, it is equally important to quantify the potential adverse effects in the environment, such as water contamination, by excess soluble nutrients washed out from the massive application of chicken manure.

FIGURE 1. SOIL REMOVAL IN VARIOUS HILLSIDE PRODUCTION SYSTEMS AS DETERMINED BY A RELIEFMETER BETWEEN MARCH AND SEPTEMBER, PESCADOR, CAUCA, COLOMBIA, 1995.



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II MARKET OPPORTUNITIES LINKED TO EROSION CONTROL PRACTICES: A KEY TO ADOPTION?

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1. Introduction

Hillside agriculture in tropical America today is characterized by a vicious circle of poverty, reinforcing environmental degradation. Most of the poor people employed in farming reside in the fragile ecosystems of the mid-altitude hillsides. Mining the environment gives farmers short-term subsistence, but creates a profound discrepancy between actual systems of land use and the ecologically sound systems appropriate for fragile soils on steep slopes. Maintenance of the natural resource base in the hillsides is thus of vital importance not only to ensure the future livelihood of resource poor farmers, but also to prevent their migrating to urban centers, where social problems are already endemic.

Soil erosion has been identified as one of the most pressing resource management problems in the hillsides. In Central America alone, for example, over 60% of the hillsides is subject to severe, recent water erosion caused by agriculture. Although an abundance of erosion control technologies exist, adoption of these technologies in tropical countries have been disappointing (Laing and Ashby, 1992; Kaimovitz, 1992). Soil depletion, in many cases, is rational from the farmer's point of view (Ashby, 1985: Anderson and Thampapillai, 1990). As soil degenerates over time, yield and income losses build up. At early stages of soil depletion, the net returns without soil conservation exceed the net returns with conservation (Figure 1). Over time, as soil degenerates further, the gap declines, until eventually at time period t*, net returns with conservation are higher than those without. Adoption of soil conservation technologies is unlikely to occur until time period t*, which one study calculates to be at least 40 to 60 years after degeneration begins, depending on the discount rate used (Seitz and others, 1979). Thus there is a conflict between the farmer's logic and ecological considerations (Gutman, 1988). The literature also points out that even if farmers consider the monetary benefits of erosion control, such as yield increases, they are unlikely to consider non-monetary benefits, such as soil resilience, or downstream benefits which accrue to others. Thus the extent to which soil conservation practices are voluntarily adopted by farmers will be suboptimal from society's point of view (Izac, 1994).

The problems with adoption raised above imply that farmers wil have to be offered incentives to induce timely adoption of soil conservation practices. Incentives have commonly taken the form of subsidies or regulations. The former is costly, and in many cases induces distortions in other sectors of the economy. The latter is extremely difficult to implement. The research reported here explores a different type of incentive. The objective is to link income earning opportunities to soil conservation practices. This is expected to increase the returns to conservation practices, resulting in earlier adoption of sustainable practices, at time period t** (Figure 1). Adoption, in many cases, may in fact occur because of the opportunity to increase income, with soil conservation occurring as a byproduct. This approach derives support from the fact that in the few cases of successful adoption that have occurred, soil conservation practices permitted the introduction of high value crops, or supported the introduction of livestock, or generated income by being associated with value added proccesses (Tiffen and Mortimore, 1992; Nimlos and Savage, 1991). Linking the market opportunity to conservation practices is however vital, as the literature is replete with cases where the introduction of income generating opportunities without any links to conservation, have exacerbated resource degradation (Thrupp, 1993).

The basic hypothesis is that the provision of better information to both technology developers and farmers can increase the adoption of soil conservation technologies. Technology developers lack information about products that meet the priorities of farmers and at the same time contribute to soil conservation. This information could be used to focus technology development efforts. Farmers lack information about product demand. This information could widen the range of crops grown to include those which can contribute to soil erosion. A subsidiary hypothesis is that Vertical Marketing Systems (VMS), which link farmer producers to product processors, facilitate the exploitation of new market opportunities by small scale farmers.

The following steps are followed:

1. Biophysical and socioeconomic characterization of a pilot study area, with special emphasis on farmer resources, production and marketing systems.

2. An analysis of the determinants of sustainability, which provides an understanding of farmer perceptions of soil degradation, and the constraints to the adoption of sustainable practices.

3. A systematic search for market opportunities is conducted by surveying potential buyers of farm products. The search is focused by considering the comparative advantage of the study area (access to markets, natural resources, labor availability, etc).

4. A list of products with potential market opportunities is characterized on the basis of the following criteria: (i) feasibility in the context of farmers in the study area (ii) the potential for incorporating the product in soil conservation technologies (iii) market conditions for the product. A sub-set of best bet options is then identified, with farmers, soil scientists and NGOs participation in the selection process.

5. An ex-ante evaluation of options is carried out using a Multiple Objective programming model. The model identifies trade-offs between adoptability and ecological objectives, which, in turn, guides the development of prototype soil conservation technologies, and recommends policy and institutional changes.

In this report we present the results of steps 1, and 2 and some preliminary results of step 3 and 4. The multiple objective model is currently under development.

2. Characterization of study area

The study area is the Cabuyal microwatershed of the Ovejas river basin in Cauca, a pilot study area of the Hillsides program.

The Cabuyal microwatershed is divided in three agro-ecological zones: high, medium and low, related to their position along the Cabuyal river. The low zone covers the biggest area of the microwatershed and has the lowest effective population density. The medium zone is the densest area of the microwatershed. Coffee is the main crop in the high and medium zones. Cassava is the main crop in the low zone. Pastures and cassava are important in the high zone, bean is important in the medium zone, and sugar cane is a major crop in the low zone (Table 1). Further details of the cropping systems are given in Rubiano, Castaño and Cabra (1995).

Table 1. Characteristics of the Cabuyal microwatershed zones

Village	Zone	Characteristics
El Oriente Buenavista La Esperanza La Primavera El Rosario El Cidral	High	Altitude: 1700-2200 m Climate: cold Soil type: Farallones-Usenda Area: 2,216 ha Population: 1211 Density: 56 inh./km^2 Farm area/person: 0.72 ha Crops: coffee x plantain, fiber, cassava, pastures, cassava x bean, cassava x maize
La Laguna Sta Barbara El Porvenir Las Ventanas Crucero Pescador Pescador Panmericana La Campiña Potrerillo	Medium	Altitude: 1500-1700 m Climate: temperate Soil type: Usenda-Pescador-Suarez Area: 2375 ha Population: 2307 Density: 97.1 inh/km^2 Farm area/person: 0.55 ha Crops: coffee x plantain, cassava, cassava x bean, pastures, bean
Palermo Cabuyal La LLanada El Socorro La Isla El Caimito	Low	Altitude: 1175-1500 m Climate: warm Soil type: Suarez-Pescador Area: 2775 Population: 1686 Density: 60.8 inh/km^2 Farm area/person: 0.74 ha Crops: cassava, pastures, cassava x bean, coffee x plantain x fruit trees, cane

Soil types: Farallones = tipyc humitropept, Pescador = oxic dystropept, Suarez: ustic dystropept, Usenda= typic dystrandept.
Source: GIS, Cabuyal census and Rubiano et al.

Table 2. Characteristics of farmers in the Cabuyal microwatershed

Farmer characteristics		
Age		47 years old
Sex	Male Female	80.7% 19.3%
Education (years)		3
No. of families per household	1 2 3	92.2% 7.1% 0.5%
No. persons per household		4.7
Occupation	Farmer Farm laborer Housewife Other	64.7 15.9 14 5.4
No. of farms per owner	1 ≥2	86.3 13.2
No. of fields per farm		3

Source: Cabuyal census

Table 2 describes the typical farmer in Cabuyal: male, 47 years old, with three years of education. He owns the farm, possesses three crop fields, and works mainly on-farm. A typical farm possesses five plazas (3.2 ha) of land, planted predominantly to a variety of crops, though small areas of pasture and fallow also exist.

Coffee (intercropped with plantain and fruits) and cassava (alone or associated with bean or maize) are the most important crops in Cabuyal. Other crops are beans, cane, tomato, fiber. Coffee and cassava are widely cropped in the region because, once they are installed, they demand little work and investment, compared to crops like bean, and vegetables. Coffee and cassava only require two weedings. In addition, cassava does not require spraying or fertilization. Sowing of crops such as bean, maize, peas, coffee and sugar cane, is mainly done in the rainy months of September and March. Vegetables and cassava are sown throughout the year.

The coffee varieties seen in the region are *Caturra* and *variedad Colombia*. Both are intercropped with shade crops such as plantain and fruit trees. Coffee is sown in September, and the first harvest takes place 14 months later. From then on, it produces two harvests a year for 7 to 9 years. Coffee processing starts the day after harvesting: depulping, fermenting, washing and drying.

Coffee quality in region is low due to the poor post-harvest devices available to farmers. Farmers do not possess drying facilities and instead, they dry the coffee beans on the floor under the sun light. Therefore, under either bad climatological conditions or lack of drying space, farmers prefer to sell most of the coffee production green or humid to traders at a lower price.

"Broca", an insect that drills and eats the coffee bean, has caused significant losses in coffee at the national level (up to 30% of losses). Some farmers prefer to harvest coffee green to prevent broca attacks. This practice further affects coffee quality and, therefore, the price the farmer receives.

Farmers prefer bitter varieties of cassava, because they yield well on poor soils and offer satisfactory contents of starch, the cassava's by-product. Cultivation of cassava exarcebates soil fertility decline because the plant is extremely well adapted to poor soils, i.e., it is efficient at extracting scarce essential nutrients from the soil (Ashby, 1995).

Algodona is the most common cassava variety in the zone with a vegetative period of 16 months. In higher lands (Esperanza, Oriente), a 20-month variety is cropped, that receives premium prices for its greater starch content. Cassava sowing is spread over the year. In the months of March and September it is intercropped with bean and/or maize, and in January and June-August it can be found in monocrop. Cassava is intercropped with maize, or maize and beans in the second semester due to the belief that maize has better results under the climatological conditions of that semester. Intercropping is an important way of self-financing, as intercrops can be harvested after three or four months and permit the farmer to recover a major part of the initial costs.

Bean plants in Cabuyal are of bush architecture. Caucayá (a Calima type bean) and Radical (a red type bean) are the major varieties. Beans are cropped twice a year. After harvesting, beans are thrashed manually or mechanically, dried and packed for sale.

The regional variety of maize is *coruntillo* or *carpintereño*, which has a vegetative period of five months. In the high zone of the watershed, farmers still crop the traditional maize with a longer vegetative period. Plantain, the shade crop of coffee, provides two or three harvests in a period of three years.

Vegetables, such as tomato and red pepper, are minor crops due mainly to lack of irrigation facilities. These vegetables are sown in January, May, and September or October, in fields close to the household for easy access to equipment and water sources for irrigation purposes. Vegetables growers sell on-farm to traders who usually provide money in advance and packing boxes to ensure the supply.

The exposure of ecologically fragile lands in Latin America to high risks of soil erosion reflects the political and institution structure of land distribution (de Janury and Garrmon 1977: 211-12). In Colombia, large scale capitalist and plantation agriculture monopolizes prime lands with crops such as sugar cane, pastures, rice and cotton, while small farmers are limited to the least fertile and most easily destroyed high lands.

Caucan farmers are indigenous by origin, and by nature they are conservationist. Their ancestors, the Inca Indians and the Aztecs of Mexico built terraces (Nimlos and Savage, 1991). The Aztecs and the Purtrepechas developed their own soil taxonomies (Bocco, 1990). However, those attitudes have been disappearing. Unequal national policies have deterred commodity prices, and as a result, such economic circumstances, have influenced conservation attitudes to a large extent (Ashby, 1985). Also, it has made attempts at promoting investments in conservation techniques unsuccessful.

Over time, farming in the watershed has been characterized by shorter fallow periods, more intensive cultivation of annual crops, and the extension of cropping into steeper and more marginal areas. Farmers have a marked preference for short-term benefits since they can only plan from one harvest to the next, and in extreme cases of poverty, from one operation such as crop establishment to marshaling of resources for the next operation, such as weeding (Ashby, 1985).

Fertility management in the region is dominated by two main practices: chicken manuring and crop rotation. Cassava is commonly cropped once in poor soils and twice in richer soils. Thereafter, the field needs at least two years of fallow for recovering fertility. Cassava can be intercropped with beans, but the field's soil must be good enough for beans to grow. Ashby (1985) reported that minifundios (agricultural-laboring farms) have cassava plots with the highest erosion score. This reflects the self-perpetuation of poverty.

Maize and beans are monocropped up to three times in a row before fallow. When a particular field comes from fallow, farmers take advantage of the renewed fertility, cropping annual crops two or three times before sowing a perennial crop such as coffee or plantain. Coffee is preceeded by rotations of high input crops such as beans and vegetables, in order to increase fertility.

Table 3. Type of fertilizer used (n=1095 farmers)

Fertilizer (%)			
Organic	Chemical	Both	None
40	13	26	22

Source: Cabuyal census

Many farmers (40%) use only organic fertilizers (Table 3), because they cannot afford chemical fertilizers or live too far from market centers, or have farms located on richer soils of the high zone.

Most of the marketed produce in Cabuyal is sold in local markets of Siberia and Pescador, or taken to the middle size markets of Piendamó and Santander. Once there, products are bought by local consumers or taken to the main market centers such as Popayán, Cali, Bogotá. Coffee and cassava are the main cash crops in the region (Figure 2).

Profitable crops, according to farmers, are coffee (when broca is not a constraint), beans, plantain, cassava (when prices are high) and vegetables. Unprofitable enterprises are maize and sole cassava. Some farmers think that at current prices, cattle is more profitable than coffee.

Contractual arrangements can be found in cassava with starch processors, in vegetables with traders or rural shops, and in beans with cooperatives. However many of these contracts fail because farmers cannot guarantee a permanent supply.

Middleman fill an important gap by buying products of various qualities and maturity levels. They disseminate information on prices, future demand, and new market opportunities. Payments are often in cash, and cash advances on the harvest are common. Although they play an important role, there is considerable dissatisfaction with middlemen (Table 4).

Table 4 Reasons for changing buyer (% farmers)

	Middleman	Wholesaler	Federacafé	Starch processor	Other	Total
Fake Weights	51	5	11	3	-	70
Did not come back	41	7	3	4	7	62
No loan availability	7	3	11	-	-	21
Total	99	15	25	7	7	

Coffee is sold in medium sized markets (Figures 2 and 3), mainly to independent traders, and to a much smaller extent to the coffee federation (Federacafé). Middlemen have a major advantage over Federacafe, because they buy all qualities of coffee, whereas Federacafe only buys high quality coffee beans. Middlemen sort and classify coffee bought from farmers and re-sell premium coffee to Federacafé for export, and the rest for domestic consumption.

Cassava harvesting can be delayed to reap the benefits from the increasingly higher price outside the main harvest season. However, this strategy is risky because of renewed sprouting and the consequent loss of starch in the roots. Ninety six percent of farmers sell to starch processors (Figure 2). Starch processors provide sacks to the farmer for packing cassava. The farmer is responsible for packing and transporting the cassava to the limits of the farm where the starch processor or trader picks up the produce and takes it to any of the 190 starch factories in the region. Coapracauca, the local cassava cooperative, commercializes around 10% of cassava's production. The northern part of Cauca produces 42,000 to 45,000 t of cassava. Around 40,000 t are processed as starch (Ostertag, 1994).

Middleman are the main buyers of beans in the microwatershed (Figure 2). Maize is mainly sold on-farm to middlemen. Plantain is also sold mainly to middlemen.

Four sources of financing are potentially available to farmers: official credit through banks; semi-formal credit from NGOs; informal credit from neighbors and traders; and self-financing.

Bank credit is offered by Banco Cafetero exclusively to coffee growers. Many have little access to this type of credit either because they lack supporting documents, or because procedures are time and cost demanding. Semi-formal loans are offered by NGOs such as FUNDAEC, CETEC, CORPOTUNIA. This source of credit ceased in 1993 when a significant number of farmers stopped payments. Interest rates were four points lower than commercial rates and credit was given for beans, cassava and livestock, mainly pigs.

In the Cabuyal microwatershed, informal credit is important because it finances daily farmer needs and the purchase of crop inputs. Informal loans are offered as short-term pre-harvest advances mainly by local market agents (middlemen and starch processors). Traders lend according to the crop's area and previous farmer performance. Loans are in the form of cash or inputs (e.g. chicken manure, the most common fertilizer). Traders consider this service important, because it assures supply. They state that "the trader who does not lend, does not buy".

Self-financing is an important way of financing farm activities. Resources can be obtained from previous harvests (mainly of coffee and annual crops) or from the family's off-farm activities. Intercropping short duration annuals with perenials or semi-perenials is another self-financing mechanism.

Farmers reduce market and agronomic risks, by spreading out crops *in space and time*. This is a particular advantage of cassava and vegetables. Other risk avoidance strategies are intercropping and sharecropping.

The poorest farmers contribute significantly to the supply of labor in Cabuyal. Wages are lower in the high zone due to scarce economic opportunities. Labor is most expensive in March, during the main coffee harvest, and most abundant in summer, when there are few farming activities.

Labor accounts for up to 60% of coffee production costs, and reduces profitability particularly when broca lowers coffee prices.

Infrastructure is poor in Cabuyal. There is only one paved road which crosses the narrowest part of the region. During the rainy season, pick-up vans and buses are common forms of transport, with passenger fares within the microwatershed being 33% more than the cost of a pound of rice. Horses are used in remote areas.

Electricity is only available to farms close to the road. There is only one bank exclusively serving coffee growers. Besides traders' warehouses, there are no public or farmer-owned storing or gathering centers, where classification and selection of products can be done on a large scale. Training on post-harvesting techniques such as crop processing, product selection and quality classification is practically inexistent.

A number of organizations work in the microwatershed, but most have a production or conservation orientation. In a participative diagnostic study done in the Caldono municipality (1993), marketing problems such as high price fluctuations, lack of credit service and infrastructure (roads, energy), high input prices, and unavailable marketing channels, were identified by farmers as the main problems after the agronomic aspects. As solutions, farmers proposed stimulating farmer organizations to establish cooperatives and storing centers. They asked for credits at affordable interest rates.

CORPOTUNIA and FIDAR are two organizations attempting to solve marketing problems. Corpotunía makes a significant contribution to commercialization through purchasing and selling unions. Fidar develops small agro-industries in the region.

Market information is poor. Farmers in general do not know prices in the nearest cities like Cali and Popayán. Chief sources of market information are neighbours and rural traders.

In summary, the microwatershed is an area of resource poor farmers, with fragile soils, highly susceptible to erosion. Availability of farm land per capita is low, labor is seasonally expensive, the area is close to major markets, but farm to market roads are poor. Cash cropping of annual and perennial crops is widespread, but the profitability of the most important crop, coffee, is currently threatened, indicating that farmers may be open to new cash crops. Indeed new crops, such as vegetables, have started moving into the area. The use of chicken manure and crop rotation for fertility management is widespread, indicating that farmers are aware of the need for soil conservation. Most farmers own their farms, but renting and share cropping are widespread, and these practices may promote "short-termism". A well developed marketing system exists. While the role of formal organizations, such as cooperatives and federations, has declined over time particularly in the case of coffee, informal integration between producers and processors appears to be highly successful, particularly in the case of cassava starch processing. Middlemen play an important role for many crops, and provide auxilliary services such as credit and market information. However cash availability remains a serious constraint, and farmers expressed the need for more reliable market information. Overall, there is considerable dissatisfaction with middlemen. Formal contractual arrangements between farmers and product purchasers have generally failed, because of the inability of farmers to provide a continuous supply, or output of a specified quality. Cassava starch processors appear to have largely overcome this problem by providing loans to farmers, which are tied to the right to purchase produce. This indicates that formalized inflexible vertical marketing systems are unlikely to succeed. A more informal approach modelled on cassava starch processors may be more promising.

3. Determinants of sustainable production practices

The conceptual model for analyzing the adoption of sustainable practices by farmers is given in Figure 4. The process starts with the recognition of a problem (e.g. erosion). That perception is viewed as a product of the landowner's personal characteristics that might cause a more acute awareness of the seriousness of the erosion (e.g., formal education), coupled with the actual physical characteristics of the land he operates. Marketing institutions, government or extension programs may heighten this perception. Once the erosion problem is perceived, the landowner decides whether to adopt the conservation practice(s), and if so, what type. The potential for physical deterioration of a farmer's land also may persuade him to choose the type of practice(s). Economic factors may either enhance or constrain farmers' dispositions toward conservation. Figure 4 shows in brackets the expected effect from selected variables within each factor. For a detailed explanation of each variable, the reader can be referred to a previous draft of this study (Castaño, 1994[b]).

Regression analysis using Ordinary Least Squares (OLS) and Limited Dependant Variable Models (PROBIT or LOGIT) will be used to analyze the determinants of sustainability.

Data collection for the model was carried out in 1994. A stratified sample of 121 farmers was obtained from a 1993 complete census of farmers in the microwatershed. Population density and road accessibility were chosen as the criteria for stratification. From each strata a 10% random sample of the population was taken. Farmers in the microwatershed had previously been categorized into 3 groups representing levels of well being (Ravnborg, 1994). Map 1 shows the 121 geo-referenced farms distinguished by well-being categories. The upper part of the map corresponds to the low zone of the microwatershed and viceversa. Farmers were asked to mention the two most important fields in the farm. Each field was visited and measured. Questions on production practices and market uses of the products were asked. Additionally, other data about attitudes, institutional links, etc. were obtained. Initial results from the survey are given bellow.

Despite coffee erradication programs and broca attacks, coffee is by far the most important crop in the microwatershed (table 5). When asked to chose the two most important fields in the farm, 78% of the farmers selected the ones where coffee was located. Other crops were beans, and intercropped cassava and beans. Fields were considered to be important by farmers primarily because they generated income. The contribution to food security was a secondary consideration (Table 6).

Table 5. Main crop in the most important field (sample = 122 farms)

Main crop (% farmers)				
Coffee	Cassava	Beans	Maize	Plantains
78	5	9	4	1

Table 6. Reason for being the most important field in the farm (sample = 122 farms)

	Main crop (% farmers)			
	Income	Consumption	Nearby home	Other
First field	74	6	10	10
Second field	64	19	0	11

Table 7. Soil conservation practices on the main field in the farm (sample = 122 farms)

	Main crop (%)				
	Coffee	Cassava	Beans	Maize	Plantains
Oxen tillage	0	33	64	73	0
Barriers	34	17	36	18	0
Bamboo trench	2	0	0	0	0
Composting	5	0	0	0	0
Manual weeding	43	17	27	18	100
Mulch	53	0	73	9	0

Most soil conservation practices are done on coffee fields (table 7). Coffee is planted on the steepest slopes (Table 8). Maize and coffee are cropped on the more fertile soils, whereas cassava is on the less fertile soils. It can be concluded that coffee, the most important crop in the microshed, occupies the best field in the farm and receives more care than any other crop.

Table 8. Slope and soils of the main field of the farm (sample = 122 farms)

	Main crop				
	Coffee	Cassava	Beans	Maize	Plantains
Field Slope (%)	30.2	24	26.7	22	40
Soil depth (cm)	19.4	13.7	19.2	47	-
Soil quality(%) good	50	33	36	80	-
fair	45	67	64	20	-

Descriptive statistics linking soil conservation practices are given in Figures 5, 6, 7 and 8. Figure 5 shows higher adoption levels for conservation practices, with the exception of barriers, for farmers who sell their produce under contractual arrangements. Farmers who favor stable commercial links with the market, e.g. informal or formal contractual arrangements with starch processors, cooperatives, retail outlets or marketing boards, may have a longer term perspective and may want to keep their productive resource in good condition for conserving that marketing relationship.

Conservation practices are more prevalent in villages with good road access. Farmers with good road access may have better access to extension services from government and private institutions. They may also have better access to banks, agricultural input suppliers, and infrastructure such as energy, allowing the broadcasting of informative and extension programs on radio and TV. Barrier adoption is particularly high in farms with good access. This may be explained by the fact that the barrier seeds (pasture, sugar cane, etc.) are more easily transported to farms accessible by trucks. Organic fertilization practices are more prevalent in farms with poor access as these farmers do not have easy access to chemical suppliers.

In Figure 4 it was hypothesized that farmers with higher economic returns are more likely to adopt sustainable practices. Considering the fact that conservation practices are in general labor intensive, wealthier farmers may have fewer constraints to the adoption of barriers, terracing and manual weeding. Poor farmers, who only have access to unpaid family labor, can adopt fewer intensive labor techniques such as green manuring, minimum tillage (probably because there is no money for oxen traction) and mulching. Figure 7 supports this hypothesis for some practices, and not for others.

Education is thought to influence the adoption of practices. Figure 8 shows that this hypothesis holds for all practices but mulching. It could be expected that more educated farmers have greater information on conservation measures and the productivity consequences of erosion. However, the average education level (3 years) seems too low to be sensitive enough to this aspect.

4. Search for market opportunities

Four complementary sets of guidelines were used to focus the search for market opportunities, as follows:

- Study market demand for products that can fit into growth strategies : market penetration, market development, product development and diversification (Figure 9).

- Explore market demand for products in which the pilot region exhibits a comparative advantage, taking into consideration factors such as proximity to markets, natural resources, labor availability.

- Determine market demand for key agricultural, forestry and animal products that are recognized as being valuable tools for promoting sustainability, directly or indirectly.

- Establish market demand for key agricultural and forestry products that used to be important in the region.

Figure 9.

	Current products	**New products**
Current markets	**Market penetration**	**Product Development**
New markets	**Market Development**	**Diversification**

A market survey, centering on Cali and its area of influence, was initiated in the fourth quarter of 1994 and was finished beginning 1995. Different questionnaires were prepared for supermarket chains, food-processing companies, milk-processing firms and flower shops. The questionnaire for supermarkets was divided in four sections, as follows: fruits, vegetables, organic products and "traditional products". The latter focused on the portfolio of products considered to be typical of small farms in the region. Questionnaires concentrated on identifying product segments exhibiting high-growth and deficient supply, as well as client requirements and prices. Other sources of information were informal contacts with non-food and food industries and secondary information from newspapers and institutions, such as the Cali-based FDI (Fundación para el Desarrollo Integral del Valle del Cauca), linked to the Chamber of Commerce. After information processing a list of 25 potential market opportunities was presented (Ostertag, 1995).

Tables 9-11 present the basic characterization for five potential market options chosen at random. The economic characterization is a preliminary draft. In addition, a soil scientist has analyzed the conservaion potential of these five options and has designed sustainable production systems for three of them.

**Table 9. MATRIX FOR EVALUATING MARKET OPPORTUNITIES IN THE RIO CABUYAL REGION.
1. BASIC ÀGRONOMICAL CHARACTERIZATION**

Potential products	total cycle	preproduction cycle	No. harvest per year	Soil type	pH	Water requirement	Irrigation	Altitude requirement	Main pests & diseases	Planting density
	years	months	Pnt = permanent			mm	N= Necessary NO= Not necessary	msnm	.	No/ha
Blackberry	5	12	Pnt (irrig.)	Loam	5.3-6.2	1400-2200	NO	1400-2500	Nematodes, red spider mites, aphids, fruit rot	2.000
Lulo	2.5-3	6-12	Pnt (irrig.)	Loam, with high organic matter	5.5	1500-3500	NO	1500-2000	Burrowing bug, nematodes, scale insects, and white mealy bugs.	1.600
Native strawberry	2	4	Pnt (irrig.)	Sandy-loam with high organic matter	5.7-6	perma-nent	N	1800-2600	Nematodes, slugs, mites, aphids, white grubs	30.000
Uchuva	3	6	Pnt (irrig.)	Genèral infertile soils of varying texture	5.5-6.8	800-1200	NO	1600-2800	Cut worm, pulguilla, miners, aphids, leaf spot, leaf wilting, nematodes	4000
Lettuce	80 days	--	--	Clay or sandy loam with high organic matter	5.2-5.8 (org); 5.5-6.7 (mineral)		N	> 1400	Aphids, cut worm rot	50.000

Table 10. MATRIX FOR EVALUATING MARKET OPPORTUNITIES IN THE RIO CABUYAL REGION. 2. BASIC MARKETING CHARACTERIZATION

Potential products	Currently marketed in study area	Types of purchasers	Services provided by purchasers	Market growth	Requirements of purchasers				
					Quality	Conditions	Continual supply	Volume demanded *	Contractual arrangement
		Sp= Supermarket FI= Food indust. I= Industries Res= Restaurant	TA= Techni. assist. Cr= Credit	H= High M= Medium L= Low N= New	H= High M= Medium L= Low	Sz= Supplied in zone Sw= Supplied in warehouse		per week	Va= verbal agreement Ic= Informal contract Fc= Formal contract **
Blackberry	Yes	Sp, FI	FI: TA	Sp - M FI - H	Sp - H FI - M	FI: Sz/Sw baskets Sp: Sw plastic basket	Yes	FI - 30 ton	Sp - Va FI - Va, Fc.
Lulo	Yes	Sp, FI	FI: TA	Sp - H FI - H	Sp - H FI - M	FI: Sz/Sw sack, box Sp: Sw plastic basket	Yes	FI - 40 ton	Sp - Ic FI - Fc
Native strawberry	No	FI		H	H	FI: Sw, plastic basket	Yes	--	Va.
Uchuva	No	Export		H	H	FI: plastic basket	Sep-Feb	--	Fc.
Lettuce	No	Sp, Rest.	Sp: TA	H	H	FI: Sw/Sz Sp: Sz/Sw plastic basket	Yes	--	Ic.

* Identified via survey.

** Types of contractual arrangements between the purchasers & suppliers. "Verbal agreement" means that if quality, price & continuity are acceptable, the commercial exchange is done. "Informal contract" implies a greater commitment from both sides. "Formal contract" involves a signed document.

Table 11. MATRIX FOR EVALUATING MARKET OPPORTUNITIES IN THE RIO CABUYAL REGION. 3. BASIC ECONOMIC CHARACTERIZATION (DRAFT) *

Potential products	Initial level of investment	Labor cost /output price ratio	Working capital /output price ratio	Technological complexity **	Perishalility	Transportation cost/kg	Purchase price vs. CAVASA price ***	Profitability ****
	H = High M = Medium L = Low	H = High M = Medium L = Low	H = High M = Medium L = Low	H = High M = Medium L = Low	H = High M = Medium L = Low	H = High M = Medium L = Low	G= Greater S= Same L= Lesser	H = High M = Medium L = Low
Blackberry	H	H	M	M	H	M	M	H
Lulo	L	L	L	L	L	M	Sp = S FI = L	M
Native strawberry	M	H	H	M	H	M	--	H
Uchuva	H	M	M	L	M	M	--	H
Lechuga batavia	M	H	H	M	H	H	--	L

* *Assumes intermediate technology.*

** High levels of technological complexity are considered to be incompatible with the small farm conditions.

*** Comparison of the purchase prices identified in the study with the list of prices in CAVASA (Corporación de Abastecimiento del Valle del Cauca, S.A.), during the same period.

**** Preliminary qualitative estimate.

5. Ex-ante evaluation of options

The ex-ante evaluation will use a Multiple Goal Linear Programming (McGregor and Dent, 1993; Cocklin et al., 1988; Kruseman et. al., 1995). This model can be used to quantify the tradeoffs between conflicting goals, such as farmer objectives (income, risk reduction, etc), and researchers' objectives, such as reduction of soil erosion. This model can be used to quantify the impact of interventions (such as new market opportunities, contractual marketing arrangements, and policies such as floor prices) on the fullfillment of farmer and researcher goals, and their tradeoffs. Thus the model is a tool for researchers and policy makers. The results are expected to provide feedback to biophysical scientists on the best bet options for erosion control. It will also provide recommendations to NGOs on appropriate marketing interventions, and to policy makers on farm level impact of price intervention and infrastructure development. The model is currently under development.

MAP 1. DISTRIBUTION OF INTERVIEWEES CABUYAL WATERSHED

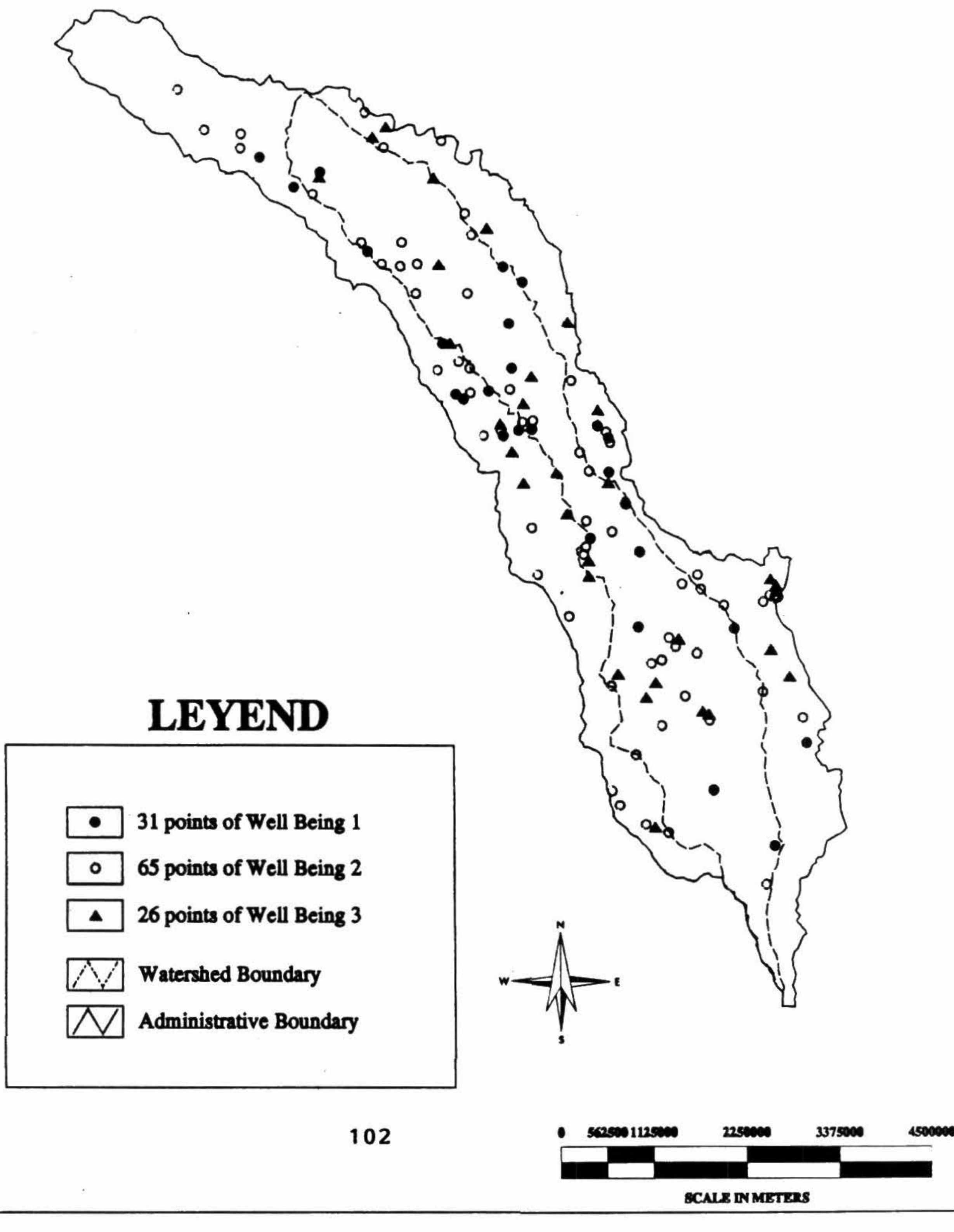
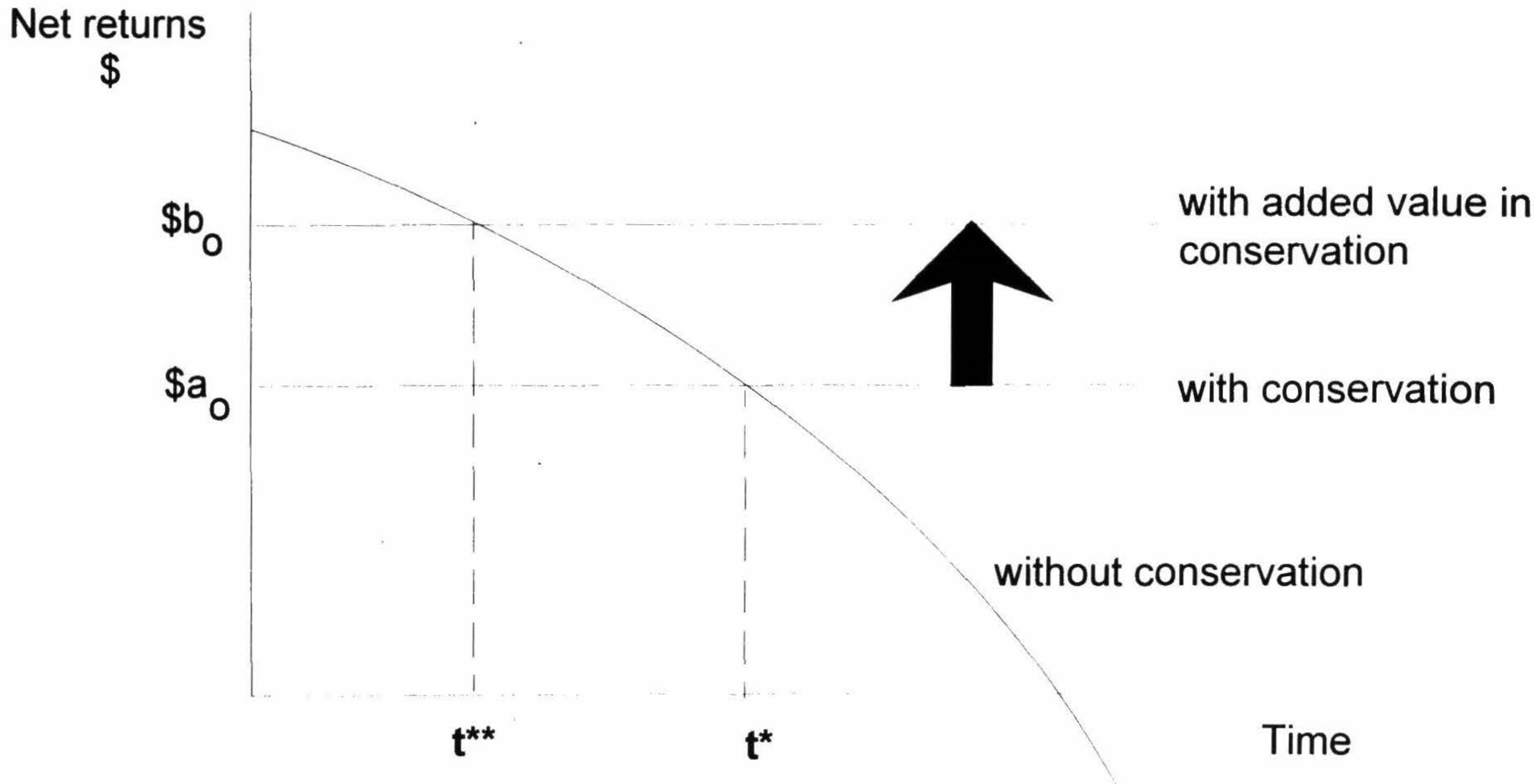
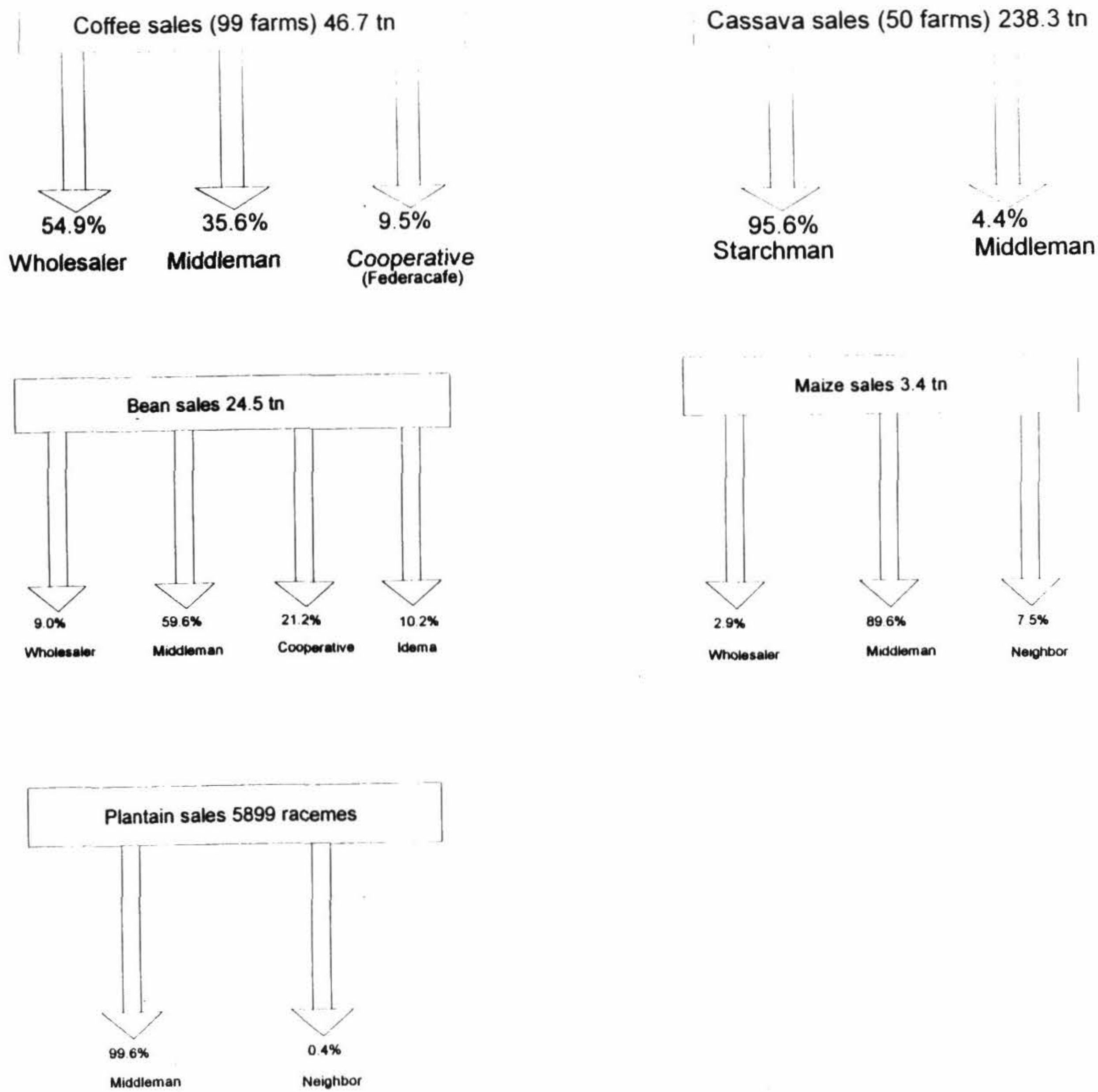


Figure 1. Net returns with and without soil conservation



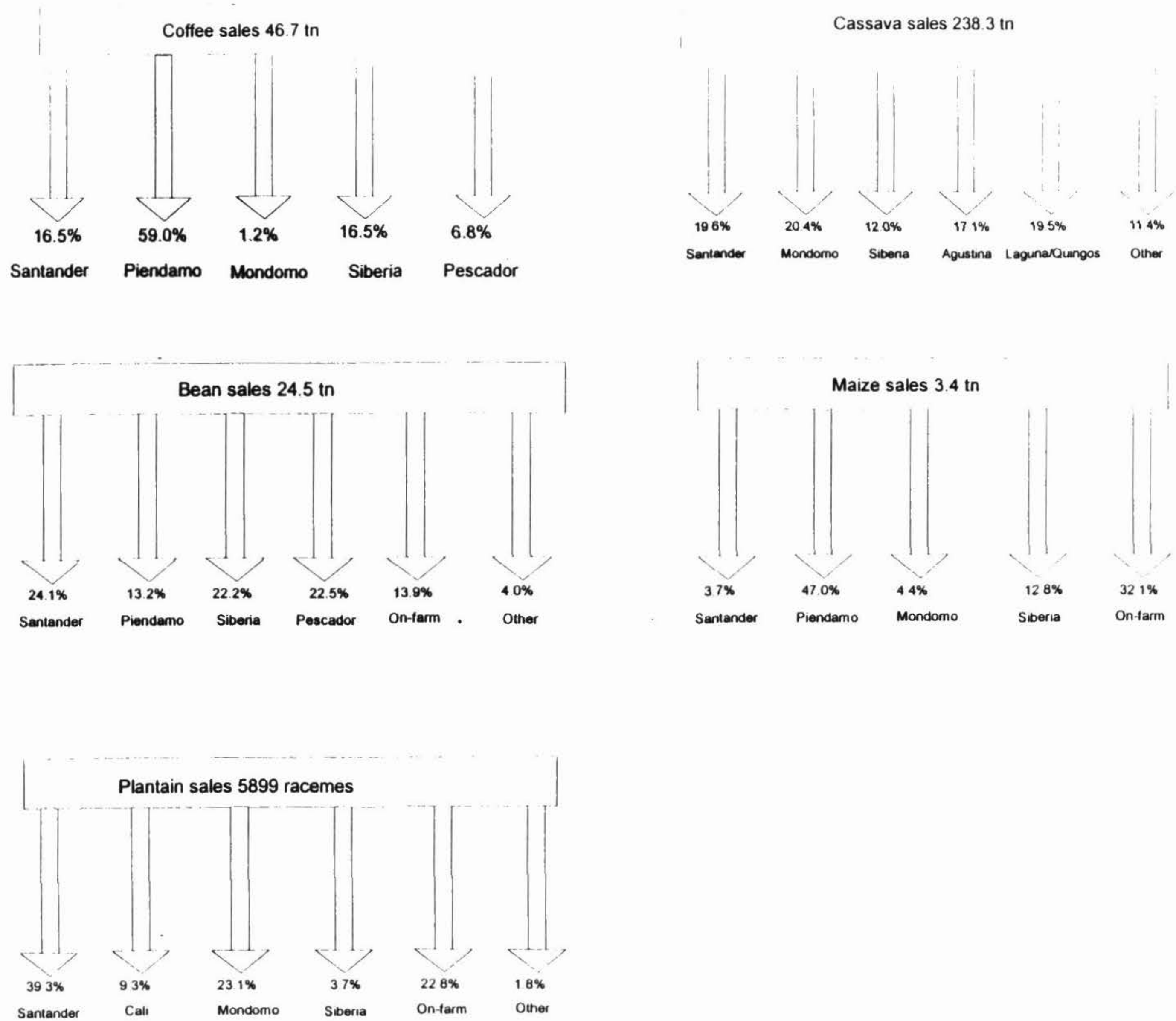
soiltime.prs

Figure 2. Annual sales by type of agent



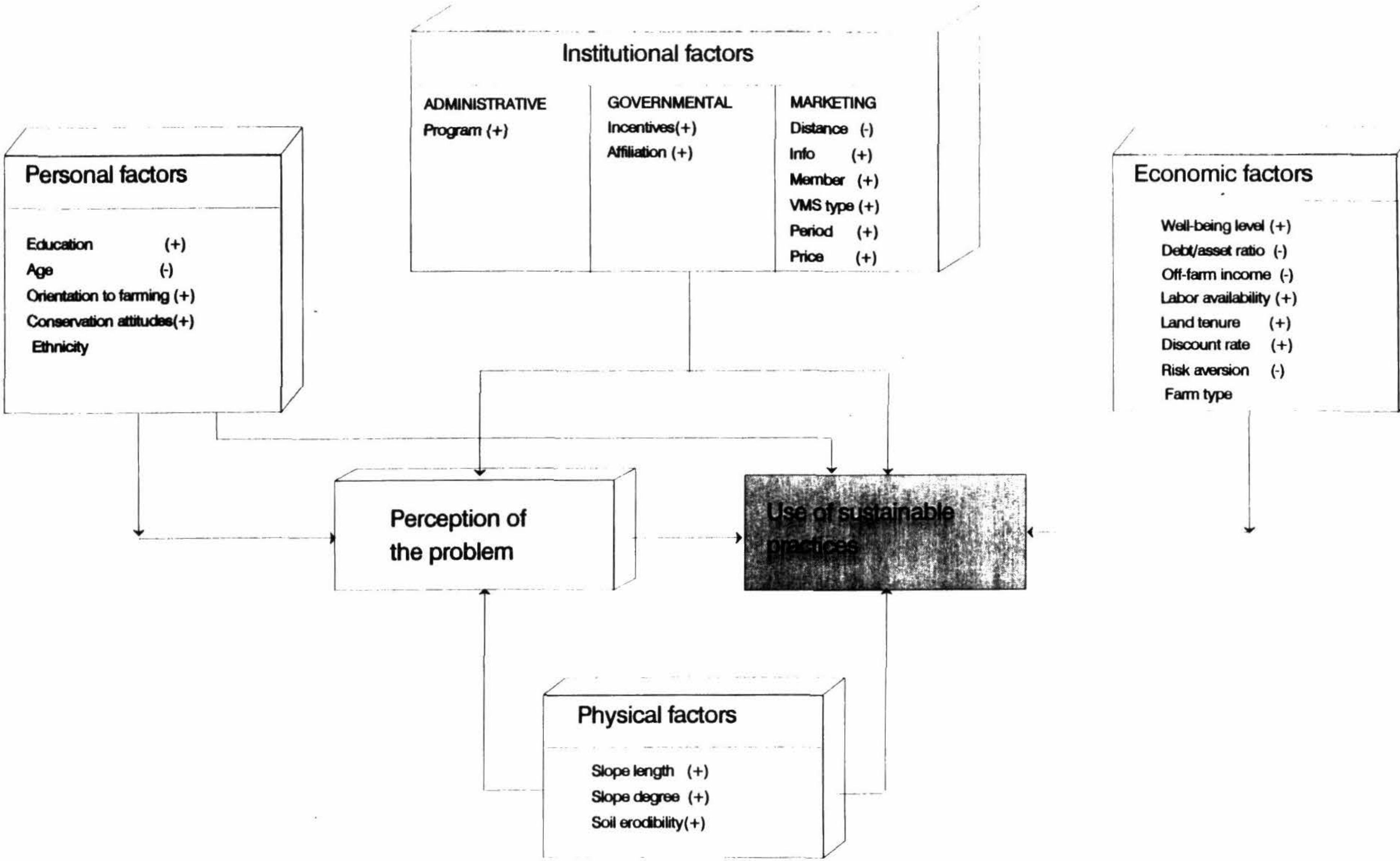
agents.prs

Figure 3. Annual sales by market center



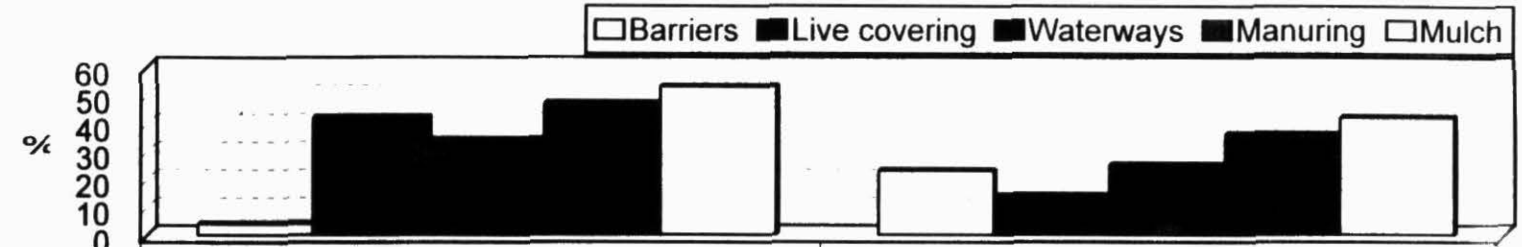
market.prs

Figure 4. Decision-Making process for the use of sustainable practices



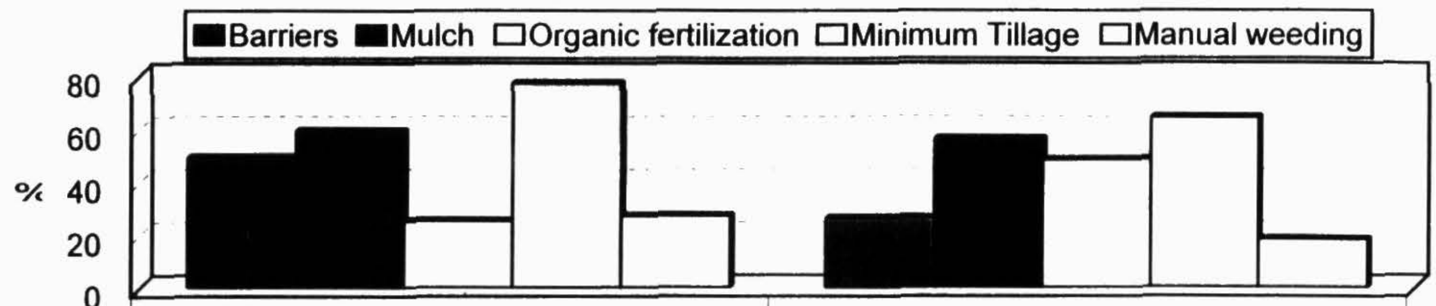
sustaina.prs

Figure 5. Conservation practices by type of market integration



	Sold to coop/starchman (38 farmers)	Sold to other (83 farmers)
Barriers	4	23
Live covering	42	14
Waterways	34	25
Manuring	47	36
Mulch	53	42

Figure 6. Adoption of soil conservation practices by road accessibility



	Good accessibility (53 farms)	Bad accessibility (68 farms)
Barriers	49	26
Mulch	59	56
Organic fertilization	25	48
Minimum Tillage	77	64
Manual weeding	27	18

adoption.prs

Figure 7. Adoption of soil conservation practices by well-being

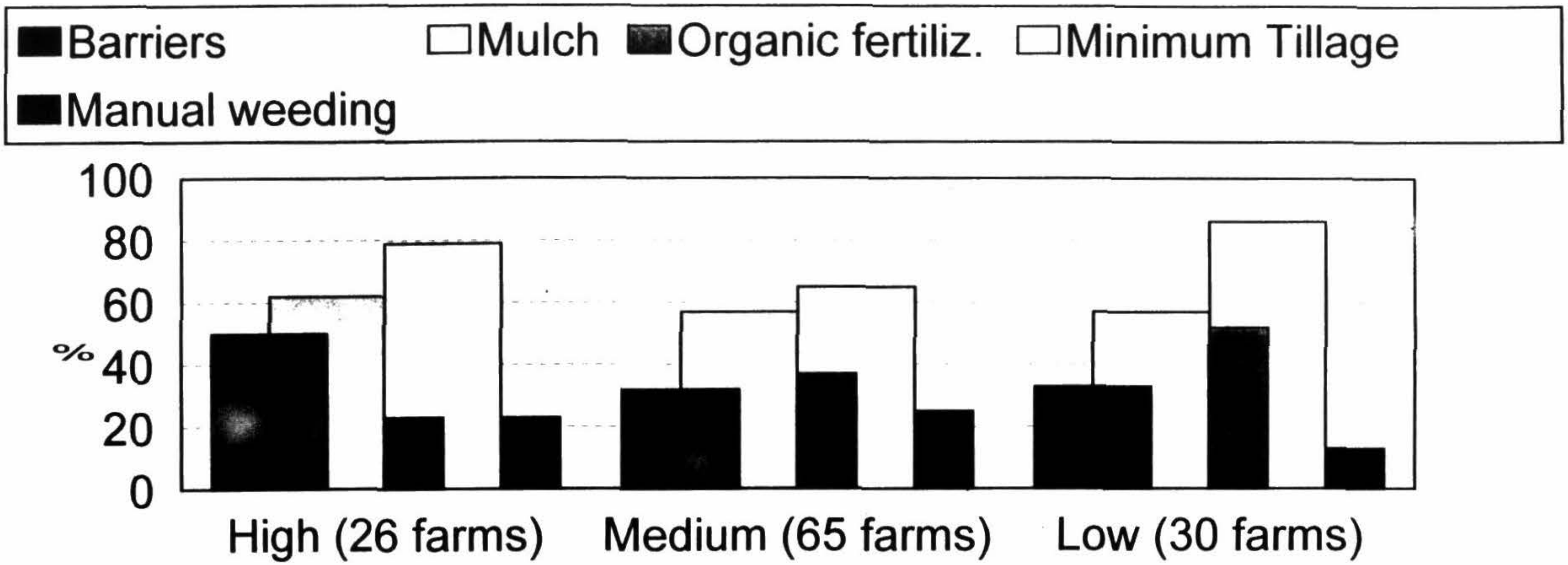
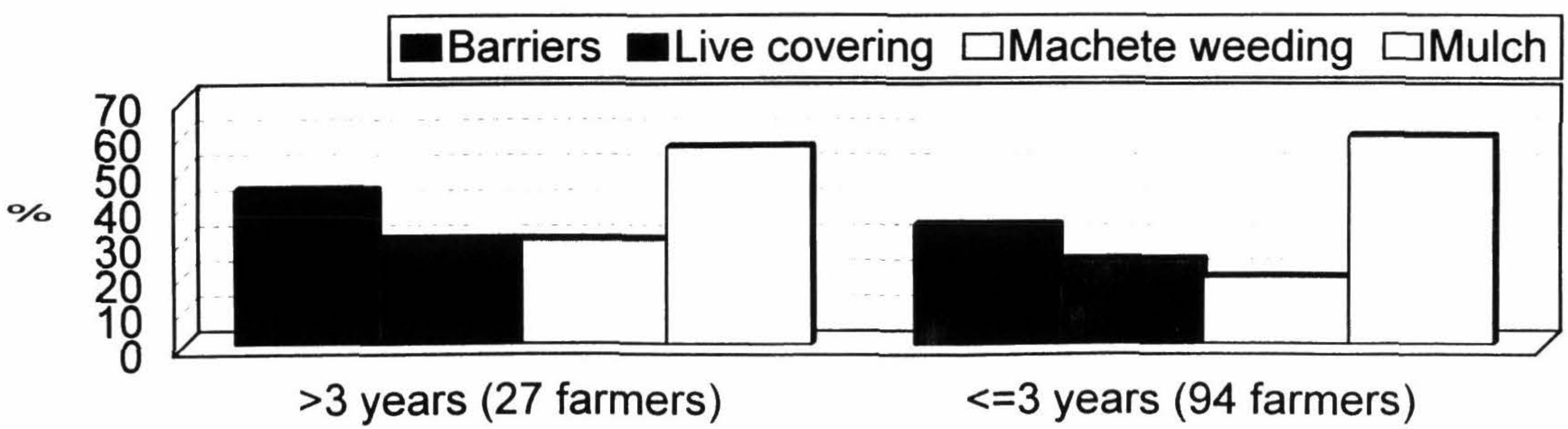


Figure 8. Adoption by owner's education



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PROJECT AREA

PARTICIPATORY RESEARCH

PROGRESS REPORT

1995

PROJECT 4 Institutional models for participatory R&D for improving technology design and adoption in the hillsides

Purpose: To develop methodologies to support a community-based, participatory R&D approach for evaluating the productive performance, ecological impact and acceptability to farmers of technologies with potential for improving land use in the hillsides of tropical America.

I. ORGANIZING FOR LOCAL-LEVEL WATERSHED MANAGEMENT - LESSONS FROM RIO CABUYAL WATERSHED, COLOMBIA

Prepared by: ***Helle Munk Ravnborg[1] and Jacqueline A. Ashby[2]***

ABSTRACT

Watershed management involves the integrated management of a multitude of resources such as crop land, pastures, forests and water to each of which a multitude of often conflicting interests relate. These interests arise from stakeholders inside as well as outside the watershed. The identification and negotiation of these interests therefore is an important element in watershed management. Based on experiences with organizing for local-level management of the Río Cabuyal watershed in Colombia, this paper discusses what should be the role of local-level organizations in watershed management and draws out some organizational principles. (9388 words, *excluding references and tables)*

1. Introduction

Successful management of natural resources to promote their conservation and where appropriate their development, is increasingly seen as dependent on the involvement of local organization. Recent literature witnesses a growing interest in and optimism about the role of local organizations in natural resource management. From having been viewed primarily as an ecological and technical issue, there is now a growing recognition of natural resource management as a social and economic issue [10]. And for good reasons: natural resource management problems tend to be of a nature where one actor's use or neglect of a particular resource influences other actors' possibilities for using that (and other) resource(s). This makes the development of institutions, i.e. of norms, rules, rights, sanctions and conflict resolution mechanisms to govern resource use a crucial issue.

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[1] CIAT Hillsides Program.

[2] CIAT Hillsides Program.

Based on game theoretic work as well as on empirical cases, primarily from the domain of irrigation management, but also from social forestry and rangeland management, lessons are being synthesized with respect to the conditions under which local organizations are likely to be successful in natural resource management as well as the organizational features that characterize successful local organizations [2][8][10][12]. However, very few empirical cases are actually reported and thus included on the role of local organizations in watershed management.

One of the lessons emerging from these syntheses is that natural resources that are naturally bounded, predictable and lend themselves to preventing others from using them, are more likely to be successfully managed by local organizations than are resources that do not possess these characteristics. Moreover, the bigger and the more heterogenous the group using the resource is, the smaller is the likelihood that local organizations will emerge and become successful in its management.

Watersheds generally do not meet these conditions. Moreover, watershed management tends to involve a complex mix of managing interlinked common-pool and privately owned resources. These are among the factors that make watershed management a special case of natural resource management - a case for which many have concluded that prospects for local organizations to take responsibility seem rather limited, e.g. [4][12]. Instead, it is argued, higher level organizations such as regional or national-level authorities have to be called upon to manage watersheds. Yet, experience shows that in low-income countries regional authorities are not particularly able to influence the direct watershed managers to adopt beneficial practices from a watershed or a regional point of view [1][13]. In the absence of local-level counterpart organizations, such higher-level organizations tend to operate in an authoritative manner with rules of compliance which are difficult to enforce, particularly when watershed resource management involves a large number of individual decision-makers.

This paper questions the implicit assumption upon which the above lessons are drawn, namely that organizational principles for local-level resource management in general and watershed management in particular can be drawn from case studies to a large extent undertaken in the context of irrigation management. The paper argues that a number of features make watershed management a special case within resource management and therefore that the role and thus organizational principles for local-level management need to reflect these special features.

Among the features that make watershed management a special case is that i) it involves the integrated management of a multitude of common-pool and privately owned resources; ii) a multitude of interests and opportunities for meeting these interests relate to the use of any given resource almost at any given place and time; and that iii) these interests and objectives originate inside as well as outside the watershed. Based on experiences gained from studying a process of organizing for local-level management of a micro-catchment area in the northern part of the Cauca department in Colombia, the paper identifies six functions which are essential in watershed management and define the role of local-level watershed management organizations as well as some principles for organizing for local-level watershed management.

The activities to build and support local-level resource management analyzed in this paper are part of a special project to improve sustainable agriculture and livelihoods in the Río Ovejas watershed in Cauca, Colombia, of which the Río Cabuyal is a tributary watershed. They cover a period of approximately two years, from November 1992 to the end of 1994. The project is managed by a consortium of organizations, including the International Center for Tropical Agriculture (CIAT), and is supported by grants from IDRC, Canada, the W.K. Kellogg Foundation and the Colombian government agency, Desarollo Rural Integrado (DRI), as well as contributions by local governmental and non-governmental organizations. Within this set of activities, the paper focuses on the process of creating a local-level watershed management organization in the Río Cabuyal watershed.

Research by the project is monitoring the process of institutional development in order to develop recommendations or design principles on institutional options that promote local responsibility for ecologically sound and economically viable use of watershed resources. The project uses a participatory action research methodology which provides feedback to the participants in a 'learning process' approach [7]. This approach promotes self-correction in the expectation that the organizational set-up for local-level watershed management will evolve over time, and that lessons will be derived as much from the mistakes and corrective actions, as from setting up the institutions as originally conceived at the initiation of the project. The results of the first two years discussed in this paper are, therefore, very much results of work in progress as opposed to definitive conclusions. The entire time-frame of the project is expected to be at least six years.

The paper is structured as follows: The following section discusses in more detail the features that make watersheds a special and, according to some, a problematic case seen from the perspective of local-level management. In section three, one of these features, namely the existence of multiple, conflicting interests is illustrated in the context of the Río Cabuyal watershed by way of introduction to the study area. Section four describes the process leading to the creation of FEBESURCA, the Río Cabuyal watershed beneficiary federation, and the wider organizational set-up within which it belongs, while section five brings out some issues that have emerged during this process. Section six identifies six functions which based on the Río Cabuyal experience appear to define some basic principles for organizing for local-level watershed management, while section seven summarizes the conclusions.

2. Five features making watershed management a special case of natural resource management

First of all, whereas irrigation schemes or forests have well-defined boundaries, the extension of watersheds is not definite, once and forever given, nor are they immediately visible. Like little chinese boxes, watersheds are nested within each other. Within a given area, it is possible to identify almost an indefinite number of watersheds. Watersheds can be defined with reference to major rivers such as the Amazonian watershed, covering a considerable part of the South American continent, or to tertiary rivers such as the Río Cabuyal watershed (see Map 1). This means that neither the physical boundaries nor the social categories of the users of the watershed are easily defined.

Second, the management of watersheds is not confined to the management solely of one resource for which there is a single predominant use, such as water for irrigation. Instead, watershed management involves the use of a number of resources such as soils, forests, crop land and water, each of which have multiple potential and actual uses. For example, water is not only used for irrigation but also for drinking water inside as well as outside the watershed. Likewise, forests are used for collection of firewood, building poles or forage to be used locally; for burning of charcoal to supply urban and semi-urban populations; as a source of important plants and animals; as an important element in determining the local microclimate and protecting water sources from drying out; and as a pool of genetic diversity. Whereas in an irrigation scheme, everyone would agree that the water should be used for irrigation once it has entered into the irrigation system (the question being who should use it, when and for how long), interests with respect to the often competing purposes for which a given resource within a watershed should be exploited are likely to be conflicting.

Third, as noted by Uphoff [12], the benefits resulting from watershed management are often deferred and/or accrue to others than those directly involved in the management. This, of course, is likely to considerably reduce incentives to people living within the watershed to undertake watershed management for the benefit of people downstream.

Fourth, it is often complicated to measure and even to perceive or sense the extent to which a watershed is degraded as well as the impact of management efforts. The concept of a watershed is a systemic one. It draws attention to the functional interrelationship between the different resources within a watershed such as land, water, vegetation and thereby between the management practices to which each of these resources are subjected. Rather than planting and protecting trees for reasons exclusively related to trees and wood, such as the need to ensure future building material and firewood supply as would be done from a forestry management point of view, the watershed management point of view is likely also to suggest the planting and protection of trees due to non-tree related objectives. Such non-tree related objectives can include reducing erosion on lower-lying fields and thereby - perhaps - increasing crop production and reducing siltation of water courses. Another non-tree related reason for planting trees can be to protect important water sources from drying out. Such interrelated or systemic effects are, however, difficult for managers to measure, valuate and perceive. This is likely to reduce the immediate incentives to the actual watershed managers.

Although the physical effects resulting from management of the individual resources within a watershed are interrelated, this is seldom the case for the decision-makers involved in this management. Typically, the wood cutters harvesting trees to produce charcoal are not involved in decisions about which forested water sources to conserve for drinking water, and vice versa, although both decisions vitally affect the outcome desired by each separate interest group. Unless the physical interrelationship between management of two resources becomes apparent to the extent that continued utilization of the resource(s) is threatened, the structure of local organizations involved in decisions about resource management does not promote management in the common interest.

A fifth reason why watershed management constitutes a special case and local organizations appear to be weak partners in watershed management, which exacerbates the effects of the many conflicting interests relating to the use of resources within a watershed, is that watershed populations, especially in the case of the Andean hillsides, tend to be heterogeneous: different ethnic groups, disparity in access to resources, in resource utilization practices and among institutions governing resource utilization all affect the capacity for local organizations to control watershed management.

3. Conflicting interests relating to the management of the Río Cabuyal watershed

In August 1994, a month before the end of the dry season, the aqueduct ran dry in El Socorro. El Socorro is one of the lower-lying communities (14-1,500 meters a.s.l.) in the Río Cabuyal watershed (see map 1) that like many other communities in the watershed gets its drinking water from an aqueduct that has its intake in La Esperanza in the upper part (19-2,000 meters a.s.l.) of the watershed. People in El Socorro said that the aqueduct ran dry because people in the mid-altitude communities like Ventanas (15-1,600 meters a.s.l.) were using all the water for irrigating their tomatoes, a very profitable crop in the area. Others claim that there is less water now because people in the upper part of the watershed are cutting down all the forest in the area from which the aqueduct takes its water. People in the upper watershed defend themselves by saying that they have no alternative sources of income to clearing woodland. Moreover, they say that they are significantly disfavoured with respect to services such as roads, schools, piped water or electricity, so why should they give up their income to benefit other better-off communities.

Social and physical boundaries rarely coincide. While the Río Cabuyal watershed from a strictly physical point of view comprises an area of 3,200 hectares, the shaded area in map 1, the area which in this paper is referred to as the Río Cabuyal watershed covers 6,500 hectares as it is delineated by the administrative (community or *vereda*[1] boundaries) within which the 'true' Río Cabuyal watershed falls. The 6,500 hectares area has a population of approximately 6,500 people living within 22 communities or communities.[2] The Río Cabuyal watershed is situated in the mid-altitude Andean hillsides at an altitude ranging from 1-2,000 meters a.s.l. The annual rainfall is approximately 2,000 mm with a pronounced dry-spell occurring between June and August. The watershed is relatively densely populated (100 persons per km^2), however, with a pronounced variation among the communities.

Small-scale farming, either on owned or rented land or through day-labouring on local small-scale farms constitutes the principal source of income in the area with the average cultivated area being just below 2 hectares.[3] Coffee, cassava, maize and beans, and in the upper watershed also fruits, are the principle crops in the watershed. Livestock production is of minor importance as only 14 percent of the households own livestock. The Panamerican Highway cuts across the middle of the watershed giving the population in lower and mid-altitude parts of the watershed relatively good access to markets in neighbouring townships as well as the bigger cities of Popayán and Cali. On average, 80 percent of the families have access to piped drinking water, although in upper part of the watershed the share is only 70 percent, while virtually all households use firewood as the primary source of energy for cooking.

Outside the Cabuyal watershed a US$ 25 million proposal has been approved by the regional watershed management authority, the CVC, to divert the flow of the Río Ovejas to which Río Cabuyal is a tributary for hydroelectric power generation [6]. This obviously introduces other, external interests to the management of the Cabuyal watershed: it not only increases the competition for water but adds requirements to the quality of water and thus to farmers to minimize erosion in order to prevent siltation of the dam to be constructed.

However, the conflicts relating to the management of the Cabuyal watershed go beyond 'on-site versus off-site' or 'upper versus lower', i.e. geographical divides, and encompass dimensions of ethnicity and access to resources.

Ethnic conflicts over land as well as cultivation practices are endemic in the area. Land which was within the indigenous Paez reserve as defined by the authorities, has gradually been sold to and/or colonized by the mestizo population and is no longer under the control of the *Cabildo La Laguna*, the local indigenous governing body. Periodically over the last two decades, the Paez have invaded lands held by mestizo landowners, cutting and burning off the forest to cultivate traditional maize and beans crops. On occasions, the return of these lands to their mestizo owners has been negotiated between the local mestizo community leaders and the Paez, usually with the intervention of outside authorities, sometimes including the military, and the Paez have abandoned the invaded lands in return for promises by the Cauca Department political authorities to supply electricity, roads or extension services within the Paez reserve. On other occasions, the land has been ceded to the invaders, often through the intervention of the regional indigenous organization, CRIC, and the national land reform institution, INCORA.

Also immigration of farmers from neighbouring department, Nariño, which has taken place since the early 1990s has given rise to ethnic conflicts over land and land use. The migrants came with capital from the sale of land in Nariño to rent land in the poorer parts of Cauca where good profits could be obtained from cultivating beans during the years when bean prices were favourable. The Nariñenses drove up the cost of short-term land rental so that local inhabitants found it difficult to obtain rented plots. The Nariñenses were especially prone to rent land from the indigenous community. They cultivated beans on steep slopes, practicing thorough ploughing and using high applications of fertilizer, and planting three or even four successive crops of beans on a plot before moving on to another. Local farmers, in particular the mestizo bean farmers accustomed to rent land from the indians, saw Nariñenses extracting profits from the land and ruining it with bad practices. In particular, three or more successive crops of beans left the plots infected with serious root rot and other soil borne diseases, never before experienced in the area. The unsuspecting local farmers who have planted plots previously used by Nariñenses have experienced major losses in their bean crop from these diseases. This situation led to a number of violent confrontations and the death of two recalcitrant Nariñense tenants and to the indian *cabildo* adopting a policy of denying rentals to the Nariñenses following persuasion from local mestizo community leaders.

Access to resources constitutes third dimension along which conflicts over natural resources arise. Land is unevenly distributed: 16 percent of farmers cultivate less than 0.5 hectare amounting to 2 percent of the total cultivated area within the watershed. In contrast, 9 percent of farmers cultivating 4 hectares or more together operate 30 percent of the total cultivated area within the watershed (see table 1).

Through a process of conducting well-being rankings to elicit local indicators or criteria for different levels of well-being, and subsequently applying these criteria to the 1993 household questionnaire survey, a classification of households into different well-being categories was undertaken. According to this classification, 28 percent (274 households) fall into the category of households enjoying the highest level of well-being, 42 percent (420 households) were classified as enjoying a medium level of well-being and the remaining 30 percent (303 households) as enjoying the lowest level of well-being. In the following, these are the categories referred to by terms such as 'poorer', 'best-off', 'wealthiest', etc. It should be noted that these categories do not coincide with the categories 'indigenous-mestizo'. Although in the communities where there is a considerable Paez population there tends to be an over-representation of the indigenous population among the households suffering the lowest level of well-being, this category includes a significant share of mestizo households.

Flat land is increasingly a rare and expensive commodity, so poorer people tend to cultivate the steeper slopes. While 30 percent of the poorer households in the Cabuyal watershed consider all their plots too steep to plough, this is only the case for 10 percent of the better-off households ($p<.00001$, Chi-square test). Moreover, because the poorer households lack capital for investment or to purchase food for immediate consumption, they tend to cultivate steep slopes extensively, i.e. without soil conservation measures, which enables them to offer their labour to better-off neighbours in return for immediate payment. Poor people are less able to maintain soil fertility by rotating cultivated with fallow land. Of the poorest segment of the population, 46 percent have land in fallow compared with 54 percent of the middle segment and 62 percent of the best-off segment ($p<.001$; Chi-square test). The poorer households are therefore associated with and blamed for causing soil degradation, not because soil degradation is their interest, but because they do not have the capacity to accept the trade-off existing between minimizing land degradation and maximizing immediate returns to labour and land.

Moreover, the poorer households have significantly less access to water and forest resources. While 31 percent of the poorer households have water springs on their fields, this is the case for 46 percent of the households in the middle category and 52 percent of the best-off households ($p<.05$; Chi-square test). Most forest resources in the Cabuyal watershed are privately owned, disfavouring the poor. Only 18 percent of the poorest households own forest compared with 48 percent of the best-off and 31 percent of the middle group ($p<.00001$; Chi-square test). Thus, the 274 households falling in the category of households enjoying the highest level of well-being command more than 50 percent of the forested area in the Cabuyal watershed while the 303 households suffering the lowest level of well-being command only 12 percent of the forested area.

Finally, conflicting interests with respect to the utilization of natural resources also exist at the level of the individual decision-maker. As an example, burning persists as a common means of land clearing both in continuous cultivation to get rid of weeds and crop residues and in semi-permanent farming to clear secondary growth after periods of fallow. Although most people recognize its harmful effects on the soil as well as more globally through siltation of water courses, and are aware that soil quality would improve if the organic matter was left to decompose, they continue to practice burning (Interviews with farmers made by FEBESURCA representatives 1994). The advantage of burning is that it speeds up land preparation, and allows the use of the entire field whereas various forms of composting take up space for trash lines and require more labour. Short-term economic gains conflict with benefits of preserving the quality and quantity and thus the continued use of natural resources.

4. Organizing for local-level watershed management - the case of Río Cabuyal[4]

It was in the context of such multiple conflicting interests that, in early 1993, an inter-institutional consortium for sustainable agriculture, CIPASLA, and within this a watershed user committee, FEBESURCA, were created.

As is so often the case, the inhabitants of the Río Cabuyal watershed were at the time of establishment of CIPASLA confronted with a bewildering array of organizations, governmental as well as non-governmental, each of which having their own and often, seen from a watershed management point of view, strongly contradictory programmes. As an example, CVC, the regional watershed authority, had a long history of conservation efforts in the area, seeking to promote or enforce various land use conventions while various public sector organizations and NGOs had been promoting credit programmes which were providing local farmers with incentives to flout these conventions. A case in point was the burning and clearing of secondary bush fallow as well as long-standing forest to plant cassava, notorious locally for its association with soil degradation, for which credit, technical assistance and market outlets were being promoted by agricultural development programmes. Efforts to tie credit to conservation practices had been rejected by farmers as they were perceived as unprofitable and downright obstructive to cassava cultivation.

The proposal to create CIPASLA emerged at two workshops bringing together a large number of government and non-governmental organizations, all working in the northern part of the Cauca department. Also local community leaders were present at the workshops, more specifically three paraprofessional extension workers ('técnico-agricultor') and a representative from one of the marketing cooperatives present in the area, all selected because of their familiarity with the area. The workshops were held late 1992 and early 1993 at CIAT which had also taken the initiative with the purpose of exploring the feasibility of establishing a mechanism that would facilitate coordination among the many organizations working on issues directly or indirectly relating to natural resource management in the area.

Among the four organizational options for creating such a consortium that had been made in the 1992 workshop and further examined in the time until the 1993 workshop, the option that was chosen consists of three committees: The first is the *inter-institutional support committee*, counting representatives from the various external organizations that had indicated interest in participating in CIPASLA. The task of the inter-institutional support committee is to plan and coordinate the activities of the participating organizations, and thereby to strengthen these organizations' ability to *support* the communities. The second committee is a *watershed user committee* for which the format at the 1993 workshop had not yet been specified. However, the tasks proposed for this committee were to provide knowledge about the problems and needs of the communities; to identify mechanisms through which concerted actions could be taken by the communities and the external organizations. Each of these committees command a separate fund. Thus, a further task of the user committee is to encourage and support the formulation of projects in the communities, to link the communities with the organizations in order for them to obtain the necessary technical support and to develop procedures for evaluating, prioritizing and implementing the projects presented by the communities. The third committee within the CIPASLA organizational set-up is the coordinating committee whose task it is to act as a coordinating body between the inter-institutional support committee and the watershed user committee and to provide technical and administrative support. The coordinating committee consists of three representatives: one governmental, one non-governmental and one CIAT representative.

In the following part of this section, we shall focus on the organizing process that led to the formal creation of the watershed user committee or FEBESURCA (*Federación de Beneficiarios de la Subcuenca de Cabuyal*), as it was later to be baptized.[5]

After returning from the 1993 workshop, the four local community representatives who had participated, initiated an organizing process which would lead to the establishment of FEBESURCA. Their first step was to make a complete list of *local* institutions present in the area and send out invitations to all of these to participate in a meeting where the idea of establishing a local watershed user committee could be further explored. In doing so, they followed the same procedure that had been used when organizing the 1992 workshop in which the proposal to form CIPASLA was first proposed. The local institutions that received such invitations included the community-based committees for planning and implementing community activities, the *Juntas de Acción Comunal* (JAC); the local indigenous government, the *Cabildo La Laguna*; the local aqueduct committee (*Junta Administradora del Aqueducto*, JA); women's groups; the teachers; the health centre; the local agricultural research committees, the CIALs; the church, etc. Not all of these institutions sent representatives to the meeting which was held in April 1993 and the organizing process thus continued with self-selected institutions that had shown interest by participating in the meeting.

To increase awareness and mobilize the communities around the importance of watershed management, a motivational campaign to the communities was proposed at the April meeting and conducted in May by the four local community leaders who that had participated in the 1993 workshop. Based on their location, communities were grouped together so that meetings could be held with more communities at one time. The plan was to hold a total of six such motivational meetings. The purpose was to inform the communities about CIPASLA and the potential role of a user committee within it, its objectives and especially about the importance of conserving natural resources. These meetings were to elect representatives to go to the constituting meeting of the user committee to be held in June. The invitations for these motivational campaign meetings were made to the *Juntas de Acción Comunal* who were then expected to call the entire community to attend the meeting. However, partly because the meetings were intended to gather people from several communities and so people had to travel some distance to reach the meeting, the participation in these meetings varied greatly.

The constitutional meeting took place in June and FEBESURCA was formally created. Moreover, the meeting elected an executive committee, agreed on a zonation of the watershed in a lower, middle and upper zone, and made the first steps towards defining a working strategy. While the institutional representation in FEBESURCA was based on the principle that the institutions who wished to participate could have a representative in FEBESURCA, the principle upon which the communities were going to be represented was more unclear. The initial intentions were to keep the number of representatives as small as possible in order for the organization to be efficient. Upper most in the local organizers' criteria for setting up the representation in FEBESURCA, was the aim to reduce their transaction costs in bringing together a decision-making body. This criterion reflected their desire not to lose the momentum of the motivational campaign, and their focus on action in the short run. Hence, ideas had been forwarded that among the representatives elected from the *Juntas de Acción Comunal* within the watershed, a single representative should be elected to represent all the *Juntas de Acción Comunal*, and thus be considered an institutional representative. Other ideas were that each zone - the upper, the middle and the lower - should elect a representative. However, the issue remained pending for a period to come.

As a result of the motivational campaign, a number of elected representatives turned up at the June meeting. Some of these were elected as representatives of a community whereas others represented a group of communities. Thus, in the absence of clear principles for community representation, the people who turned up for the meeting were allowed to continue not as community but as zonal representatives, with the result that the number of representatives by which each zone was represented varied between two and five.

The zonation of the watershed was done with the aim of being able to prioritize where to begin the work. Because the upper part was found to have received less technical assistance on how to develop a sustainable agriculture than the other zones and based on the assumption that the upper part of the watershed had strategic importance to the lower-lying parts, e.g because it is in the upper part of the watershed that the drinking water aqueduct has its intakes, it was decided that priority should be given to activities in that zone. Thus, it was decided to organize an excursion to the upper zone in order for the representatives from the lower parts of the watershed to familiarize themselves with the zone.

For almost all of the representatives from the lower and mid-altitude areas of the watershed, this was the first time they had gone to the communities in the upper reaches. Many were shocked at the much greater poverty they observed in those communities; the impassable cart-tracks, absence of schools, the low quality housing, the poor straggly crops and the extensive wasteland of bracken-covered fallow left after cropping. The agenda they heard from people in the upper watershed was very different from the one they had been proselytizing.

In the period following, the user committee started developing statutes for FEBESURCA as well as procedures for how to solicit projects from the communities and evaluate and implement these projects. In this process, FEBESURCA was drawing on outside organizational assistance provided by CIAT.

In the statutes, which were approved in April 1994, it was finally determined that rather than having zonal representation, each community should have its own representative and a delegate. This was decided in order to facilitate communication between FEBESURCA and the communities. Today 18, out of the 22 communities have formally nominated their representatives. Moreover, the work included the development of a format according to which projects should be presented to FEBESURCA and a set of criteria according to which proposed projects should be evaluated by a project evaluation committee set up within FEBESURCA. According to these criteria and the weights assigned to them, projects benefitting the 'community' were given priority to those only benefitting individual families or smaller groups of families; projects relating to forests and water conservation were given higher priority than those relating to conservation measures undertaken at field level; projects taking place in the upper zone were given priority to those taking place in the middle zone which in turn were given priority to those in the lower zone; and long-term projects were given priority to short-term. Thus, apart from a number of school garden projects which were approved before the introduction of the set of criteria, projects which have been approved by FEBESURCA have aimed at conserving water sources primarily in the upper zone through reforestation and the creation of buffer zones (in cooperation with CVC) and the recuperation of a lake within the watershed.

5. Emerging issues of stakeholder representation

Already at the second FEBESURCA meeting, held in October 1993, lack of participation from the lower part of the watershed was noted. One reason for this might be the generally low level of institutional participation in the lower part of the watershed. The proportion of households participating in institutions like the *Juntas de Acción Comunal* or the local drinking water committee which appoint representatives to FEBESURCA, is significantly lower in the lower zone than in the middle and high zone with only between 10 and 20 percent participating as compared to 30 to 40 percent for the upper and middle zone. Only for the more production-oriented institutions such as the cooperative or the local agricultural research committees, is the pattern different (see table 2).

Another and probably more important reason might be that people in the lower zone felt that there was not a lot to gain from participating in FEBESURCA. The initial decision to focus on activities in the upper zone which was later spelled out in the criteria for evaluating projects proposed by the communities, clearly limited the lower zone's chances of getting projects approved. Moreover, efforts to protect water sources in the upper zone were by lower-zone farmers first and foremost seen to be of benefit to the population in the middle zone who as explained by farmers in Socorro were likely to use the aqueduct water not only for domestic purposes but also for irrigating crops such as tomatoes. They judged that the aqueduct would continue to run dry part of the year before reaching the lower zone. Actually, farmers in Socorro together with communities outside the Río Cabuyal watershed, are involved in constructing an aqueduct which will take its water from the mountains outside the Cabuyal watershed.

Hence, the formulation of the FEBESURCA agenda seems to a very large extent to have been captured by a coalition between middle and upper-zone farmers where middle-zone farmers have used FEBESURCA as a mechanism for attracting services from outside organizations and for trading these for a commitment from upper farmers to protect water sources. Thus, although the lack of participation from the lower-lying communities was noted already at an early stage of the organizing process, no corrective measures were taken. In other words, the participation from the lower-lying communities was apparently not sufficiently important to make its absence prevent the mid-altitude and upper communities for pursuing their agenda.

It is important to observe, however, that the logic behind this agenda only holds when viewing the Río Cabuyal watershed in terms of the goals of local inhabitants to protect their water supply. If external interests are taken into account, it is the amount of water flowing *out* of the watershed which is important the strategic importance of the lower zone becomes more evident. Studies undertaken by CIAT show that tributaries to Río Cabuyal originating in the lower and middle zones are just as important for determining the amount of water that Río Cabuyal carries out of the watershed as are tributaries originating in the upper zone (Rubiano, personal communication). Taking external interests into account could therefore substantially change FEBESURCA's priorities to the advantage of farmers in the lower zone. Another important point is, however, that to argue this case, information about water flow within the watershed is essential. Thus, this case illustrates the potential role that access to information about resources within the watershed has for the definition of strategies and further for the negotiation between stakeholders within as well as outside the watershed.

Yet, there are other factors for which lack of participation does matter. At least, this was the lesson learned by FEBESURCA representatives in August 1994. August and September is the season of fires in Cabuyal. Some fires are 'natural', caused by the relentless sun and the dry vegetation. Others are intended, meant to clean fields for crop residues, weeds and/or fallow vegetation as part of the land preparations. Usually, these fires are controlled and confined to the field, but of course accidents happen, fires go wild and spread. According to many people in the Cabuyal watershed and especially according to FEBESURCA representatives, the fires were particularly serious in 1994. To a large extent, this impression probably owed to the fact that one of the apparently 'natural' fires took place in the upper part of the watershed right next to an area where FEBESURCA together with CVC in the first half of 1994 had created a buffer zone and planted trees in order to protect three water springs. A fire partly destroyed this work.

Speculations started mounting among local people that perhaps the fire had been started deliberately as some kind of protest against the creation of the buffer zone. The fire took place in an area largely inhabited by indigenous people. One interpretation was that people around the water source were unhappy with the fact that the protection of the area did not conform with the rules developed by the Cabildo which prescribes a buffer zone of 30 meters around water springs but instead with the rules of CVC which prescribes a buffer zone of 50 meters.[6] Other speculations suggested that perhaps the indigenous people and/or their local organization, the Cabildo, had not been sufficiently involved in FEBESURCA and perhaps therefore they were resentful towards and were trying to undermine FEBESURCA's activities. Still other speculation suggested that the fire was caused by individuals in search of land who were seeing their opportunities for being allocated land by the Cabildo shrinking due to the creation of the buffer zone.

These speculations were aired at the FEBESURCA meeting held in September 1994. Different options for dealing with the problem were discussed. Some wanted to introduce sanctions and wanted CVC to enforce these. CVC, however, refused this, claiming that they would be seriously threatened by local people if attempting to impose such sanctions. Others leaned to the opinion that the role of FEBESURCA was to raise awareness rather than to impose sanctions.

The incidence gave rise to the formulation of a special agreement between FEBESURCA and the Cabildo which was already member of FEBESURCA specifying some procedures for protecting water sources in areas under the jurisdiction of the Cabildo. Moreover, the incidence of fires made it clear how vulnerable FEBESURCA was to individuals or groups who did not feel their interests sufficiently accommodated in FEBESURCA.

And indeed, analysis shows that FEBESURCA only represents a certain section of the multiple interests relating to the management of the Cabuyal watershed. Viewed on the basis of information available from the questionnaire survey, conducted in 1993, the participation in the institutions responsible for electing representatives to FEBESURCA does not as an average exceed 34 percent of the families within the watershed (see table 2). Unfortunately, the questionnaire survey from which this information stems did not inquire about participation in the *Cabildo La Laguna*, the local indigenous governing body. However, based on inventories made in 11 out of the 22 communities during 1994, participation in the bi-weekly Cabildo meetings appears to be high, especially, of course, among the indigenous population, but also among the non-indigenous population who at times turn to the cabildo as a conflict resolving body e.g. for settling debt cases among neighbours, marital disputes, land disputes, thefts etc.

On a whole, 53 percent of the households did *not* participate in neither the *Junta de Acción Comunal*, the drinking water committee, the cooperative nor the local agricultural research committees, varying from 44 percent in the upper part of the watershed to 53 percent in the middle and 65 percent in the lower part of the watershed. Non-participation is, however, more widespread among the poorest households with 61 percent not participating in any institution than among households enjoying the highest level of well-being (45 percent). Only 21 percent of the poorest households participated in two or more of the above mentioned organizations as opposed to 30 percent of the best-off ($p<.01$; chi-square test). Participation in the sense that it was measured in the questionnaire, however, comprises everything from participating in an assembly once every second year to regularly being in contact with representatives or being a representative.

With respect to mere awareness of the *existence* of the above organizations, only 10 percent of the poorest households were aware of the existence of all four, while this was the case for 24 percent of the best-off and 14 percent of the middle category ($p < .00001$; chi-square test).

Looking at the well-being status of the actual members of two of the above organizations and thus at the origin of the interests that are most likely to be represented, a similar and even more pronounced pattern emerges.[7] Of the members of the JACs and the CIALs, close to 60 percent belong to the category of households enjoying the highest level of well-being while barely 10 percent belong to the category of poorest households. Furthermore, a considerable degree of overlap between the members of the JACs and the CIALs occurs with 29 percent of the members being members of both organizations. Perhaps even more telling is the fact that including the representatives to FEBESURCA does not add any the total number of representatives. In other words, all FEBESURCA representatives are already members of other local institutions.

This means that the interests and more specifically the possibilities for meeting these interests of families having only little and often very poor and sloping land, with poor access to forests and natural water springs at present are poorly represented in FEBESURCA. This means that FEBESURCA faces the risk that its agenda will only partially mobilize support on issues such as burning.

6. Six functions for local-level watershed management organizations

Based on these experiences, six functions emerge as essential for local-level watershed management organizations. Of these, at least three appear to be specific to watershed management. Besides being important in themselves, these functions provide some principles for the process of organizing for local-level watershed management.

Identifying stakeholders and ensuring their representation in management effort

The first of these functions is to identify the distinct local-level interests or stakeholders that relate to the use and management of resources within the watershed and ensure their representation in management efforts.

Local-level organizations can be either community or interest group based. With the majority of its representatives being appointed on a community basis, FEBESURCA is an example of a community-based organization. In cases where the individual resource manager's interests are determined by his or her geographical location, community-based organizations are likely to be representative. However, when other factors such as ethnicity or a resource manager's access to resources are important determinants, chances of community-based organizations being representative of such diverse interests are limited, since a representative might have to represent interests different and perhaps entirely in conflict with his or her own. Our analysis confirms a caveat expressed elsewhere, that organizational participation in community-based organizations tends to be skewed towards resource-rich households, e.g. [3][9], as is the case in Cabuyal. This case study illustrates that the likelihood is that in community-based organizations, certain stakeholders are left unrepresented and perhaps even unrecognized.

In many cases, this might not hamper institutional effectiveness. A credit project, for example, does not depend on 100 percent participation for being effective seen as a *credit* project[8] as long as the number of participants is large enough to allow for an efficient management of the credit. The case of watershed management, however, is different due to the interdependency that exists among different users: i.e. one group's use of a resource directly or indirectly affects other groups' possibilities for using the same or other resources within the watershed. This makes the participation of all interest groups or stakeholders, and thus stakeholder-based rather than community-based organization essential to effective watershed management. This, for instance, became clear to FEBESURCA representatives in the case of the presumed intentional fires that threatened the FEBESURCA efforts to protect important water sources during 1994.

Because of the tendency of local organizations to be community-based and representative only of a certain set of stakeholders, building organizations that include *all* stakeholders will often require strong efforts to circumvent this 'default' situation and instead to guide the organizational process so that the various stakeholders get identified and subsequently represented. Only then will local-level watershed management be effective. Our case study shows that when local representation is organized in a 'participatory' fashion that allows for self-selection by the established elite, then the definition of relevant stakeholders is likely to be incomplete. Such processes require input (from outsiders) in the form of methods for stakeholder analysis, which facilitate identification of all relevant stakeholders.

Provide forum for analysis and negotiation of diverse interests

Once the diverse stakeholders are identified and have found representation, the second function which local-level watershed management organizations should perform is to provide a forum or platform as suggested by Roling [11] where these interests can be analyzed and negotiated. In the first place, this means specifying time and place for such negotiations as well as who should participate.

Because the conflict of interests relating to watershed management are not easily overcome, such negotiations cannot realistically aim for everyone to share the same common goal. Again turning to the case of the 1994 Río Cabuyal fires, subsequent stakeholder analyses conducted by FEBESURCA representatives on the initiative of CIAT researchers, showed that very concrete interests lead particularly poorer households, who are either short of labour or are renting in land and therefore do not have incentives to engage in long-term land improvements, to prefer burning as a method of cleaning fields despite their awareness of the harmful effects of burnings. In such cases, it is almost Utopian to imagine a shared sense of a common goal. More realistically, and to some extent happening in FEBESURCA, such negotiations need to take as their point of departure, the existence of conflicting interests and aim at identifying compromises between these as well as at exploring mechanisms of compensation.

In such negotiations, participatory techniques which do not insist upon identifying common goals and objectives but rather draw the attention to the conflicts, constantly contrasting different interests, and in which the principal role of the facilitator is that of the 'devil's advocate' are important tools. Examples of such techniques are described e.g. in [5]. In most cases, the facilitation skills necessary to lead such negotiations do not exist locally, but will, at least in the early stages of organization have to be provided from outside. This underlines the importance for local-level organizations of not only being in contact with external organizations which can provide technical advice on how to control soil erosion, measure water flow or calculate rates of return to different management efforts, but also with organizations which can provide advice and skill formation with respect to the organizational process as such. We shall return to this point below.

Define rules and norms for the use of resources within the watershed

Apart from identifying mechanisms of compensation, an important outcome of such analyses and negotiations is the definition of norms and rules for the use of specific resources within a watershed as well as sanctions for not complying with these. This is the third functions of local-level watershed management organization and is shared with other types of local-level resource management. Thus, Ostrom [8] ascertains that rules regulating resource use through specifying e.g. time, place, technology and quantity of resource units as well as rules specifying resource input obligations to support management activities relating to common-pool resources, need to be carefully tailored to the local conditions. Uniform rules established for an entire nation or region cannot take into account such specificities and are therefore bound to fail, she argues.

Experiences with creating buffer zones to protect water springs and water courses in Río Cabuyal provide a case in point. CVC has for many years attempted to create such buffer zones in the area, applying national laws prescribing a buffer zone of 50 meters around water springs and 20-30 meters along water courses, although with little acceptance from the local population and thus with little success. As a result of the involvement of FEBESURCA in the creating of buffer zones during the second half of 1994, adherence to these general rules was relaxed and negotiated on a case by case basis, often being determined by the existing boundary between natural vegetation and cultivated area. This has significantly increased the creation of buffer zones by the local population: as an indication, a considerable amount of community labour was mobilized to actually create these buffer zones. However, neglect of mechanisms to monitor and enforce continued protection undercut this effort.

Initiate a process of local-level resource monitoring research

A fourth function that should be undertaken by local-level watershed management organizations is to initiate local monitoring research. Rather than monitoring individual resource users' performance and compliance with agreed norms and rules on the basis of which sanctions might be made, the primary function of such monitoring research should be to allow assessments to be made of the state of resources within the watershed. Monitoring research has specific importance in watershed management due to the complexity of and the often poorly understood interdependence between different resources within the watershed. This means that efforts to regulate use or to protect resources in a watershed are often decided on the basis of weak information. The previously mentioned example of the relative importance of upper versus lower tributaries in determining the water flow of Río Cabuyal at the tail end of the watershed is a case in point.

The experience of burning new plantations of trees illustrates the need to minimize dependence on external institutions to define and undertake such monitoring. FEBESURCA mobilized local input (labour) into the creation of protected areas and reforestation, but did not set up any monitoring by locals of enforcement on these. And once, the need for sanctions based on monitoring was recognized, the problem of where in the organizational structure to locate enforcement had to be resolved. This was only brought to light by the involvement of FEBESURCA in interviewing locals about their reasons for burning. This illustrates that such monitoring should, to the extent possible, be determined and undertaken locally. Moreover, the Río Cabuyal experience shows that the provision of information about the state of resources in itself is an important part of the negotiation of conflicting interests and the definition of compromises and rules for resource use.

Formulating and exerting demand for services from external institutions in support of local management efforts

The fifth function which should be undertaken by local-level watershed management organizations is to formulate and exert demands on external organizations such as NGOs and government organizations providing services to local communities. As was the case in Río Cabuyal when CIPASLA was formed, local populations are so often confronted with an array of organizations each having their own agenda, resulting in a supply-driven rather than demand-driven provision of services, be they technical, social or organizational.

One of the tasks of local-level watershed management organizations is to attempt to change this situation by formulating agendas, identifying problems and/or defining concrete proposals for action to which external organizations can respond. To be successful, this obviously requires a willingness on the part of the external organizations to listen and respond to such demands as well as an institutional mechanism through which such demands can be communicated. The creation of CIPASLA and within it, of FEBESURCA and the inter-institutional support committee as two equal bodies were attempts to foster such willingness and an institutional mechanism through which such communication could take place. The creation of a mechanism through which local organizations could 'pull in' services (or the promise of services) lacking in the upper-watershed communities was critical to the success of their motivational campaign to protect the upper-watershed water sources.

Negotiating internal versus external watershed interests

Without the process of organizing for local-level watershed management, described in the first four functions, and thus of ensuring that all internal interests are represented in the negotiation with external interests, attempts to accommodate external interests in watershed management are likely to fail.

The sixth fifth and final function to be carried out by local watershed management organizations is to negotiate internal versus external interests relating to the management of the watershed. As already emphasized, interests in improving watershed management in Río Cabuyal and elsewhere originate as much from stakeholders outside the watershed such as urban populations in need for drinking water or producers of hydro-electrical power, as from stakeholders within the watershed. Just as in the case of negotiating interests originating within the watershed, the likelihood of reaching a shared sense of a common goal is limited. Instead, based on a process of acknowledging the existence of legitimate but often conflicting interests within as well as outside the watershed, compromises will have to be made that provide incentives for watershed farmers to erode less, for urban and semi-urban populations to consume less charcoal, etc. The search for such compromises rather than for modes of enforcement should be the aim of such negotiations.

7. Conclusions

Analysis of the process of organizing for local-level watershed management in the Río Cabuyal provides several insights into the strategy for organization which needs to be followed. In summary, 'participation' needs to be structured in relation to a stakeholder analysis conducted by local people, and facilitated by outsiders. Community-based participatory approaches are likely to reproduce the representation of already organized and usually, more well-to-do elites which characterizes the existing local power structure. When this stakeholder analysis is overlooked or incomplete, the capacity of the resulting organization to provide an effective forum for conflict resolution, is likely to be truncated. As the Río Cabuyal case shows, conflict is likely to arise between the elite stakeholders included in the organization, and those who are under-represented, perpetuating difficulties of resource management in the watershed. Stakeholder-based participation is therefore, a crucial element in an organizational strategy for watershed management.

A second feature of such strategy, which the Río Cabuyal experience brought to light, is the importance of institutionalizing monitoring of the status of resources which is implemented locally, but which is able to 'draw down' information from external agencies, not necessarily available to locals. The involvement of external agencies in regulating watershed management will need to be redefined as a support role (providing information and other services), but cannot be dispensed with. In addition, technical information about the watershed resource system needs to be fed into local people's analyses of their situation, particularly once the trade-off between external versus internal interests becomes relevant to local people's objectives for managing the watershed. Shaping the institutional mechanisms for managing the interface between local organizations and external agencies, therefore emerges as a vital part of a process for strengthening local capacity for watershed management.

Footnotes

1. The *vereda* is the smallest official administrative unit in Colombia.

2. This excludes the semi-urban community, Siberia, a township situated within the watershed.

3. This and following figures on distribution of resources among households in the watershed and their involvement in various activities are derived from a questionnaire survey that was administered to the entire population of the Rio Cabuyal watershed in September 1993.

4. This section is based upon interviews made by María del Pilar Guerrero Arango with key informants concerning the creation of FEBESURCA as well as on participation in and minutes from meetings held in CIPASLA and FEBESURCA.

5. Although it was not until July 1994 that the watershed user committee actually got the name FEBESURCA, we shall use it here for the sake of convenience.

6. It should be noted, however, that CVC later agreed to relax its rules with effect for the buffer zones that were created in the second half of 1994.

7. It has only been possible to identify 35 percent of the JAC members (39), 68 percent of CIAL members (41), and 72 percent of FEBESURCA representatives (13).

8. Yet, if in addition broader social objectives are attached to the project, such as the objective of improving the conditions of the poorest, the case might be different.

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TABLE 1. Distribution of cultivated land, Río Cabuyal watershed

Cultivated area (hectares)	Mean cultivated area per household (hectares)	Distribution of households (percent)	Distribution of cultivated area (percent)
< 0.5	0.2	16	2
0.5-0.9	0.8	24	10
1-1.99	1.5	29	24
2-2.99	2.5	14	19
3-3.99	3.5	9	17
=> 4	6.2	9	30
Total	1.9	100	100

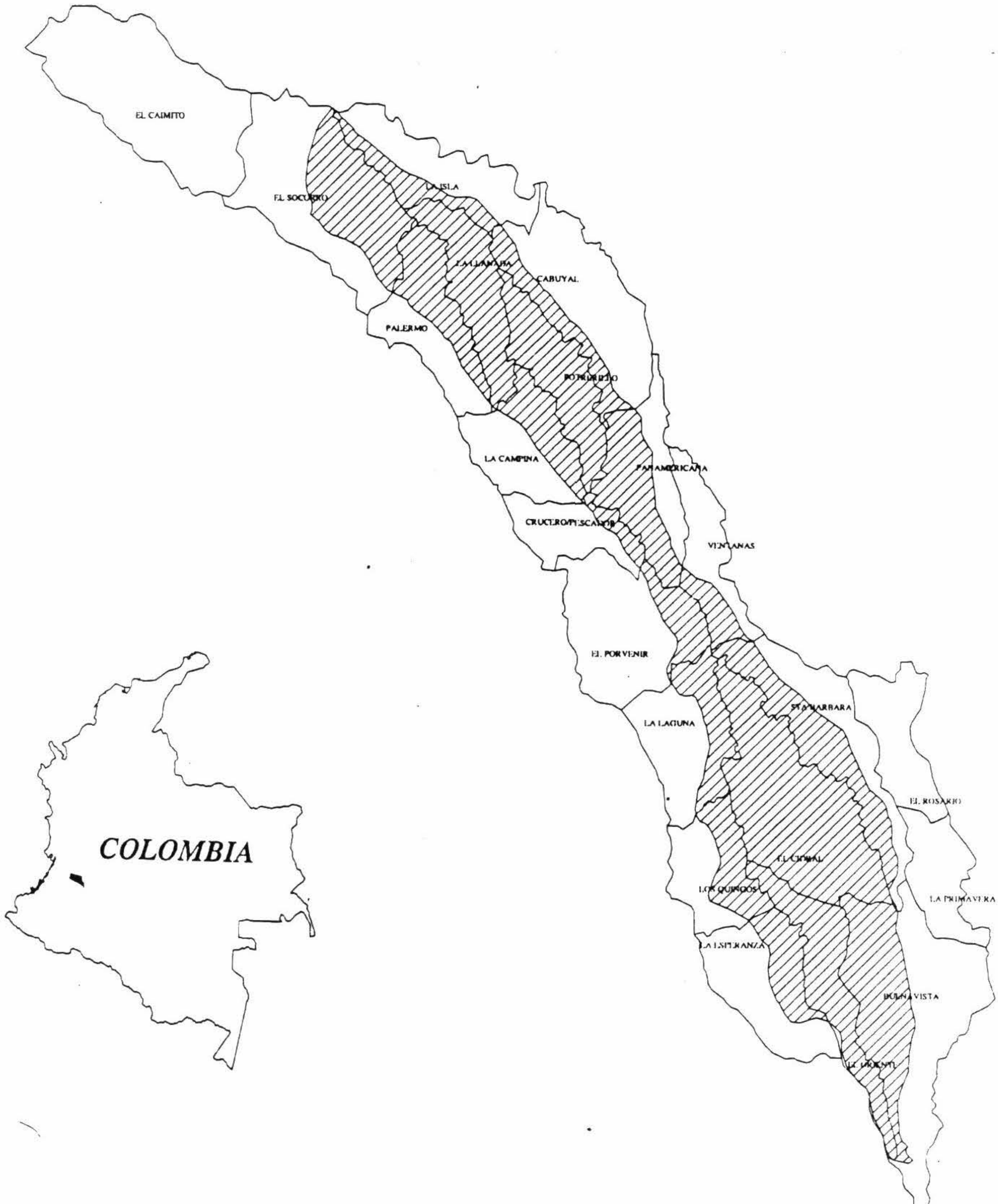
Source: 1993 household questionnaire survey, Río Cabuyal watershed, Cauca Department.

Table 2. Participation in selected local organizations

Percent households participating

Organization (significance level in brackets)	Lower zone (n=327)	Middle zone (n=370)	Upper zone (n=388)	Total (N=1087)
JAC ($p<.00001$)	20	36	43	34
JA ($p<.00001$)	10	27	34	24
Cooperative ($p<.00001$)	10	11	1	8
CIAL ($p<.001$)	10	4	12	9

Source: 1993 household questionnaire survey, Río Cabuyal watershed, Cauca Department.



Map 1
Río Cabuyal watershed and its communities
The shaded area shows the extension of the 'true' watershed

II. EXPERIMENTS WITH A STAKEHOLDER APPROACH TO WATERSHED MANAGEMENT - THE ISSUE OF BURNINGS IN RIO CABUYAL

Prepared by: ***Helle Munk Ravnborg, Jorge Rubiano, María del Pilar Guerrero***

Introduction

In watershed management, the existence of conflicting interests is the rule rather than the exception. Within a watershed, the same resource - be it trees, water, soils, plants - have competing uses. Trees, for example, are used for firewood, for burning charcoal and for timber at the same time as they serve to protect soils from erosion and water sources from drying out. In some cases, those using trees for firewood coincide with those who see trees as protecting the water sources; in other cases not. In some cases, those who own the trees coincide with those who depend on firewood for cooking and heating; in other cases not. The fact that what one person decides to do in one part of the watershed often effects what other persons can do in other parts of the watershed complicates the issue of watershed management even more.

In the Río Cabuyal watershed, by far most of the natural resources are privately owned. This means that the management of these resources - trees, soil, water and plants - depends upon and is the result of the combined actions of more than 1,000 families or 6,500 individuals inhabiting Río Cabuyal whose interests far from always coincide. As an example, some families have sufficient land to sustain themselves and some have resources that allow them to pay labourers to help them in sowing, weeding, harvesting or perhaps in planting and maintaining grass strips to prevent erosion. Others are less fortunate. The land they own is not enough to sustain their family, and to make a living, they therefore have to work for others. Thus, they are not only resource-poor with respect to land but also with respect to time for cultivating the little land, they have got.

Burning as a means of land preparation is but one example around which different interests exist relating to watershed management. One of the features which makes burning a preferred means of land preparation by many farmers is that it is fast and that it kills weeds. Among its drawbacks is that it involves the risk of fires going wild and that it increases erosion.

August and September is the season of fires in Cabuyal. Some fires are 'natural', caused by the relentless sun and the dry vegetation. Others are intended, meant to clean fields for crop residues, weeds and/or fallow vegetation as part of the land preparations. A questionnaire survey administered to a sample of 122 households in the Río Cabuyal watershed late 1994[1] showed that half of the households use burning as a means of land preparation. Usually, these fires are controlled and confined to the field, but of course accidents happen, fires do go wild and spread.

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[1] The questionnaire survey was conducted by Jairo Castaño, Hillsides Program.

Although the general impression was that the number of fires had diminished in 1994,[2] the fires that did occur were viewed with great concern, particularly by FEBESURCA[3] and CIPASLA[4] representatives. This owed to the fact that one of the apparently 'natural' fires took place in the upper part of the watershed right next to an area where FEBESURCA together with CVC, the regional watershed management authority and member of CIPASLA, had created a buffer zone and planted trees in order to protect three water springs. The fire, which by some was believed to be intentional, partly destroyed this work.

The burnings therefore became an issue on the FEBESURCA meeting held early September 1994. The representative from Buenavista, the community where the three water spring protection zones had been affected by fires, argued that it was necessary to find ways to penalize people setting fires. This, in turn, led to a discussion of penalizing versus awareness-raising campaigns as a feasible way to deal with such problems.

The discussion revealed the dilemma that attempts to promote certain watershed management practices involve in the area. On the one hand, neither CIPASLA nor FEBESURCA has the mandate to institute nor to enforce sanctions against individuals. Therefore, CVC which has such a mandate and a long history of developing and enforcing rules relating to land and water use practices was asked at the FEBESURCA meeting to enforce existing rules prohibiting burning. CVC, however, declined due to fears from its staff of being personally threatened. Moreover, the fact that the use of burnings as a means of land preparation is not limited to a couple of families but is actually practiced by some 500 families obviously complicates the task of enforcement in practical terms.

On the other hand, fires do not only occur as a result of lack of awareness but sometimes also as a consciously chosen land preparation method and, as presumed in this case, as a manifestation of protest against taking up land for the protection of water springs and rivers and thus water resources serving downstream populations.[5] This points to the

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2 This and the following description is based upon the minutes from the FEBESURCA meeting held September 2, 1994, and observations made by Pilar Guerrero who participated in the meeting as an observer.

3 Federación de Beneficiarios de la Subcuenca de Cabuyal

4 Consorcio Interinstitucional para una Agricultura Sostenible en Laderas

5 In order to win acceptance of the protection of two water springs situated in El Oriente on land belonging to the Cabildo La Laguna, the indian local government, which is an institutional member of FEBESURCA and thus indirectly of CIPASLA, CIPASLA had to enter a specific agreement with the Cabildo. This agreement underlined the Cabildo's right to relax the CVC rules prescribing a buffer zone of 50 meters around water springs and of 30 meters along river banks; its right to deny outsiders access to its land (including roads); and its right to use natural reserves

potential limitations of awareness-raising campaigns.

The discussion of burnings at the FEBESURCA meeting and the emerging recognition of the insufficiency of conventional measures such as enforcement and awareness raising thus gave rise to a feeling of powerlessness among the participants.

It was on this background that the CIAT hillsides team decided to offer the FEBESURCA representatives an alternative approach - a stakeholder approach - to deal with problems such as burnings involving a multitude of conflicting but legitimate interests and offering no immediate opportunities for regulating individual people's actions to conform with some decided 'norm' through enforcement of sanctions or simple awareness-raising campaigns.

The stakeholder approach

The basic principle of the stakeholder approach which guided a series of two workshops and a task force held for FEBESURCA representatives is to lead the participants through a process during which they analyze and come to recognize the existence of conflicting but nevertheless legitimate interests, in this case relating to burnings. This implies a recognition of the limitations of the more conventional approaches to deal with such situations of conflicting interests, according to which the dominant or most powerful interest group(s) formulate rules to which they seek to make less powerful interest groups comply either by means of enforcement, or, based on the assumption that 'the others' are acting out of 'ignorance', by launching awareness-raising campaigns aimed to make 'the others' understand and hence comply. On this basis, the objective is to facilitate a search for ways in which to reconcile and identify viable compromises between the different interest groups.

The ideal situation would be for all interests to be directly represented at the workshops in order to allow for a direct analysis and negotiation to take place. This was, however, not immediately possible in the present case, since among FEBESURCA representatives there is an overrepresentation, compared to the population as a whole, of farmers who do not use burning as a means of land preparation and who have sufficient

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within its jurisdiction without abuse. Moreover, the agreement commits CIPASLA to allocate resources to the Cabildo's office in Siberia; to the construction of a community hall in El Oriente, and to provide technical assistance for agricultural projects. Despite this agreement and despite the agreement between the Cabildo and INCORA for the handing over of the land in El Oriente to the Cabildo saying that buffer zones to protect water courses had to be installed prior to redistributing land to individual members of the indigenous community, there were still people opting for land from the Cabildo and thus seeing their opportunities threatened, saying that they were not going to accept the creation of buffer zones.

land to sustain their family. However, at the end of the first workshop, the participants themselves expressed the wish to invite people for the following workshop who would be likely to use burning as a means of land preparation and to hold this workshop in the upper part of the watershed where problems caused by burnings were perceived to be most serious. Thus, in the second workshop and the subsequent task force, some of persons belonging to the Cabildo participated who had expressed strong opposition to the creation of buffer zones on the Cabildo's land.

The first workshop consisted of three phases: a problem analyzing phase, a stakeholder identification phase and a phase preparing for future action.

Although it had been specific fires causing the issue of burnings to be taken up at the FEBESURCA meeting, the subsequent discussions to ban, penalize and launch awareness-raising campaigns concerned all types burnings without discrimination from controlled burnings in the middle of a field to fires caused by carelessness of Sunday visitors to the area.

Thus, a first objective of the workshop was to provide a framework for distinguishing between different types of burnings in order to be able to prioritize these in terms of their seriousness as well as be able to direct measures to deal with or prevent such fires. Following a number of uncommented slides showing different fires in Río Cabuyal, participants were invited to suggest as many different types of fires as possible in a brainstorming session[6] and subsequently to 'vote' for the three types of burnings they see to have the most serious consequences.

After the prioritized typology of burnings had been developed, workshop participants were encouraged first to brainstorm on the reasons explaining why the above identified burnings take place. Rather than at this point judging whether or not these are 'good' reasons, the purpose of this session was to identify how things might look like from the point of view of those people responsible for the burnings, be it for land preparation or 'out of pleasure'.

However, there is another set of the stakeholders, namely those who view burning as harmful. Thus, in a second brainstorming session, the viewpoints of this set of stakeholders were identified guided by the question of why the specific types of burnings are considered harmful.

As a temporary conclusion of the stakeholder identification phase, workshop participants were asked to compare and make observations with respect to the reasons that had arisen during the previous two brainstorming sessions.

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[6] The workshops made extensive use of brainstorming sessions, facilitated by two to three people who besides introducing the issues and steps, had as their task to write suggestions from participants on wall-paper.

Following the above burning typology and stakeholder identification, workshop participants were invited, in smaller groups, to identify needs for further information in order to be able to prepare a plan of action on the issue of burnings. These could be information relating to the physical effects of burning or the existence of alternatives. Moreover, due to the fact that a number of stakeholder interests were not directly represented at the workshop, there would be a need to assure that the reasons suggested in the previous sessions for why people burn as well as why people consider burning to be harmful, actually correspond to the reality. Workshop participants committed themselves and each other to acquire the desired information to be presented at the second workshop.

The objective of the second workshop was to present the information acquired since the first workshop and to formulate a plan of action of how to deal with the problem of burnings.

Results from the workshops

Typology of burnings and selection of types to be considered in this workshop

Based on the brainstorming session with respect to different types of burnings the following typology and prioritization in terms of seriousness was made:

Box 1. Typology of burnings and ranking in terms of seriousness *(no. of points received)*

Type no.	Type of burning	No. of points received
	Controlled burnings	
1	• burning where the field has been cleaned prior to the burning	0
2	• burnings where the field has not been cleaned prior to the burning	3
	Accidental burnings	
3	• burnings taking place around water springs and forests	10
4	• burnings taking place e.g. on fallow land or pastures	2
	Others	
5	• burnings due to 'evilness'(intentional) (by adults, young people, workers)	10
6	• burnings due to ignorance	6

One of the lessons from this session was that there are types of fires that are *not* considered to be a serious problem. Thus, rather than seeking to eliminate all types of burnings, emphasis can be directed towards the types of fires which are considered to be most harmful.

Stakeholder identification

In the brainstorming session relating to reasons for burning, it took some effort to move beyond the type of explanations taking point of departure in the participants' own normative viewpoint that 'burnings are bad' and into imagining the 'positive' reasons that people actually doing the burning would have for doing so. However, once this step was taken, the participants faced no problems in imagining the types of reasons that people could have for burning. These are shown in box 2 below.

Box 2. Reasons for burning

- lack of knowledge
- lack of awareness
- lack of resources and services
- to avoid having to pay day labourers
- due to conflicts between or within families
- for personal economic benefit
- to sow
- to obtain firewood
- to obtain charcoal
- due to resentments
- for pleasure
- to fight crop pests
- to facilitate the sowing of maize and beans
- increase the area under production
- to attract attention/protest
- due to lack of organization

The participants did not face any problems in brainstorming on the harmful effects arising due to burnings, perhaps because many of these cause-effect relationships have so often been 'preached' to them by technicians from the various organizations working in the area. Box 3 below shows the result of the brainstorming session.

Box 3. Harmful effects caused by burnings

- destruction of forest reserves (firewood, wood for timber and poles)
- drying out of water
- destruction of vegetative cover and organic material and microorganisms in the soil
- erosion and the subsequent drying out and acidification of the soil
- extinction of fauna and flora (wild animals)
- diminishing rainfall
- climatic changes
- destruction of human life
- monotonous landscapes
- environmental pollution
- reduction in the production
- poverty and misery
- social problems (e.g. migration in and out and to the city)
- violence
- increased food costs
- decline in the value of land
- increased prices for wood
- natural disasters (land slides, accidents, avalanches, destruction of communication)

Based on these two sets of interests relating to burnings, the workshop participants made the following observations:

Box 4. Observations from comparing reasons for burning and harmful effects

- the reasons are individual while the consequences are general (for the whole community)
- people burn in the low zone; in the high zone, it is less common
- there are no fertilizers
- people leave due to lack of resources
- lack of organization lead to social disintegration
- burning is a instantaneously solution whereas its harmful effects present themselves in the future
- due to ignorance, everything will finish
- there is a lack of adequate education with respect to the environment
- mankind is the hope of our planet to make a higher level of well-being
- the future of the children
- egotism
- the big fires are in the indigenous zone
- we are exploiting to the maximum at present without thinking about the future generations
- we are all guilty
- while some are trying to do something, others are destructing
- people will see the problem when they are suffering
- it is the indigenous community which burn most
- the mestizos are more responsible

Towards a plan of action

Finally, as the conclusion of the first workshop and as a first step towards developing a plan of action, workshop participants identified the following topics on which more information would be needed.

Box 5. Topics on which more information is needed

Needs for further information	Responsible
Technical issues: • How is it possible to verify that the microorganisms die as a result of the burning? • How is it possible to demonstrate the beneficial effects of the soil 'insects'? • How is it possible to demonstrate that the soil becomes more acid and the harm that this does to the crops? • Which are the alternatives to burning, and where is it possible to see them so that people can be motivated to adopt them	CIAT
Social issues: • Which are the reasons that make people burn? • Which pedagogy/approach would be best to tackle the problem of burning? • Which concrete alternatives are there in order to avoid burning? • How do we better get to know the problems of each community and plan solutions?	FEBESURCA representatives

Report from FEBESURCA representatives with respect to reasons for burning and possible alternatives

Without having been encouraged to do so, two of the participants from the first workshop had undertaken structured questionnaire surveys to a small sample of farmers living within their community (samples of 8 and 12 farmers), focusing on reasons for using burning in the field, its beneficial and harmful effects, and possible alternatives. Others had done their enquiries more informally.

Among the conclusions that emerged from these enquiries was that the use of burnings for land preparation is beneficial in the short run. It is fast and it allows all land to be cultivated which is important to people who either have very little land or are renting land. Leaving weeds etc. to decompose, on the other hand, is beneficial in the longer run as it takes time before its beneficial effects prove themselves and take up land where organic material is left to decompose, e.g. 'dead barriers'. Hence, the conclusion was that unless solving the problem that some people have very little land, it would be difficult to convince people having limited resources not to burn.

Another conclusion that emerged from the enquiries was that almost everybody is aware of the harmful effects caused by burning, e.g. erosion, the loss of fertility, killing of the microfauna, etc. When people nevertheless prefer to burn, it is because they have to sow in time, e.g. because they are short of labour.

Report from CIAT representatives with respect to technical aspects

The report made by CIAT representatives (Jorge Rubiano) was based on a literature search and described the effects of burnings on the soil, distinguishing between the physical effects, the chemical effects and the biological effects, emphasizing the different types of micro-organisms present in the soil and their functions. Moreover the presentation described possible alternatives to the use of burning for land preparation, e.g. agroforestry, the use of cover crops and mulch etc.

Conclusions and plan for future actions

Based on these reports, the following conclusions and points for action were made:

- Lack of land and resources is considered as the principal causes for the continued use of burning as a means of land preparation

- There should be more participation from the communities in the meetings

  This might be achieved through:

  - strengthening the present group (participants in burning workshops)
  - call for the participation of the FEBESURCA representatives not participating

- Alternatives[7] to burnings should be implemented

The following proposals were suggested:

i to create a group in each community to control burnings
ii to form institutional back-up for local persons/groups appointed by the Juntas de Acción Comunal or the Cabildo to control burnings in the season of burnings
iii formulate norms for the management of burnings
iv provide subsidies for crops in return for not burning
v request that CIPASLA should provide training and technical assistance with respect to burning and alternatives

A task force was commissioned to elaborate norms for the management of burnings to be presented to FEBESURCA and further to the Juntas de Acción Comunal and the Cabildo. The results from this task force is shown below in box 6.

Box 6. Norms for conducting burnings

NORMS FOR CONDUCTING BURNINGS *Proposals from a meeting held 21 January 1995*

[7] Besides alternatives as such, emphasis was put at installing procedures for minimizing the harmful effects of burning, either through guarding that fires are not spreading (i and ii) or through formulating norms or regulations that should be followed when people use burning to clear their fields (iii).

1. When is a burning absolutely necessary?
    - when there are big shrubs which are two to three years old
    - when the shrubs are less than two years old, they can be used as:
        - organic manure
        - dead barriers
        - mulch to avoid weed growth

2. It is preferable to make participatory or community burnings, for example with the help of neighbours, exchanging labour with other farmers or voluntarily

3. To make boundaries or firebreaks
    - If the area is flat and there is no tall vegetation in the near surroundings, the firebreaks should be two metres wide
    - If the area is slopy, or flat but with tall vegetation in the near surroundings, the firebreaks should be five to six metres wide

4. The burning should be conducted early in the morning and at latest at 10 a.m.

    The reasons for this are:
    - in the morning the vegetation is cold
    - because people are more alert in the morning
    - because in the afternoon, there are strong winds

5. We should pay special attention when, in the neighbourhood there are pines, sugar cane, forest or houses

6. Avoid the use of fuel close to the fire

7. Avoid the presence of children or elders

8. In case of suffocation due to smoke, we should:
    - throw ourselves to the ground, face down
    - cover nose and mouth with a wet cloth

9. Preferably use clothes made of cotton or linen

10. Use high boots made of leather or rubber

11. After one or two hours, we should check the burning to avoid that the fire spreads

12. If there are water springs, a 50 metres wide vegetation barrier should be left. If there are rivers, the vegetation barrier should be 20-25 metres wide

Conclusions

What happened afterwards?

The most concrete result of the workshops was the *norms for conducting burnings* prepared by the task force. These were presented first to FEBESURCA at its monthly meeting in February 1995 and later, via the FEBESURCA representatives to the local village governments (Juntas de Accion Comunal) and the local indigenous government, the Cabildo.[8] To a large extent, farmers in Río Cabuyal seem to have accepted the recommended norms. Thus, in August and September 1995, it could be observed as something new in the area that farmers were making firebreaks on their fields before burning.

The successfulness of the norms in terms of making people follow them, probably owes to the fact that they implicitly accept the fact that some farmers use burning as a means of land preparation whether out of mere preference or because their access to land and labour make burning the most feasible option, and moreover that they have been developed by farmers themselves, thus being sensitive to local circumstances.

Furthermore, the norms provide a good indication of the move which had taken place through the workshops from the *impasse* in which FEBESURCA representatives found themselves at the September 1994 meeting. At that meeting, all burnings - whether accidental or controlled - were seen as bad and the only ways to deal with such burnings were seen as prohibiting and penalizing and/or by launching awareness-raising campaigns. However, through the workshops, participants came to appreciate the existence of legitimate interests and concerns leading some farmers to prefer burning as a land preparation method and that no immediate alternatives exist, while, on the other hand, there are fires arising out of carelessness or as a means of revenge or protest that should not be accepted and therefore has to be cracked down on. Thus, the norms reflect a much more balanced and constructive approach to the issue of burning than that being voiced in September 1994.

[8] A follow-up study is presently being carried out to identify how the norms were actually communicated from the FEBESURCA representatives to the farmers in the area.

III. POVERTY PROFILES FOR DESIGNING AND EVALUATING RURAL RESEARCH AND DEVELOPMENT ACTIVITIES - A methodology

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CHAPTER I. INTRODUCTION

Poverty reduction is an important part of the objectives of many projects, programmes and entire organizations.

Knowing what it means to be poor and how the conditions of poor people differ from those of the not-so-poor, as well as being able to measure how many people are poor are obvious preconditions for designing activities that address this objective as well as for monitoring and evaluating the extent to which such activities are or have been helping poor people to reduce or escape poverty.

It is, therefore, disturbing to discover how little is often known in these respects. Often, only very rough information is available, describing and measuring poverty using measures such as the head-count index. This index signifies the proportion of a given population at a given time with e.g. income or consumption levels below a certain level which is considered necessary to meet per capita minimum nutritional requirements. Such information might be available only at a regional level and thus will not help to reveal differences that exist within a region. Moreover, it is rarely clear on which data such information is based and thus how reliable that information is.

More fundamentally, however, the meaningfulness of such conventional measures is increasingly being questionned. Such measures, it is maintained (e.g. Chambers 1988; UNDP 1990; Jazairy *et al.* 1992), are imperfect measures of the real-world phenomenon 'poverty', i.e. the multi-faceted predicament experienced by poor people because they only capture a single aspect (e.g. income or expenditure) of this predicament It is in this context that e.g. UNDP's attempt to develop a broader, multi-dimensional poverty measures, the *human development index*, should be seen. The human development index combines figures on life expectancy at birth, adult literacy rate and (adjusted) real GDP per capita.

Another criticism, which applies to conventional as well as to multi-dimensional indices such as UNDP's human development index, is that these are static measures in the sense that they describe poverty as a *state* of deprivation while providing very little or no information with respect to the *processes* that lead to or intensify poverty. Neither do they reflect the *relations* that exist between the poor and the non-poor (e.g. Rahman and Hossain 1992; Jazairy *et al.* 1992; Ravnborg and Sano 1994).

These shortcomings, particularly those relating to the meaningfulness or conventional poverty measures, severely limit our ability to assess which of two (or more) situations, e.g. two regions or before and after an intervention, has *more* of which *type* of poverty. But not only that. Poverty measures also play an important role in shaping our understanding of poverty and thus in the identification and design of interventions intended to reduce poverty since they encourage interventions to be designed so that their impact can be measured and recognized. As an example, conventional poverty measures prompt the design of interventions aimed improving the statistics on a particular dimension of poverty which is measured, e.g. increasing the proportion of a population having an annual income above a certain 'poverty level', while causing other - and non-measured - dimensions to be neglected, such as the seasonal variation in income (Ravnborg and Sano 1994).

'The present paper addresses the understanding and measurement of poverty. By way of a manual, the paper describes a practical approach - a methodology - for how to develop an understanding of poverty as it manifests itself within a specific context *and* how to translate this understanding into a quantifiable measure of poverty.

The methodology is developed with reference to rural areas - e.g. regions, districts or watersheds - where small-scale agricultural production predominates. It is intended for professionals who are involved in designing, planning and evaluating research and/or development activities as well as in setting priorities between such activities.

The methodology consists of nine steps. These are:

Step 1	Selecting sites
Step 2	Conducting well-being rankings
Step 3	Grouping households into average well-being categories
Step 4	Comparing well-being rankings from different communities
Step 5	Making the well-being indicators quantifiable
Step 6	Constructing a well-being index
Step 7	Checking the contribution of the individual indicators to the well-being index
Step 8	Checking the level of correspondence between the well-being index and the ranking-based well-being categories
Step 9	Defining index-based well-being categories

The first four steps concern the development of an understanding of what constitute poverty - or as described within the methodology - different levels of well-being within the area of interest. This is done through employing the well-being ranking technique in a number of sites within the area of interest, selected from a maximum variation sampling strategy. The well-being ranking is a technique for obtaining insight into local perceptions of well-being and the indicators that are used to describe different levels of well-being. The technique was first used by Silverman in Italy in the 1960s (Dewalt and Dewalt 1980) and has later been modified and described by Barbara Grandin (1988) in her field manual *Wealth Ranking in Smallholder Communities*. Apart from concerning the well-being ranking technique as such, the first four steps deal with the issue of site selection and with assessing the extent to which descriptions of different levels of well-being identified through the well-being rankings can be taken to apply to the entire area of interest - the study area.

The steps 5-9 relate to the translation of such descriptions of well-being into a quantifiable poverty or rather well-being index, based on the identified well-being indicators. Data on these indicators is suggested obtained through a questionnaire survey, administered to a random sample drawn from the population within the study area. The well-being index allows for assessments of the prevalence of different levels of well-being among the population within the study area.

In the following chapter, these nine steps are described one by one.

CHAPTER II. METHODOLOGY FOR DEVELOPING A REGIONAL POVERTY PROFILE

Step 1. Selecting sites

Typically, a research programme, a government agency or a NGO has as its mandate to operate within a much larger area (population as well as space-wise) than what normally, given available time, manpower and operational resources, can be covered through direct inquiries into what in each locality constitute the perceptions and indicators of well-being. Therefore, it is necessary to select a few sites or localities within the mandate area, where such well-being indicators can be identified and subsequently consider to which extent and how these can be used as well-being indicators for the entire area of interests, whether a region, a watershed or an otherwise defined area. Due to the method, we have in mind for identifying such well-being indicators (the well-being ranking technique), the sites or localities should have a population between 40 and 100 households. The reasons for this will be described in the section below, explaining the method.

Rather than seeking to identify some sort of 'average perception' of well-being and a related 'average set of indicators', the emphasis at this stage should be to *identify as distinct sets of well-being indicators as possible* in order to later be able to *validate* a possible extrapolation of these indicators to the entire area. Thus, the sites should be selected according to a ***maximum variation sampling strategy.***

This, however, does not answer the question of *which* and *how many* sites to choose. To answer these questions, we need to make some assumptions with respect to which *factors* are important determinants for the existence of different perceptions and indicators of well-being, i.e. what conditions the variation. Moreover, we need to find out on which among these factors, information is likely to exist or could easily be made available at the level of disaggregation which we need, i.e. the community level.

Many factors can be assumed to condition the existence of different indicators of well-being. Examples are land distribution; agro-ecological conditions; presence of institutions such as credit institutions, schools, health, NGOs; *ethnic composition*; population density (as an indication of overall pressure on resources); physical accessibility and local opportunities for non-agricultural employment.

It is, however, rare to find community level data on all such factors. Either such data is not collected at all or it is not collected (or available) at the 'community level' of disaggregation but only at e.g. municipality level. While, for instance, population density in most cases can be obtained from population censuses at relatively detailed levels, detailed data on land distribution only rarely exists.

The sampling strategy therefore has to be further adjusted to the availability of data. Some of the factors on which in most cases it will be possible to obtain rough information at least, are population density; broadly defined agro-ecological conditions, expressed e.g. as altitude, annual rainfall, broad soil types (deep/shallow; fertile/unfertile; acid/non-acid) or topography; physical accessibility, e.g. based on the road network; and ethnic composition, expressed as the predominant ethnic group. Which factors are chosen to guide the site selection will, however, have to be considered from case to case. The factors that are chosen to guide the site selection can be referred to as *sampling factors*.

Agro-ecological conditions, physical accessibility and population density all serve as indications of overall physical conditions that exist for production and thereby of material sources of well-being, whereas ethnic composition, or predominant ethnic group, takes into account that different ethnic groups might have different perceptions of what constitutes well-being, even given similar physical conditions or material sources of well-being.

Apart from taking into consideration the influence that each of these factors have in isolation, it is necessary also to take into consideration the *interaction* that might exist between them. As an example, high population density in combination with good accessibility might condition the existence of different well-being indicators from high population density in combination with poor accessibility.

Let us look at the case of the Río Cabuyal study where the above four factors were chosen as sampling factors. In this case, altitude was taken as a proxy for agro-ecological conditions and a distinction was made between sites in the 'low' zone (1,200-1,500 m a.s.l.), in the 'middle' zone (1,500-1,700 m a.s.l.), and in the 'high' zone (1,700-2,200 m a.s.l.).

With respect to physical accessibility, two categories of sites were distinguished, namely those with good accessibility in the rainy season and/or short distances to the Panamerican Highway ('good' accessibility) and those with poor accessibility in the rainy season and/or long distance to the Panamerican Highway ('poor' accessibility).

With respect to population density, a distinction was made between sites with a population density above ('high') and below ('low') the average population density for the area.[1]

Finally, with respect to ethnic composition, a distinction was made between sites having a predominantly 'mestizo' population and those having a predominantly 'indigenous' population. Thus, for three of the sampling factors, two options exist while for the fourth factor (agro-ecological conditions), three options exist, which gives 24 possible combinations of these four factors.[2] This implies that to take all of these theoretically possible combinations and thus patterns of interaction into account, 24 sites should be selected, each representing one of these combinations.

However, in reality, it might not always be possible to take all such theoretically possible combinations into account: some combinations might not exist due to some sampling factors being closely associated; the study area might simply not contain 24 sites; or time and other resources might not allow for 24 sites to be selected. In such cases, the number of sites will have to be reduced. Since it is not possible *a priori* to exclude any of the sampling factors as less influential in determining the existence of different sets of well-being indicators[3] and in this way reduce the number of sites, the principle guiding the selection of the reduced number of sites should be to constantly aim at choosing as *contrasting* sites as possible, considering all sampling factors simultaneously.

Let us assume that we should select four out of the eleven sites described below in box 1 with respect to the four sampling factors.

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1 The average population density of the area is 70 persons/km^2, varying from 20 to 270 persons/km^2 (Río Cabuyal census, 1993).

2 2 options x 2 options x 2 options x 3 options = 24 combinations.

3 Later we shall describe the method for identifying well-being indicators. However, an analysis of variance according to the four sampling factors of the frequency with which different indicators used by the 31 informants from 11 different veredas in Río Cabuyal to describe different levels of well-being showed that although *most* of these indicators were used in all sites irrespective of accessibility, population density etc., the use of *some* of these indicators *was* related to one or more of the sampling factors. The analysis does not, however, allow us to conclude that some factors are less important than others in determining the use of different indicators for well-being.

Box 1. Río Cabuyal sites described with respect to sampling factors

	Accessibility (good - poor)	Population density (high - low)	Ethnic composition (mestizo - indigenous)	Altitude zone (low - middle - high)
Socorro	good	low	mestizo	low
La Isla	poor	low	indigenous	low
Panamericana	good	low	mestizo	middle
Porvenir	poor	low	indigenous	middle
La Laguna	poor	high	indigenous	middle
Ventanas	good	high	mestizo	middle
Santa Barbara	poor	low	mestizo	high
Buenavista	poor	low	mestizo	high
Crucero el Rosario	good	high	mestizo	high
El Oriente	poor	low	indigenous	high
La Llanada	good	high	mestizo	low

Based on the above principles, it is possible to draw several sets of four sites. Some examples are:

Ventanas • good-high-mestizo-middle	La Llanada • good-high-mestizo-low	La Isla • poor-low-indigenous-low
Socorro • good-low-mestizo-low	Buenavista • poor-low-mestizo-high	Buenavista • poor-low-mestizo-high
La Laguna • poor-high-indigenous-middle	La Laguna • poor-high-indigenous-middle	La Llanada • good-high-mestizo-low
Buenavista • poor-low-mestizo-high	Panamericana • good-low-mestizo-middle	Crucero el Rosario • good-high-mestizo-high

Step 2. Conducting well-being rankings

Wealth or well-being[4] rankings is one of several techniques for obtaining a picture of the kind of socio-economic differentiation that exists within a community and the indicators that local people use to describe different levels of well-being.

There are several ways of undertaking wealth or well-being rankings (e.g. Grandin 1988; Scoones 1988; IIED 1992). These include:

- card sorting done by individual community members
- card sorting done by groups of community members
- group discussions (possibly in 'stratified' groups, selected on the based on gender, cattle ownership etc.) of wealth or well-being, possibly in combination with card sorting
- social mapping

The method described in this paper is the *card sorting done either by individual community members or by groups of community members*. This is probably the easiest method to handle since it requires less of the researcher in terms of group discussion facilitation skills and is easier to report. The description below is based on Barbara Grandin's field manual (Grandin 1988) and own experiences.

Defining the community

Conducting a well-being ranking requires the identification of a well-defined community or neighbourhood, small enough for people to know about each other's level of well-being and large enough to encompass differences. Experience tells that in most rural settings, this corresponds to communities of between 40 and 100 'units' or households.

Defining the units to be ranked

In this paper, we are referring to the household as the unit of analysis and therefore also as the unit to the ranked in the well-being ranking. However, depending on the purpose of the study, other units of analysis than the household might be more relevant, such as 'individuals', 'adult women' or entire 'neighbourhoods'. In such cases, these should be defined as the units to be ranked in the well-being ranking.

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[4] Initially, this type of rankings was referred to as *wealth* rankings (Grandin 1988). However, later it has been recognized that the term *wealth* might not always be the ideal term since it implies a materialistic focus. Increasingly, the term 'well-being' is being used since it associates more with the broader notion of *quality of life* and thus relates more directly to poverty.

In all cases, it is important that the selected *unit* is properly defined. For instance, it should be clear whether two families living in the house or compound are ranked individually or as one household. Such clarification should primarily be based on local concepts. As already mentioned, we will in the following be referring to 'households' rather than to more abstract term 'units'.

Making a complete list of all the households within the community

A list including all households in the community should be prepared, taking great care that it is exhaustive. Households can be referred to e.g. by the name of the household 'head' or the names of husband and wife, according to what is most convenient within the local context. Each name or 'household' is then transferred to a card or a slip of paper so that there will be as many cards as there are households with the community. Make sure to write in big letters! Each card is given a number for ease of reference.

Finding reliable informants

The most practical approach to identify informants often is to ask community leaders to identify 3-5 informants who would be willing to participate in the ranking exercise. The criteria for selecting these informants should be that they have been living in the community for an extended period of time for them to be knowledgeable about the level of well-being of other households. Moreover, they should as far as possible represent a wide cross-section of the community in terms of gender, ethnicity, status, etc.

Since the level of agreement among the individual informants normally is quite high with respect to how they group households and the type of indicators they use to describe the different well-being categories (see example below!), it is usually sufficient to undertake three to five rankings. However, in cases where there seems to be a high level of disagreement between the informants, more rankings will have to be undertaken and subsequently more informants will have to be chosen.

If a number of community members decide to undertake the ranking together (group sorting), this should only count as one ranking.

Finding local terms for 'well-being' and introducing the purpose of undertaking the well-being ranking

A crucial stage in the well-being ranking obviously is finding a accurate translation of the term 'well-being'. Well-being is a 'neutral' concept in the sense that it does not imply any specific components or elements as constituting well-being. Thus, when translating 'well-being' into the local language, care should be taken to preserve this 'neutrality'. In explaining the concept, general phrases like 'living a good life' can be used whereas giving specific examples of what *could* define the level of well-being must be carefully avoided.

In explaining the purpose of undertaking the well-being ranking, it is important to stress that the purpose is *not* to obtain information about the level of well-being of *individual* households (e.g. what they have and what they do), but rather to obtain information about groups or categories of households. Moreover, care should be taken in as openly and detailed as possible explaining the broader scope of conducting well-being rankings as it applies within the specific context. An example could be that households enjoying different levels of well-being also tend to face different types of problems and to have different opportunities and strategies for solving these problems. They are therefore likely to benefit from different types of research programmes, projects, etc. To define such programmes etc., it is therefore important to have insight into the different conditions that households within a community experience.

Card sorting

The card sorting should take place in a quiet and undisturbed place.

Apart from introducing the overall purpose of the well-being ranking, it is important to briefly describe the procedure of the well-being ranking and, if the household is the unit of analysis to ensure that the informant will consider and rank the household as such rather than only the persons whose names appear on the cards.

If the informant is literate, he or she can read the card; otherwise the names will be read aloud to him or her. The informant is asked to take each card, consider the level of well-being of the household represented by the card and then place the card in a pile with households enjoying a similar level of well-being. It is not necessary that the informant explains his or her judgement of each household. The informant is asked to make at least three piles. If the informant is unsure about or hesitates to rank a particular household, he or she should be encouraged to put that card aside in order not to get any 'false rankings'. When the informant feels satisfied with the piles, these should be ordered in sequence from highest to lowest level of well-being.

Describing the 'piles'

Thereafter, the informant is asked to characterize each pile of households, i.e. to describe how households in one pile resemble each other and how they differ from households contained in the other piles. It is often useful to encourage the informant to take a look at the cards in pile which is to be described to ensure that the description does not only refer to the card or the household being on top of the pile. The descriptions made by the informant are carefully noted down (or perhaps tape recorded) as they constitute the principal information obtained from a well-being ranking. In order to distinguish between indicators or descriptions given by the informant and those directly or indirectly provoked by the researcher, the researcher should only ask additional or clarifying questions about the households in each pile once the informant has described all the piles.

Box 2 gives an example of a description of three different well-being categories from Río Cabuyal, Cauca, Colombia.

Box 2. Descriptions made of different levels of well-being in La Laguna, Río Cabuyal

Informante I

Categoría de bienestar I:

Caleños. Esa gente más bien han favorecido a la gente de aquí porque han abierto fuentes de trabajo. Esa gente colabora con los gastos de la vereda.

Los caleños tienen cómo defenderse... tienen su posesion.... tienen sus profesiones, tienen recursos, montan graneros... . Cuando empezó la invasion , no iban a dejar un solo caleño y él les habló. A los indigenas les han colaborado con el carro, drogas.... tienen allá sus buenos puestos..les traen ropas, zapatos a los niños...son muy beneficiosos... . En las fincas de caleños trabajan los indígenas del Cabildo cuidan y jornalean.

Categoría de bienestar II:

Guambianos. Hacen grupos entre ellos.... no se mezclan. Ellos son muy trabajadores. Les gusta cultivar todo lo que les produzca. Ellos también jornalean; se defienden mucho; tienen tierras en Silvia que son mejores o dan mejores ganancias; cebolla, ulluco, linaza, papa, amapola... .

Categoría de bienestar III:

Son los que más jornalean. Tienen propiedad pero les gusta más al jornal. Tal vez hay menos recursos..... no tienen con que defender mucho el hogar. Tenemos que arañar mucho para conseguir el sustento, el vestido... si se enferman mucho

Informante II

Categoría de bienestar I:

Caleños. Dueños de rallanderias. Dueños de la plata, de fincas, le dan trabajo a uno; pagan barato, pero le dan.... .Ellos trabajan en Cali, tienen su estudio y nosotros en el campo solo con tercero o cuarto primaria.... .

Categoría de bienestar II:

Cuidan fincas. Estan ganandose la plata porque les llega. Tienen cómo pagar al diario. Les pagan cuarenta mil la quincena. Reciben su platica, tienen su palo de yuca, su mata de plátano, no les cuesta y sólo reciben es lo de la remesa. Unos no tienen casa.

Categoría de bienestar III:

Los que tienen entradas de algo. Algunos trabajan con bueyes. Tienen sus cafeteras y se defienden. No sufren en cuanto a que tienen hijos en Cali. Les traen los hijos. Hacen préstamos a la Caja, porque tienen escrituras propias. A la gente de la comunidad les ayuda el CRIC de Popayán. A los blancos nos separan. Dicen que la vereda es Resguardo, para que cobijen a todos. A los indígenas no les hacen prestamos. La tierra no es de negociarla, solo las matas. A los caleños no los dejan comprar, pero ellos han servido.... les traen remesa cuando no tienen. Hay parte de la comunidad ...(?) tienen otras entradas. Siempre tienen algo. Salen a Santander.

Informante III

Categoría de bienestar I:

Gente del Valle, o de otras partes que se quedan, que han comprado fincas, tierras, tienen mejores entradas, casa buena, alimentación mejor. Los servicios son mejores, las instalaciones; tienen baño, piscina, estufa, electrodomésticos. Incluyo unos que regresan los fines de semana.

Categoría de bienestar II:

Medios. Vienen a cuidar fincas de otras partes, otros son de por aquí.... Nariñenses... de nivel medio. Aunque no tienen todas las comodidades, no es malo ni bueno. Algunos tienen licuadora, otros televisión, casas de teja, ladrillo, tienen cafeteras, platanales, yuca... Viven aquí, pero otros son llegados que han comprado aquí.

Categoría de bienestar III:

Nativos de aquí. Tienen un nivel medio de vida. No poseen tantas comodidades, unos tienen estufa, otros television... . En cuanto a la alimentación unos comen carne, otros nó. La vivienda no es muy adecuada. Todos tienen agua. Son mas que todo la gente de la zona. Pueden ser mestizos. Gente de recursos bajos. Hay Guambianos, y Paeces llegados y otros de aquí. Tienen tierras pequeñas. De escazos recursos económicos. Los techos son de cartón, las casas de bahareque. Los paeces y guambianos tienen diferentes costumbres en el matrimonio. A la muerte de un casi no tienen con que.... algunos sacan créditos y quedan mal, sacan platas prestadas para sembrar frijol pero por el mal tiempo quedan en situación grave. Prestan de 500 mil a 1 millon y quedan endeudados... .

Categoría de bienestar IV:

Los menos-menos. Son pobres. Ya criaron los hijos, si les pueden ayudar, les ayudan. No pueden pasar buena vida. Hay parte de los de la comunidad de los que invadieron vivian a orillas del río. Hay unos que tienen casas de cartón.... trabajan al día, jornalean, no tienen nada de tierras, ni matas . Hay mujeres y ancianos solos, y viudos. Otros con hijos ...solos.... . No salen a mercar.

Les suspenden compra de tierra a los pastusos, porque mataron a dos de aquí y acaban la tierra con el frijol. La gente de la comunidad no tiene cómo tener dinero.

familiar pasan hasta 2 días velándolo y todos recurren durante 2 días con comida.

Note: *Information in italics was given, following questions made by researchers.*

Recording the ranking

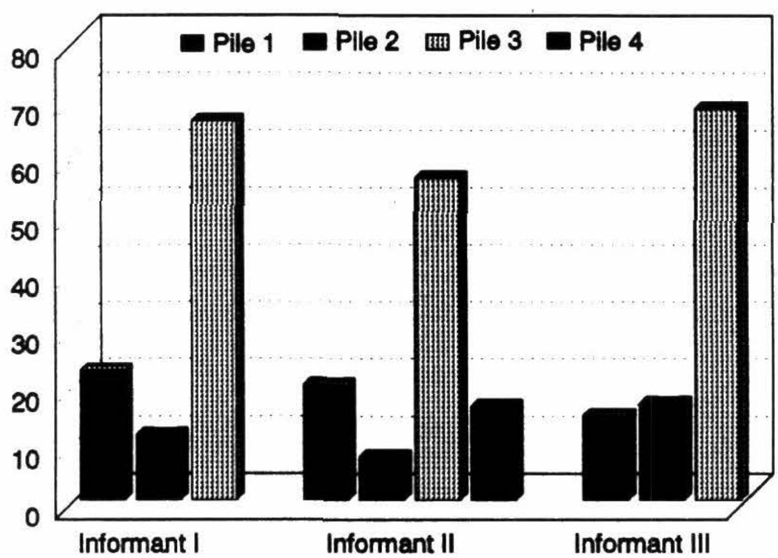
In order to be able to assess the degree to which informants agree with respect to a given household's level of well-being, the rank given to each household is noted down. To ensure openness about which data is taken 'out of the community', it is preferable that noting down the rank given to each household is done when the informant is still present.

The piles are numbered from 1,2,... to P, where P is the total number of piles made by the informant, in descending level of well-being so that pile 1 represents the households enjoying the highest level of well-being, etc. For each household, the pile to which it has been allocated is noted.

Figure 1 presents graphically how the households were distributed among the different piles in the three rankings conducted in La Laguna.

Figure 1. Household frequency by well-being 'pile', by informant, La Laguna, Río Cabuyal

Percent households



Step 3. Grouping households into average well-being categories

Instead of having to operate with a number of individual rankings for each community, we are interested in constructing some sort of an average ranking.

To do so, we first have to calculate *an average well-being score*, based on the individual rankings. Second, we need to check the *level of agreement* (or disagreement) between the individual rankings. Only if there is a significant level of agreement between the rankings, we can proceed to actually group the households in 'average well-being categories' for each community.

Computing an average well-being score for each household

Based on the individual rankings, an average score, S, is calculated for each household, indicating its position on the 'well-being scale'. For each of the rankings, a score, $S_1...S_x$, where 'x' is the number of rankings, is calculated. This is done by taking the number of the pile to which the household is assigned, 'p', and dividing it by the total number of piles made by the informant, 'P'. To avoid operating with decimals, this figure is multiplied by 100. The formula for calculating the scores $S_1...S_x$ thus is $p_{1\rightarrow x}/P_{1\rightarrow x} * 100$. Through this procedure all households considered to have the lowest level of well-being will obtain a score ($S_1...S_x$) of 100 and households considered to have the highest level of well-being, a score of 33, 25, 20 etc. depending on the total number of piles made by the informant. The average score, S, is thus calculated for each household as the average of the scores, $S_{1\rightarrow x}$, obtained in the individual rankings. Box 3 shows the calculated scores.

Box 3. Extracts of average well-being score calculation, La Laguna, Río Cabuyal

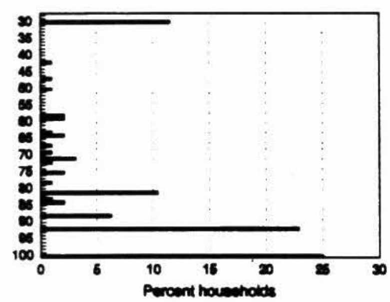
Household identification number	Informant I (3 piles)	Informant II (4 piles)	Informant III (3 piles)	Average score
.	.	.	.	.
.	.	.	.	.
11	67	75	100	81
12	67	75	100	81
13	67	25	100	64
14	100	75	67	81
15	100	75	100	92
16	33	25	33	30
17	67	-	100	84
18	67	75	100	81
19	67	75	100	81
20	33	75	67	58
.	.	.	.	.
.	.	.	.	.

The first and the third informant chose to make three piles while the second informant chose to make four. A score of 100 indicates the lowest level of well-being while a score of either 33 (informant I and III) or 25 (informant II) indicates that the household has been placed in the pile of households considered to enjoy the highest level of well-being.

Figure 2 below shows the distribution of households along the average well-being score.

Figure 2. **Household frequency by ranking based average well-being score, La Laguna, *Río* Cabuyal**

Percent households



Checking for level of agreement between the individual rankings

In order to test the level of agreement (or disagreement) between the individual 0rankings, each of these scores ($S_{1\rightarrow x}$) can be compared to each other pair-wise, using Spearman's rank order correlation test (Spearman's Rho). Table 1 below summarizes the comparisons made for the three rankings conducted in La Laguna which showed a significant association (at 99.99% confidence level) pair-wise between the three rankings.

Table 1. Level of agreement between rankings conducted in La Laguna, Río Cabuyal

	Spearman's Rho	Average Spearman's Rho
Inf I by Inf III	0.59****	0.59
Inf II by Inf III	0.54****	
Inf I by Inf II	0.63****	
**** Significant at 0.0001 level		

Of the 31 comparisons made between the rankings conducted in 11 different sites, all but one showed a significant association at 95 percent confidence level. We can therefore continue to group households into average well-being categories.

Constructing average well-being categories for each community

Based on the individual rankings and the average well-being score, we can now proceed to construct what can be called 'average well-being categories' for each community. To do so, we need to determine the number of categories to be made, and how to define these categories, i.e. where on the average well-being score axis (figure 2) to put the limits between them.

As a general rule, the number of categories should correspond to the average number of piles made by the informants and should never exceed this number since this would convey a false impression of precision. In the case of La Laguna, the average number of piles made by the informants was 3.3. In this case, we therefore chose to construct three categories. Moreover, when well-being rankings are conducted in more than one community with the aim of later comparing the rankings, it is useful (to the extent possible) to construct the same number of average well-being categories for each community. Still, the number of categories should not exceed the average number of piles made by the informants. In the case of Río Cabuyal, we opted for making three categories in each of the eleven sample communities.

Having decided upon the number of categories to be made, the next step is to determine how to define the categories, i.e. where to put the limits between them.

Here, the guiding principle should be to make these categories correspond as closely as possible to the information given by the informants with respect to both the *numerical distribution of households among the different well-being piles* (i.e. the percentage of household in each pile) and the *level of agreement between informants on the ranking of individual households*. This can be done following the procedure described below, using the example of La Laguna.

First we should look at the numerical distribution of households between the piles in order to establish the *average numerical distribution*. Looking back at figure 1, there seems to be a high level of agreement between the three informants with respect to the number of households they have put in each pile with the exception that informant II apparently chose to distinguish the households having a *very low* level of well-being (pile 4) from the households having a *low* level of well-being (pile 3) while informants I and III chose to put all of these households in their respective pile 3. Thus, in order to determine the average numerical distribution considering only three categories, we can combine informant II's pile 3 and 4 into a single pile. This gives an average distribution of 19 percent of the households in category 1, 12 percent in category 2 and 69 percent in category 3 (see table 2).

Table 2. Constructing the average numerical distribution of households between well-being piles based on the individual rankings, La Laguna, Río Cabuyal

Percent households per pile

	Informant I	Informant II	Informant III	Average numerical distribution	
Pile 1	23	20	15	Category 1	19
Pile 2	11	8	17	Category 2	12
Pile 3	66	56	68	Category 3	69
Pile 4	-	16	-		-

This, however, does not take into consideration the *disagreement* that is likely to exist between the informants with respect to how they have ranked the individual households. As our comparisons between the individual rankings indicated (table 1), although the individual rankings are significantly associated, some households have been ranked differently by the three informants. For instance, some households might have been ranked in the lowest well-being pile by one informant while in the middle or highest well-being pile by others.

Second, therefore, we need to take the level of agreement (or disagreement) into consideration. Instead of defining the categories based on average numerical distribution as done above, we now define a new set of three categories based on the level of agreement between the informants and the distribution of households according to average score. First, we define a category containing the households which according to *all* informants would fall into the category of households defined above considered as enjoying the highest level of well-being, i.e. having the lowest possible average score. In the case of La Laguna, the lowest possible average score is calculated as the average of the lowest possible scores for each of these informants (33+25+33)3=30.3. Next, we define a category containing those households which according to *all* informants would fall into the category of households defined above having the lowest level of well-being. Since, in the case of La Laguna, we have chosen to merge informant II's pile 3 and 4, the average scores qualifying a household for this category are scores greater than 91, i.e. (100+75+100)/3=91.67. Finally, we define a third and middle category consisting of the households about which there was either disagreement between the informants or which all the informant ranked in the middle category. In the case of La Laguna, this category consists of households having an average score between 31 and 91.

Having defined the limits of the categories, we can now determine the percentage of households belonging to each of these categories. We do this by looking at a frequency table of the average score. This gives the distribution showed in column [2] in table 3 below.

The third and final step towards defining the average well-being distribution is to combine the two above distributions by taking the simple average between them ([3]) as shown in table 3. This distribution, however, has to be adjusted according to the actual distribution of households along average score. Thus in the case of La Laguna, category 1 contains 17 percent of the households and is defined by an average score less than 58.5; category 2 comprises 26 percent of the households and is defined by an average score between 58.5 and 81; while category 3 contains 57 percent of the households, having an average score greater than 82.

Table 3. Average well-being categories, based on average numerical distribution and level of agreement between informants, La Laguna, Río Cabuyal

	Average numerical distribution (from table 2) [1]	Distribution based on level of agreement among informants [2]	Average distribution ([1]+[2])/2 [3]	Final distribution [3], adjusted to actual distribution of average score
Category 1	19	12	16	17
Category 2	12	40	26	26
Category 3	69	48	59	57

Step 4. Comparing well-being rankings from different communities

So far, the descriptions or indicators of well-being (as well as the distribution of households among the different well-being categories) have only been considered with respect to the community for which they were given. However, as discussed in the section on site selection, in most cases, there will be an interest in seeking to extrapolate these descriptions to a larger area. The purpose of the present step, step 4, is to assess the extent to which the well-being descriptions or indicators identified in one community can be applied to categorize households in neighbouring communities. This is done by comparing the well-being indicators identified in the selected communities.

The selected communities were sampled from a maximum variation sampling strategy (step 1). Therefore, if major similarities in terms of the indicators used to describe different levels of well-being are found across the selected communities, these indicators can be assumed *valid* for the entire set of communities from which the selected communities were sampled. If, on the other hand, major differences are found between groups of communities, e.g. between communities of different accessibility, indicators identified in one of these groups can only be extrapolated within that group of communities, i.e communities having similar degree of accessibility. Obviously, a third possibility exists, namely that some indicators are found to be generally used across the selected communities while others are specific to specific types of communities. In this case, a set of indicators that contains some common indicators and other (alternative) indicators that vary between groups of communities but have the same significance, can be extrapolated to the entire study area. An example of such 'alternative' indicators could be 'livestock ownership' and 'ownership of capital, cars, etc.' both signifying 'resourcefulness' although in different material forms.[5] We shall discuss this in more detail below.

Basically, the comparison of the indicators identified in the sample communities is done by reading through *all* the descriptions of the well-being piles given by the informants. The aim is to extract the indicators used and subsequently assess the extent to which they differ. Preferably this should be done by more than one person in order to ensure the *reliability* of the 'translation' or rather 'reduction' of *descriptions* to *indicators*.

However, before this is done, the number of well-being levels to be distinguished, should be determined. It is useful to operate with a fixed number of levels for all the communities and preferably the same number as the number of average ranking-based well-being categories that were constructed during the previous step. In the case of Río Cabuyal, we therefore chose to distinguish three levels of well-being. Box 4 shows how the descriptions of the well-being piles made by informant I in La Laguna (presented in box 2) were translated into indicators.

Box 4. Translation of well-being descriptions to indicators using the example of informant I, La Laguna, Río Cabuyal

Highest level of well-being	Middle level of well-being	Lowest level of well-being
• caleños • non-agricultural sources of income • resourceful • agriculturally related sources of income • capacity to give presents, loans, etc. to neighbours • capacity to employ day-labourers • own land	• guambianos • work together/collaborate • day-labour besides own farming • have land • have many different crops	• day-labour a lot • resource-poor • problems with getting sufficient food • health problems • cannot repay credit

[5] This corresponds to the distinction made by Sen (1984) between *commodities*, *characteristics* and *capabilities*. Sen illustrates this distinction using the example of a bicycle. A bicycle itself is a commodity. It has several characteristics and one among them is transportation. Having a bike gives a person the ability to move about in a way that he or she could not without the bike. So the transportation *characteristics* of the bike (the *commodity*) give the person the *capability* of moving or functioning in a certain way (Sen 1984:334). In our case, the commodity is the cattle, the car, the capital in the bank, which all have the characteristic of being investment objects that give the owner the capability of coping with crises.

In order to facilitate the comparison of indicators used by the different informants, it is useful to *count* the number of times these indicators are used in the different communities to describe different levels of well-being. This can be done using a matrix form as the one shown below in table 4. The indicators (rows) are listed in the sequence in which they are encountered and translated from the descriptions, and counts are made in the columns, distinguishing the informant, the community and the well-being level which the indicator was used to describe.

Table 5 summarizes the frequency with which the indicators were used in the 11 communities where well-being rankings were undertaken in Río Cabuyal while table 6 shows the frequency with which the different indicators were used to describe the different levels of well-being.

Table 4. Matrix to count frequency of indicators by informant, community, and well-being level, La Laguna, Río Cabuyal

	Informant ID-number	1	1	1	2	2	2**	3	3	3
	Community ID-number	7	7	7	7	7	7	7	7	7
	Level of well-being*	1	2	3	1	2	3	1	2	3
I1	non-agricultural source of income	1			1			1		
I2	capacity to give presents, loans, etc.	1			1					
I3	have resources, capital...	1			1					
I4	capacity to employ people	1								
I5	agriculturally related business	1			1					
I6	own land	1	1		1			1		
I7	caleños	1			1			1		
I8	good houses							1	1	
I9	guambianos		1							
I10	collaborate		1				1			
I11	day-labour besides farming		1							
I12	have many different crops		1						1	
I13	day-labour a lot			1			1			
I14	resource-poor			1						1
I15	own very little land			1			1			1
I16	problems with getting sufficient food			1			1			
I17	problems in repaying credit			1						
I18	health problems			1						
I19	mayordomos					1	1		1	
I20	get incomes					1				
I21	no problems in getting sufficient food					1		1	1	
I22	own their house					1			1	
I23	poor houses						1			1
I24	do not go to the market						1			

* '1' signifies highest, '2' middle and '3' lowest level of well-being.
** The descriptions made by informant 2 in La Laguna (community no. 7) of well-being pile 3 and 4 have been combined into a single set of indicators in accordance with the discussion above under step 3.

Table 5. Frequency of indicators for different levels of well-being by community, Río Cabuyal

Number of times used

	Socorro	La Isla	Panamericana	Porvenir	La Laguna	Ventanas	Santa Barbara	Buenavista	Crucero el Rosario	El oriente	La Llanada	Total
Non-agricultural sources of income	-	-	1	3	3	3	-	1	3	-	2	16
Agriculturally related business	1	-	-	-	2	-	-	1	1	-	2	7
Get income/have sufficient resources, though not a lot	-	-	-	-	2	-	-	-	-	-	-	2
Day-labour a lot	1	2	3	1	2	3	2	2	3	-	3	22
Day-labour besides farming	-	-	1	2	1	1	1	3	2	1	-	12
Do not have to day-labour	-	1	-	1	-	1	-	2	-	1	1	7
Do not have to work on the farm themselves	-	-	-	-	-	1	1	-	-	-	1	3
Cannot get work	-	-	1	1	-	-	-	1	2	1	-	6
Women have to work outside the family	-	1	-	1	-	-	-	-	-	-	1	3
Have to rent in land	3	-	1	-	-	-	-	-	-	-	-	4
'Mayordomos'	-	-	1	1	2	3	-	-	-	-	-	7
Capacity to give presents, loans, etc. to neighbours	-	1	2	-	2	-	-	1	1	-	-	7
Capacity to employ people in their farm	1	2	1	1	1	1	2	-	2	-	2	13
Own livestock	1	-	-	1	-	-	2	3	-	-	1	8
Have resources, capital, cars, etc.	2	1	2	2	2	3	1	-	3	-	2	18
Obtain credit and/or buy inputs	1	-	1	-	-	1	1	-	-	-	3	7
Own land	4	3	3	5	4	4	2	3	1	-	4	33
Own very little land	4	2	2	3	3	4	2	1	4	-	-	25

Lack resources, e.g. to farm	3	-	2	-	2	-	3	2	-	-	-	12
Don't manage to sow the land they have due to lack of resources	-	-	-	1	-	-	1	1	-	-	-	3
Problems in repaying credit	-	-	-	-	1	-	-	-	-	-	-	1
Cannot afford to go to the market	-	1	1	-	1	-	1	-	-	-	-	4
Cannot afford to educate their children	-	-	-	2	-	1	-	-	1	-	-	4
Migrate to Santander or Cali	1	-	-	-	-	-	-	1	-		1	3
Depend on others for land, housing or food	-	-	1	-	-	1	-	-	-	-	-	2
Have to get food on credit	-	-	-	-	-	-	1	-	-	-	-	1
Poor health	-	-	-	-	-	3	-	1	-	-	1	5
Have few different crops	-	-	-	1	-	-	1	1	-	-	-	3
Have many different crops	2	3	-	-	2	2	3	1	2	-	-	15
Have problems in getting enough food	2	1	2	3	2	2	3	4	2	-	-	21
No problems in getting enough food	-	2	-	2	3	2	2	3	2	-	2	18
Poor houses	3	1	2	3	2	3	3	4	2	1	1	25
Own their houses	-	1	-	1	2	-	-	-	-	-	-	4
Good houses	2	2	4	1	2	2	4	1	1	1	-	20
Guambianos	-	-	-	-	1	-	-	-	-	-	-	1
Caleños	-	-	-	3	3	-	-	-	-	-	1	7
Big families - many children	1	-	-	-	-	-	-	1	1	-	1	4
Collaborate within and/or outside the family	-	-	1	1	2	-	-	2	-	-	2	8

Table 6. Frequency of indicators for different levels of well-being, Río Cabuyal

Number of times used

	High level of well-being (29 piles)	Middle level of well-being (29 piles)	Low level of well-being (31 piles)	Total (89 piles)
Non-agricultural sources of income	15	1	-	16
Agriculturally related business	5	2	-	7
Get income/have sufficient resources, though not a lot	-	1	1	2
Day-labour a lot	-	2	20	22
Day-labour besides farming	-	10	2	12
Do not have to day-labour	5	2	-	7
Do not have to work on the farm themselves	3	-	-	3
Cannot get work	-	-	6	6
Women have to work outside the family	-	1	2	3
Have to rent in land	-	1	3	4
'Mayordomos'	-	3	4	7
Capacity to give presents, loans, etc. to neighbours	7	-	-	7
Capacity to employ people in their farm	12	1	-	13
Own livestock	7	1	-	8
Have resources, capital, cars, etc.	18	-	-	18
Obtain credit and/or buy inputs	5	2	-	7
Own land	18	15	-	33
Own very little land	-	3	22	25
Lack resources, e.g. to farm	-	3	9	12
Don't manage to sow the land they have due to lack of resources	-	2	1	3
Problems in repaying credit	-	-	1	1
Cannot afford to go to the market	-	-	4	4
Cannot afford to educate their children	-	2	2	4
Migrate to Santander or Cali	-	-	3	3
Depend on others for land, housing or food	-	-	2	2
Have to get food on credit	-	-	1	1
Poor health	-	-	5	5
Have few different crops	-	-	3	3

Have many different crops	7	8	-	15
Have problems in getting enough food	-	8	13	21
No problems in getting enough food	10	8	-	18
Poor houses	-	2	23	25
Own their houses	-	4	-	4
Good houses	14	6	-	20
Guambianos	-	1	-	1
Caleños	7	-	-	7
Big families - many children	-	-	4	4
Collaborate within and/or outside the family	1	5	2	8

From table 5, it can be seen that in the case of Río Cabuyal, some indicators are widely used across communities to describe well-being such as 'own land', 'day-labour a lot', 'good houses' etc. while other indicators, such as 'mayordomo', are more site-specific, used only in a few communities. Taking a closer look at the indicators, some appear to be (site) specific expressions or exemplifications of of others. An example is 'problems in repaying credit' or 'don't manage to sow the land they have due to lack of resources' which both can be seen as more specific expressions of the indicator 'lack resources, e.g. to farm'. Another example is the indicator 'own livestock' used primarily in Santa Barbara and Buenavista to describe high levels of well-being which seems to be a specific expression of the more general indicator 'have resources, capital, cars, etc.'. Thus, there is a high degree of complementarity between the use of these two indicators.

Table 6 shows a high degree of consistency between the informants with respect to whether the individual indicators are used to describe respectively high and low levels of well-being. As an example, 'having capacity to employ people in their farm' is an indicator used almost exclusively to describe a high level of well-being (12 times out of 13 times used) while an indicator like 'having poor houses' almost exclusively is used to describe a low level of well-being (23 times out of 25 times used). Only one indicator, 'collaborate within and/or outside the family' was used to describe all three levels of well-being.

Thus, in the case of Río Cabuyal, there appears to be a high level of similarity across the communities with respect to the indicators used to describe different levels of well-being. In this case, it is therefore justifiable to identify a common set of indicators to be extrapolated to describe differences in well-being in the entire study area.

Figure 3 depicts the way in which the most frequent indicators were used.

Figure 3. Most frequent well-being indicators in Río Cabuyal and their usage

	Highest level of well-being	Middle level of well-being	Lowest level of well-being
Day-labour besides farming		■	
Day-labour a lot			■
Own land	■	■	
Own very little land			■
Have non-agricultural sources of income	■		
Capacity to employ people	■		
Good houses	■		
Poor houses			■
Have many different crops	■	■	
Have resources, including livestock	■		
Lack resources			■
No problems in getting sufficient food	■	■	
Problems in getting sufficient food			■

Table 5 moreover allows us to explore what would have happened, had we drawn samples of four rather than of 11 communities as discussed in the section on site selection. Based on table 5, box 5 shows the top-10 sets of indicators for the entire set of eleven communities and for each of the three samples of four communities drawn to represent the maximum variation possible with respect to the four sampling factors as mentioned towards the end of step 1.

Box 5 shows that eight out of the ten indicators used most frequently for the sample of 11 communities were also among the ten most frequently used indicators in all of the three samples of four communities and that the two remaining indicators were among the most frequently used indicators in two of the three samples.

Box 5. The ten most frequently used well-being indicators for different samples of communities, Río Cabuyal

Numbers in brackets indicate number of times used

All 11 communities in Río Cabuyal *89 piles*	Three samples of four communities		
	Ventanas, Socorro, La Laguna and Buenavista *35 piles*	La Llanada, Buenavista, La Laguna and Panamericana *36 piles*	La Isla, Buenavista, La Llanada and Crucero el Rosario *33 piles*
• own land (33) • poor houses (25) • lack resources (25) • day-labour a lot (22) • have problems in getting enough food (21) • good houses (20) • no problems in getting enough food (7) • have resources, capital, cars, etc. (18) • non-agricultural sources of income (16) • have many different crops (15)	• own land (15) • own very little land (12) • poor houses (12) • having problems in getting enough food (10) • day-labour a lot (8) • no problems in getting enough food (8) • non-agricultural sources of income (7) • have resources, capital, cars, etc. (7) • lack resources (7) • good houses (7) • have many different crops (7)	• own land (14) • day-labour a lot (10) • poor houses (9) • have problems in getting enough food (8) • no problems in getting enough food (8) • good houses (7) • collaborate within and/or outside the family (7) • non-agricultural sources of income (7) • have resources, capital, cars, etc. (6) • lack resources (6) • own very little land (6)	• own land (11) • day-labour a lot (10) • no problems in getting enough food (9) • poor houses (8) • have problems in getting enough food (7) • own very little land (7) • non-agricultural sources of income (6) • capacity to employ people in their farm (6) • have resources, capital, cars, etc. (6) • have many different crops (6)

Step 5. Making the well-being indicators quantifiable

We have now assessed to which extent the well-being indicators, identified through the well-being rankings can be applied to the entire study area. Furthermore, we have identified one or more sets of indicators that will help us to categorize the entire population according to well-being. We should now find a way to actually apply these indicators to the entire study area. One and probably the most practical way of doing this is through a questionnaire survey. By formulating questions that will be able to tell us if a given family has problems in getting food, own very little land, day-labour a lot and live in a poor house, or, on the other hand, has various sources of income, own sufficient land and perhaps has the capacity to employ day labourers, or some combination hereof, we will be able to determine the proportion of the population enjoying or suffering the various levels of well-being, provided that the questionnaire is administered to a *representative* sample of the entire population.

In the first place, we therefore need to make the identified well-being indicators quantifiable. As an example, we need to elaborate questions that will tell us whether a given household has problems in getting sufficient food. Thus, a possible set of questions providing this information could be:

Q1	Within the last year, has there been a period when your household did not have sufficient food?	1: Yes, __________ 0: No, __________
Q2	[If 'yes' in Q1] How long was this period?	1: < 1 week, __________ 2: < 1 month, __________ 3: < 2 months, __________ 4: >= 2 months, __________
Q3	[If 'yes' in Q1] What did you and your family do during this period?	1: Cut down on meat etc. __________ 2: Reduced the number of meals, e.g. from 3 to 2, __________ 3: Got food from friends or family for free, __________ 4: Borrowed food from neighbours, friends or family to be paid back, __________ 5: Husband got (more) day-labour __________ 6: Wife got (more) day-labour __________ 7: Children got (more) day-labour __________ 8: Looked for work but without success __________ 9: Nothing __________

In this way, questions need to be elaborated that throw light on the entire set of identified indicators.

In the case of Río Cabuyal, a questionnaire, administered as a census survey to the entire population, had been carried out in 1993 covering many, though not all of the aspects reflected in the set of well-being indicators reflected in figure 3. It was therefore decided to use this information rather than conduct yet another survey. Unfortunately, however, the questionnaire did not include questions relating to problems of food security, neither was it able to tell us whether a household member was partially day-labouring for other farmers ('day-labour besides farming'), but only whether he or she had day-labouring as principal occupation ('day-labour a lot').

When conducting the questionnaire survey, it is important that codes are assigned to the respondents in a way which allows the identification of households that were included in the well-being rankings so that a comparison later (see step 8) can be made between how they were ranked during the well-being rankings and how they are ranked according to the quantifiable well-being indicators (see step 6).

Box 6 in the section below shows how in the case of Río Cabuyal, the well-being indicators for which we have information from the questionnaire survey have been made 'quantifiable'.

Step 6. Constructing a well-being index for the entire study area[6]

We now proceed to construct *a well-being index*, i.e. to combine the above quantifiable well-being indicators into a single 'measure' of well-being. In doing so, it is important that the meaning, i.e. the way in which the indicators were used by the informants to describe the different well-being levels, is preserved. One thing that has to be remembered is that rather than being used as strict criteria defined on beforehand for grouping households in different well-being piles, the indicators emerged in retrospect after the piles were constructed as partial descriptions of the more complex feature of well-being, using phrases such as "...most households in this group...", "...some families...", etc.

Moreover, as depicted in figure 3, certain indicators are used to describe high levels of well-being while others are used to distinguish middle and low levels of well-being, etc.

Finally, based on the descriptions of the well-being piles, an indicator like land ownership appears important, not so much as an indicator telling how much land a household owns but rather for distinguishing between households that have their own labour as the only source of income and those that in addition to their own labour have access to land as a means of production that allow them independently to employ their labour. This introduces the notion of certain threshold values which give e.g. land ownership a second and more qualitative meaning than that derived simply from its numerical size (the more land, the higher the level of well-being).

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6 The procedure for constructing the well-being index was initially developed together with Jannik Boesen (see Boesen and Ravnborg 1993).

Based on these principles, a score system is developed for the indicators identified under step 4 and made quantifiable under step 5. The score system assigns a score to each household for each individual indicator. The household well-being index is thus defined as the sum of the scores that a household obtains on each indicator. This has the advantage that different combinations of scores on the individual indicators or variables may result in the same well-being index value.

The scoring system developed for Río Cabuyal operates with three levels of score, corresponding to the three levels of well-being. In our case, these scores are 33, 67 and 100. However, the actual values of these scores are arbitrary; what is important is that the number of levels of scores corresponds to the number of levels of well-being included in the analysis *and* that the distance between the scores is uniform. Thus, instead of 33, 67 and 100, we could have chosen 100, 200 and 300; 6, 12 and 18, etc.

Figure 3 helps us to assign scores for the individual indicators. Let us look at some examples: Owning land as long as it is not 'very little' was taken as an indicator both of high and middle levels of well-being, while owning very little land was used to characterize the households with the lowest level of well-being. The score assigned to this indicator should therefore help us to distinguish between high and middle level of well-being on the one hand, and low level of well-being on the other. Households owning more than 1 hectare of land (which is considered 'very little' in Río Cabuyal) therefore receive 67 points while households owning less receive 100 points. Non-agricultural sources of income provides another example. This indicator was primarily used to describe households enjoying the highest level of well-being. Therefore, households having non-agricultural sources of income (exemplified as cassava or sugar cane processing plants or being an employee) receive 33 points while households not having such sources of income which could be *either* having a middle *or* a low level of well-being receive a score of 67 points.

Box 6 below shows how scores were assigned to each of the quantifiable indicators forming part of the well-being index, while table 7 shows the distribution of households according to each of the index-constituting variables.

Box 6. Quantifiable well-being indicators and their scores

INDICATOR	Score
Doing day labouring for other farmers (JORNSCO)	67
• if nobody in the household has day labouring as his/her principal occupation	100
• if a household member has day labouring as his/her principal occupation	
Land ownership (LANDSCO)	67
• if the household owns 1 hectare (1.5 plazas) or more	100
• if the household owns less than 1 hectare (1.5 plazas)	
Non-agricultural sources of income (NOAGSCO)	
• if the household (or a household member) owns a cassava processing plant, sugar cane	33
processing plant or is an employee	67
• if nobody in the household owns a cassava processing plant, sugar cane processing plant or is	
an employee	
Use of day-labourers (USESCO)	33
• if the household solely uses day-labourers for coffee and/or cassava harvesting	
• if the household uses day-labourers in combination with family labour for coffee and/or	67
cassava harvesting	
• if the household does not employ day-labourers either in coffee or in cassava harvesting	100
Housing quality (HOUSESCO)	
• if the household lives in an owned house that has both a good roof (tile) and floor (cement or	33
tile)	
• if the household lives in a house that has either a good roof or a good floor *or* that has both	67
but is rented	100
• if the household lives in a house that neither has a good roof nor a good floor	
Crop diversity (DIVSCO)	67
• the household cultivates four different crops or more	100
• the household cultivates three different crops or less	
Resourcefulness (RESSCO)	
• the household owns livestock or obtained credit from Caja Agraria or a commercial bank the	33
previous season	
• the household does not own livestock and did not obtain credit from any of the above	67
institutions	
• the household does not own livestock, did not obtain credit from any of the above institutions	100
and failed to buy fertilizers (mineral as well as organic)	

The **well-being index** is computed as:
JORNSCO + LANDSCO + NOAGSCO + USESCO + HOUSESCO + DIVSCO + RESSCO

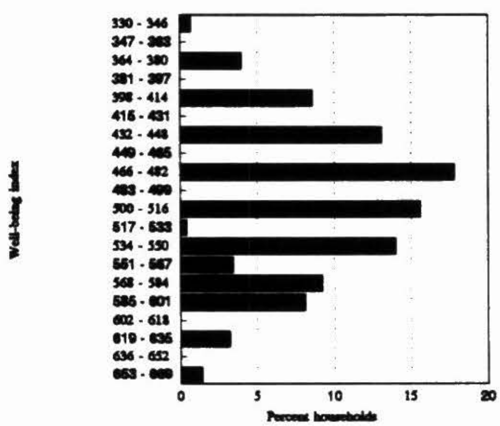
Table 7. Distribution of households by options on index-constituting variables
Percent households

	33 points*	67 points*	100 points*
Day-labouring	-	69	31
Land ownership	-	69	31
Non-agricultural sources of income	15	85	-
Use of day-labourers	19	35	46
Housing quality	45	38	17
Crop diversity	-	43	57
Resourcefulness	23	60	17

* For significance of points, please refer to box 6 above.

Figure 4 shows the distribution of households along the well-being index which has 333 as its minimum and 667 as its maximum value.

Figure 4. Distribution of households by well-being index
Percent households



Step 7. Checking the contribution of the individual indicators to the well-being index

Before we proceed to actually use the well-being index, we have to assure that the individual indicators contribute to the overall well-being index in the way they were intended to. This can be done through an analysis of variance of the well-being index caused by the constituting variables.

In the case of Río Cabuyal, such an analysis of variance showed that all[7] constituting variables were significant sources of variation (significance of $F < 0.001$) and that significant two-way interaction between the index-constituting variables was only present between four[8] out of the 15 possible pairs of variables at 0.05 level. On this basis, we can conclude that all index-constituting variables made a significant contribution to the overall well-being index.

Moreover, the analysis of variance tells us how the individual variables contribute to the well-being index. This is illustrated in figure 5, using the case of Río Cabuyal.

Figure 5 shows the deviation from the grand mean well-being index value (=499) caused by variation in each of the constituting variables (unadjusted for effects of other variables and co-variation between variables). For example, for households that do not have day-labouring as principal occupation, the mean index value is 478 (deviation of -21 points), whereas for those who have day-labouring as their principal occupation, the mean index value is 547 (deviation of +48 points). Based on the figure 5, we can thus conclude that in the case of Río Cabuyal, the individual indicators contributed to the well-being index as intended.

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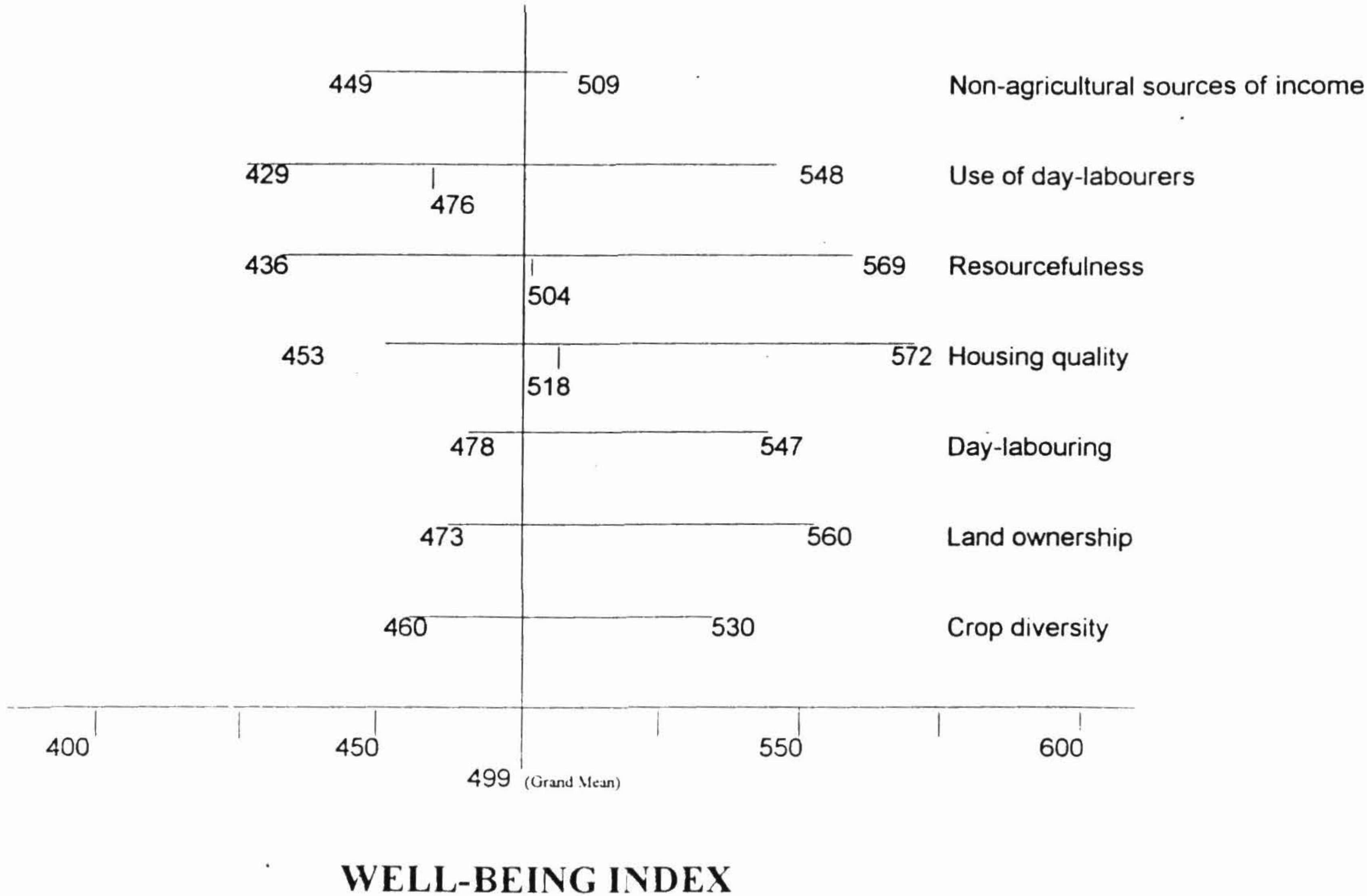
7 'Use of day-labourers' had to be left out of this analysis due to its categories having unequal variance. However, a Kruskal-Wallis test showed that also 'use of day-labourers' is a significant source of variation to the well-being index (at 0.00001 level).

8 Non-agricultural source of income and housing quality; housing quality and crop diversity; day-labouring and land ownership; and day-labouring and crop diversity.

Figure
Effect of individual variables on well-being index, Río Cabuyal



Step 8. Checking the level of correspondence between the well-being index and the ranking-based well-being categories

Besides checking the well-being index for its 'internal logic', i.e. that the constituting variables contribute to the well-being index in the way they were intended, we have to check the level of correspondence between the well-being index and the ranking-based well-being categories. Also this can be done through an analysis of variance where we analyze whether the mean well-being index is significantly different for the households falling in the respective ranking-based well-being categories. In case the mean well-being index is not found to be significantly different for the ranking-based categories, this is an indication that we have failed to construct the well-being index so that it captures the different levels of well-being as described by the informants. The well-being index therefore has to be reconsidered.

In the case of Río Cabuyal, the analysis of variance showed the mean well-being index to be pair-wise significantly different for the three ranking-based well-being categories (see table 8).

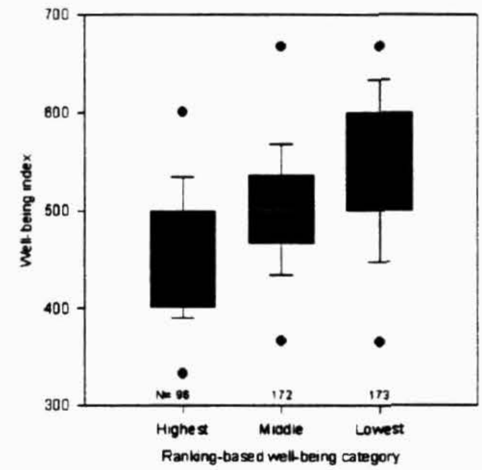
Table 8. Mean well-being index by ranking-based well-being category, 11 sample communities, Río Cabuyal

	Ranking-based category I (n=96)	Ranking-based category II (n=172)	Ranking based category III (n=173)
Mean well-being index	453	499	544
The means are pair-wise significantly different at 0.05 level (Scheffé test).			

Figure 6 gives a more complete picture of the variation in the well-being index for the different ranking-based well-being categories. The boxes demarcate the 25-75 percentile range, while the line inside the box indicate the median, meaning that e.g. for ranking-based category I, the mid-50 percent of the households (the 25-75 percentile range) obtained a well-being index between 401 and 500 points, while the lower 50 percent of the households obtained an index of 435 points or less.

Figure 6. Variation in well-being index by ranking-based well-being category

25-75 percentile range (box); 10 and 90 percentiles (⊥; ⊤); minimum and maximum (•)



Based on the above, we can conclude that there is a significant level of correspondence between the well-being index and the ranking-based well-being categories and thus that the well-being index reflects the descriptions of well-being provided by the informants.

We can therefore now start using the well-being index e.g. to compare the level of well-being not only between the communities where we initially did the well-being rankings but between communities in the entire study area. Doing this for the 22 communities in Río Cabuyal provides the results presented in the last column of table 9 below.

Instead of working with an index variable, it is, however, often convenient to work with levels or categories of well-being distinguishing between those households having a higher, a middle and a lower level of well-being. Such categories can be constructed on the basis of the well-being index, again guided by the ranking-based well-being categories. This is described in the following step.

Step 9. Defining index-based well-being categories

Having assured that the well-being index corresponds significantly with the ranking-based well-being categories, we should now look for how to define categories based on the well-being index so that these index-based categories to the maximum possible extent would correspond to the ranking-based categories.

One way of doing this is to list the number of households falling into each ranking-based well-being category for each value of the well-being index or for the values around which the limits between the index-based categories are likely to be defined. Such a listing is shown in table 9 for Río Cabuyal. Considering to construct three categories, it suggests that the limits should be around the values of 434-467 and 533-567.

A second or rather additional guiding principle could be that the median index values for the two extreme ranking-based well-being categories (I and III) should be included in index-based well-being category I and III, respectively. In the case of Río Cabuyal, this would mean that index-based well-being category I should be defined so that it includes the value 435, and index-based category III so that it includes the value 535.

In the case of Río Cabuyal the index-based well-being categories were defined so that category I contains households with an index value less than 440, category II contains households with an index value between 440 and 534 and category III contains households with an index value of 535 or above.

Table 10 shows the level of correspondence between the index-based and the ranking-based well-being categories.

Table 9. Well-being index by ranking-based well-being categories
Number of households per ranking-based category

Well-being index	Ranking-based category I	Ranking-based category II	Ranking-based category III	Total
401	14	7	4	25
433	2	0	0	2
434	12	8	2	22
435	8	13	8	29
467	5	15	2	22
468	10	19	11	40
469	2	6	2	10
500	4	5	2	11
501	5	21	10	36
502	3	9	10	22
533	0	3	1	4
534	6	13	12	31
535	2	13	19	34
567	3	5	10	18

Table 10. Index-based well-being categories by ranking-based well-being categories
Percent households

	Ranking-based category I (n=96)	Ranking-based category II (n=172)	Ranking-based category III (n=173)	Total (N=441)
Index-based category I	54	20	10	23
Index-based category II	37	53	29	40
Index-based category III	9	27	61	37
Total	100	100	100	100
Significant at 0.00001 level (Chi-square test)				

Thus, we can now describe the distribution of household in all of the 22 communities within Río Cabuyal according to these three index-based well-being categories. This is shown in table 11 below.

Table 11. Community by well-being category and mean well-being index, Río Cabuyal

Percent households per category

Vereda	Highest level of well-being (n=258)	Medium level of well-being (n=387)	Lowest level of well-being (n=315)	Total (N=960)	Mean well-being index value
Caimito	39	39	21	3	473
Socorro	43	38	19	7	470
La Isla	6	41	53	2	531
Palermo	45	40	15	4	466
Panamericana	12	56	32	4	519
Porvenir	10	36	55	4	532
La Laguna	16	37	47	7	514
Los Quingos	24	44	31	7	500
Ventanas	20	47	33	5	508
Santa Barbara	26	33	41	6	509
Cidral	16	40	45	6	517
Primavera	20	47	33	2	499
Buenavista	18	41	41	5	515
Crucero el Rosario	17	51	33	8	514
La Esperanza	19	39	42	3	506
El Oriente	0	40	60	1	558
Pescador	24	55	21	3	488
Crucero Pescador	46	29	26	4	467
Campiña	55	27	18	3	462
La Llanada	35	42	23	5	483
Potrerillo	39	31	29	5	492
Cabuyal	40	38	23	6	480
All veredas	**27**	**40**	**33**	**100**	499

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IV. DEVELOPING AN IN-COUNTRY CAPACITY FOR TRAINING IN THE CIAL METHODOLOGY (IPRA Proyect)

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Planning workshop - Andean Region

From 16-19 January, a meeting was held at CIAT with potential participants in the project from the Andean region (Bolivia, Colombia, Ecuador). The meeting focused on the concept of focus sites, the strategy for building co-participation and development of a work plan for each country. Each potential participating institution was then to seek other collaborating institutions in their respective countries and send a draft proposal of the interinstitutional agreement to CIAT for revision.

The main objective of this project is to develop a long-term, institutionalized capacity to train professionals and farmer-paraprofessionals in the CIAL methodology. The concept of focus sites as permanent training ground where university and research (NARI) programs work with NGOs and communities is essential. In order to establish such sites, it was found necessary to (1) establish relationships with potential partner institutions and inform them of the project's objectives, and (2) develop the terms of the interinstitutional agreement. The search for partners is organized around two vital institutional functions: teaching and research capacity (e.g., national or regional agricultural research institutes and agriculturally oriented universities) and development work with small farmers.

With respect to the management of the rotating funds for the CIAL operations, it was decided to opt for a fiduciary-type fund. When the CIALs grow in number, then they will eventually assume management of this fund.

In 1995 agreements were signed with Bolivia and Ecuador and their staff received two weeks of in-service training at CIAT.

Partnerships

- **Bolivia**.

  The two institutional actors are a research program and an agricultural university: The Bolivian Institute of Agricultural Technology (IBTA) has as its mission to develop and transfer appropriate technology for increasing production and productivity, involving the farmer in the process using participatory methodologies. FACP-UMSS. The School of Agricultural Sciences "Martín Cárdenas" of the Universidad Mayor de San Simón is an educational center that prepares professionals and technicians to resolve agricultural and agroindustrial problems in rural areas of the country.

Ecuador.

The participating institutions are an international graduate program in the social sciences FLACCSO and the regional branch of an international NGO: IIRR (The International Institute for Rural Reconstruction). IIRR's principal objective is to improve the general welfare of small farmers with limited economic resources. This is done by training rural development organizations in project management, sustainable agriculture, health, education, economic improvement and community development. Their activities are guided by a participatory learning-by-doing approach and the participatory workshops on development of information kits. The Regional Office for Latin America is in Quito. The institute focuses its activities in four countries: Colombia, Ecuador, Guatemala and Honduras. FLACCSO. The Latin American School of Social Sciences is the most important regional program offering graduate studies in the Social Sciences in Latin America. The Ecuador program has a staff of 20 professors, all with PhDs, who are complemented by visiting professors from other countries. They offer, among others, a graduate program in hillside societies and sustainable development in the Andes Region. The program is based on five guiding principles: interdisciplinarity, interinstitutional cooperation, participatory action research, macro or regional processes, and a holistic systems approach to sustainable development at the local level. The focus site activities will be linked to Condesan/CIAT Hillside benchmark site research in Karchi, Ecuador.

Brazil.

In Brazil collaboration begun via the CIAT special project (UNDP funded) on integrated pest management in cassava, known as PROFISMA. The CIAL handbooks have been translated into Portuguese. Training of national program staff from three states took place, and to date 19 CIALs (baptized COPALs in Portuguese) have been formed in the Northeast. The project proposal as well as the draft of the format for interinstitutional agreements was translated into Portuguese and distributed to various institutions that expressed interest in collaborating in the project. Partnership among two or more of these institutions in a long-term teaching or focus site is being explored.

Colombia.

Interest in participating has been explored with the Universidad Nacional-Palmira. At the same time the State Secretariat of Agriculture and the municipal-level technology transfer agency (UMATA) have expressed interest in creating a permanent fund for the CIALs they have created in the Valle del Cauca.

Central America.

In Honduras, where the CIAT Hillsides Program has research sites in Danlí, La Ceiba and Yoro-Yorito, an inventory was made of institutions working in the priority areas of the country in order to identify the best institutional possibilities for partnerships.

Training.

Although the focus of staff activity has been on training materials development and institutional relations, there has been a continued demand for training. IPRA has held the following training events this year:

- South East Asia

  Training course in Participatory Research in a CIAT smallholders project in Southeast Asia - 20 researchers coming from China, Vietnam, Philippines, Thailand, Malasya, Indonesia and Laos, received traiing from the IPRA Project in participatory research methods to involve farmers in problem identification, participatory planning and evaluation of technology. Trainees were also prepared to replicate training in their home countries.

- Secretaría de Agricultura-Valle.

  An agronomist and a zootechnician working with the Secretaría in Palmira and an agronomist from the Pacific Coast region received training in the CIALs. Given the warm reception by small farmers and their enthusiasm for the methodology, plans are now under way to provide training to other members of the Secretaría in other municipalities, as well as the technical transfer groups known as UMATAs.

- IPM researchers from CORPOICA.

  The Colombian Agricultural Research Institute made a special request for training in the CIAL methodology for their regional staff who will be implementing CIALs working on integrated pest management programs. Eight participants attended the workshop from 8-13 May.

- Cassava cooperatives from the North Coast.

  In collaboration with the Cassava Program, CORPOICA and several other groups, three CIALs will be established with funds from the Integrated Rural Development scheme (DRI) on the Atlantic Coast. These CIALs will be part of the Cassava Farmers and Processors Cooperatives. Initial training has been provided by the IPRA team, and two members from the CIAT-CORPOICA collaborative agreement attended the workshop held at CIAT from 8-13 May. For the first phase of the CIAL experimentation, one of the farmer technicians will be sent to the North Coast to work with the farmers.

- FUNCOP. This Foundation, which works with farmer cooperatives throughout the state of Cauca, has already implemented a number of CIALs in the state. Two of their staff from other areas received training at the May workshop.

Methodology Development.

Organizational Model

CIALs

The Colombian second-order association CORFOCIAL (Corporation for the Promotion of Local Agricultural Research Committees) has now been granted its official status as a nonprofit corporation, registered in the city of Popayán (Cauca). CORFOCIAL has developed a set of internal regulations with respect to the profile of a farmer-paraprofessional and of their Coordinator, their functions, and the profile of the President of the Corporation, as well as the norms for using the rotating fund. There are three farmer paraprofessionals who are employed by the Corporation to cover the 57 CIALs that are functioning.

Strengthening of the grassroots organization FEBESURCA.

The IPRA team has worked with the watershed users federation throughout the year in order to learn more about how to strengthen their organizational and decision/making capacity and to develop methods and training materials based on an analysis of the most critical tasks required. Thus far a draft handbook has been developed and is being tested.

Training material development

Four handbooks written towards the end of the previous phase of this project are now in the final stages of being field tested before they are printed.

Three short training videos were made in Spanish on the following topics: Participatory research skills; diagnosis; planning and evaluating trials. The purpose of these three videos is to show trainees ways to interact with farmers and how to work with a CIAL during the different phases of their research. The videos have been translated into English and will then be translated into 8 Asian languages for use in training Asian researchers working with tropical pastures and forages in how to interact with farmers.

Impact of methodology development

An inventory was made of participatory research and training activities of CIAT programs and partners which have received input from the IPRA project, which follows in Annex 1.

LIST OF IPRA TRAINING MATERIALS

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V. Investigating Local Knowledge on Plant Genetic Resources A Methodology Based on the Case of Laguna La Cocha, the Colombian Andes.

Prepared by: *Jakob Kronik*

The present paper intends to try out and contribute to the development of methodology for how to gain insight into the processes through which rural people develop and maintain knowledge on genetic diversity. Rural livelihood is the broad framework being explored. Among important dimensions of livelihood is the age, gender, social status and production system of the farmer. In this paper we'll look into the importance of these dimensions for the development and maintenance of local knowledge.[1]

1. Introduction

Local people's knowledge of plants, animals and ecological processes is important for the use and conservation of biological and cultural diversity. decision makers, researchers, and NGOs engaged with the implementation of the Biodiversity Convention are becoming increasingly aware of this fact, and the subject is being openly discussed in many documents (...1992-95).

A full understanding of the importance of local people's knowledge, however, depends on understanding the processes through which it is generated, maintained, and changed. This is the subject of this paper.

This paper departs from the hypothesis that local knowledge on biological diversity is linked to the rural livelihood system. The paper has a particular focus on agricultural production, which means a focus on the farmers role in production and the conditions for the satisfaction of their needs. Here, livelihood is defined in the widest possible sense as leading to social and cultural well-being as well as to material survival (Wilson and Folke Frederiksen 1995).

2. Knowledge

When we find local knowledge being employed in a part of production, the knowledge doesn't necessarily have to originate from the production process, in other words, the origin of this knowledge is not necessarily linked to production. Knowledge doesn't have to be invented every time it is being employed by a farmer. Naturally, knowledge comes from a wide array of sources. Therefore, an important part of studying the generation and

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[1] For the purpose of communicating results back to the community, and to provide easily accessible training material, the video "Estudiando Conocimiento Local de Biodiversidad" or "Local Knowledge on Biodiversity - A Methodology"(Kronik 1995) was produced in Spanish and English.

maintenance of local knowledge is concerned with tracing the people and places from where this knowledge has been picked up, or even, if possible, from where it originates. When investigating the development and transformation processes of local knowledge, a view over time is therefore essential.

One way of getting a view over time of its development is by performing in-depth interviews with selected elders concerning the impact of significant societal changes, such as migration or changes in peoples production system etc. upon the way natural resources were and are being managed. This information can be supplemented with historical data from local archives, etc., which might bring examples of previous management of the local environment. Thereby valuable data will be derived concerning the local history being explored. But this information is seldom specific enough about the origin of local knowledge, nor of the impact on this knowledge from changing societal conditions. One could then analyze sources of formalized local knowledge as Levi-Strauss (1994 (1962)), amongst others have done by analyzing mythologies. Such an approach, though, is not useful in rural communities dominated with recent settlers, as in the case- area selected for this study. In this case we must concentrate on more recently discovered knowledge, with the people living and working in the area. But asking people into the past concerning the state and origin of different pieces of local knowledge can give problems with validation, people forget or tend to reconstruct their memory with the benefit of hindsight. To obtain this sort of information one need to be more concrete.

Focusing on the way farmers tackle different **needs** and **problems** that arise in a household by using the plants at their disposal is intended to get us a further look into both changes in livelihood system, production and related knowledge. Concrete examples of how a specific problem has been dealt with should emerge of such problem-oriented interviews. These examples give insights into the processes that had lead to the generation of new knowledge or the drawing upon other peoples knowledge. Levi-Strauss (1994 (1962)) has discussed these processes by using the metaphor of the "handyman's knowledge", or "bricolage". He says that new plants are not necessarily discovered for a particular purpose, but simply recorded as information, while doing other activities. Maybe the plant is even brought back for domestication, but not necessarily. While the handyman (or farmer) is solving a problem, he might come to think of this plant and try it out in the new context. These two different processes of gaining and storing knowledge, could be called "passive and active local knowledge". It is very difficult to access the passive knowledge, as it has not yet been formulated, or developed into a solution to a problem.

Levi Strauss further demonstrate that this kind of knowledge is linked to cultural structures (1994 (1962)), Stjernefelt (1994) argues, interpreting Levi-Strauss that *transformation* is a key concept when investigating these structures and the local knowledge linked to these, as it enables the researcher to look at both variations of the same system i.e. before and after the system has been influenced by an external agent of change, as well as it allows you to see the actual movement that develop one variation of the structure into the other. The post- and neo-structuralist (Foucault, Lacan a.o.) critique of Levi-Strauss mainly focused on what they, wrongly according to Stjernefelt (1994), saw as rigid structures. Responding to the somewhat deterministic view of the different structuralist approaches to knowledge and human agency, there has been a search for a more actor-oriented-approach (Long and Long 1992). Giddens, too, changes the focus from structure to actor, saying that structures are not something external to social actors but are rules and resources produced and reproduced by actors in their practices (Marshall 1994). In general though, there is agreement between the above mentioned researchers that knowledge to some degree is dependent upon societal structures and that the transformation processes these structures undergo as a result of internal and external agents of change are central to the investigation of knowledge generation and maintenance. This is important to keep in mind when setting up a research strategy for the exploration of local knowledge.

Thus externally, as well as internally initiated developments that change both the way production takes place and the conditions for satisfying peoples needs, indirectly might affect the development and maintenance of local knowledge. Hence a better understanding of the influence of such changes on the knowledge generating processes, would enable better support to decision making concerning the use and conservation of biological diversity and the potential role of indigenous knowledge in this respect. However, in order to achieve this, there is a need to further develop methodology aimed at exploring these processes of development and change.

The present paper intends to contribute to the development of methodology for **how** to gain insight into the processes through which rural people develop and maintain knowledge on genetic diversity.

In correspondence with the above it is the intention that when this research strategy or methodology is employed, it will provide the researcher as well as the studied community with useful knowledge on the status and development of local knowledge on genetic resources, within a reasonable time frame and budget. The aim is thus to show ways of focusing the interviews and -techniques to some key communities in the study area, how to achieve an overview of production, then how to focus research to a central part of production and finally how to select local persons, while controlling for biases.

In this paper Scoones and Thompsons definition of rural peoples knowledge (RPK) will be used, and only substituted by "local knowledge" for language reasons. They claim that indigenous knowledge should be considered:

> "as cultural knowledge, producing and reproducing mutual understanding and identity among the members of a farming community, where local technical knowledge, skills and capacities are inextricably linked to non-technical ones (i.e. cultural, ecological and sociological factors: Richards 1985, 1986; Moock and Rhoades 1992). In this way "ITK" (indigenous technical knowledge, ed.) becomes "RPK" (Scoones and Thompson 1994)[2]

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[2] This is a broader definition than the production-oriented definition of "Indigenous Technical Knowledge" (ITK) (IDS 1979) and "Indigenous Agricultural Knowledge" (IAK) definitions (Bebbington 1989). The acronym "IK" for indigenous knowledge

Local knowledge is often defined in contrast or in comparison to scientifically based knowledge. Defining local knowledge this way is not meant to rate it inferior to science-based knowledge. It rather serves to emphasize local knowledge as emerging from a different set of processes.

Experience is an important phase for both but its characterization and limits differentiate them (Reichel. pers. comm.). Within farming systems research circles it has for some time been argued (Richards, Chambers, Fujisaka, Ashby...?....) that farmers experiment, and that some (a few?) of these might be called farmer scientist (Aron,S Auge, Bahuchet et al 1993), but where the function of the scientist is to dedicate full-time in the search for new knowledge through methods of verification (or falsification), standards, and the rigors of conceptual and technical procedures, most local knowledge seem to develop, while the local person is doing something else, drawing upon experience with similar problems. Local knowledge is thus generated differently and the processes leading to the generation of local knowledge must therefore be studied where they occur, i.e. in the location of production and reproduction of knowledge.

Local livelihood systems include practices as different as: spiritual and religious ceremonies, production techniques, sports and art etc. Different needs and conditions correspond to each of these practices. This provides us with a wide range of options for studying local knowledge, both theoretically and empirically. Within the broad concept of rural livelihood systems, we are going to focus on production and, more specifically, on agricultural production. This focus is motivated by a variety of reasons the prime being a wish to contribute to the understanding of the beneficial role local knowledge play in developing and maintaining biological diversity. Agricultural production has often been related to reducing biodiversity, which might be correct mainly in industrial and larger scale agriculture. In small-scale agriculture (Wood 1992) and in shifting cultivation in tropical rain forest (Balée 1989) human and other disturbances to the ecological conditions, such as domestication of wild species have actually increased biodiversity.

Several options for focusing can be thought of. One is to focus on a single crop or a plant family, another on specific production processes. Agricultural production both in the forest and on cleared land is organized into processes such as buying, swapping or collecting bred species, or their wild and weedy relatives; clearing, sowing, weeding, fertilizing, harvesting and so on. A third is to focus on categories of plants produced with a common purpose, such as food, fuel, forages, medicine etc. (Vickers 1984; Kainer 1991). While establishing the local criteria for either approach we will simultaneously obtain an overview of production.

As we are interested in the ties between local knowledge and the organization of production, and the motives for the development and maintenance of such knowledge, the latter, which might be called a plant-use-category-approach, is to be preferred.

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is similar in content to RPK, but leaves the reader with the confusing difference between the definition of "indigenous", which means of local origin when referring to knowledge, and "suppressed, colonized" when referring to -peoples (ILO).

To understand how and why local knowledge on plant genetic diversity is developed and maintained you need to focus on where the plant-material is collected or obtained, whether it is domesticated, how this is achieved and for which purpose (use). A plant-use-category provides a better frame for these kinds of questions than the production-process-approach, because it covers questions related to the end-product (use), to the societal organization of production (gender, age, socioeconomic status, etc.) as well as to the production processes necessary to produce the product.

Times of transition or conflict provide good options for studying aspects of the livelihood that are otherwise tacit, including knowledge (Giddens 1984). This is because people will be more aware of the changes they are confronting, so their knowledge and the processes through which it is generated, maintained and communicated, become more explicit. Like any other form of knowledge, local knowledge must always confront other knowledge systems. Innovation and creativity operate on these "battlefields of knowledge" through contest and assimilation (Long and Long, 1992 from; Scoones and Thompson, 1994).

Working from the hypothesis that social, economic, geographical and other conditions impinge on the development and maintenance of local knowledge, we need to select sites and/or local persons exposed to different conditions.

The focus on production via the use-category approach within the above mentioned thesis provide an idea of the issues on which to focus our attention. But so far we haven't touched upon, whom we are to direct these interviews.

It has been argued that knowledge might well be shared and developed among people sharing similar conditions or experiences. Nevertheless, it is kept, or stored on an individual basis (Havelock 1986; Röling 1989). Thus, when collecting knowledge this points to a research strategy orientated towards individuals. But local knowledge is not necessarily equally spread or shared out. Categorizing local knowledge as primarily experience-based, means, in the case of production, that its generation might depend upon how work within production is organized. Gender and age are often found as factors that condition a division of labor within the household, while socio-economic status often conditions involvement in different types of production. Ethnicity is also seen to affect both of these aspects of the organization of production especially in a multi-cultural country like Colombia where the case material (see chapter 4) to this paper is collected. Thus the social and material dimensions that are considered, on a subjective basis are: gender, age, socio-economic status and dominant production system. These are the selected 'dimensions' relevant to this research strategy.

3. The Study of Local Knowledge - A Five Step Research Strategy

We investigated what lead to development and maintenance of local knowledge; which actors and relations in the community are important in this sense; and how this might be changing over time. To do so, we have to join different information gathering techniques.

These tools are described in the following five steps.

3.1 Identify Study Area and Research Sites - A Mapping Exercise

A study area is chosen on the grounds of a desk study. The conditions vary for each researcher. Time and costs provide natural constraints. Other factors though are of equal importance, such as institutional back-up and informed consent from local and other authorities.

Once arrived at the study area, the first step is to select one or several sites appropriate to pursuing the objectives.

As mentioned one criterion for selecting sites is that the households in the sites selected represent different conditions in terms of production systems. The presence or lack of influence from for example a forest-based knowledge system upon an agriculturally based system and vice versa may affect the use of plants.

The villages are selected by mapping inhabitants and other actors and their production systems on a **hand-drawn map**, with the help of an local person. Census, or similar data concerning the number of households and inhabitants are taken into account, in order to limit the choice to villages with a substantial number of households, to ensure the presence of a varying range of potentially important "dimensions", such as gender, age and socioeconomic status.

3.2 Local Knowledge over Time - Interview Elders

By asking into changes in the management of natural resources over time it is expected to obtain insight into the changing conditions for the development of local knowledge. For this purpose we will interview a few elders from each village, selected on the basis of gender and social status.

The following subjects should be covered in the interviews, as they will contribute to the understanding of current management of local natural resources:

- Changes in migration (demographic pressure on resources) can have lead to intensification of the use of resources, and/or moved the agricultural frontier and/or to the introduction of new knowledge on management of local resources.
- Legislative measures changing the use and access to resources
- Infrastructural development providing easier access to the market can affect consumption patterns etc. and thereby impact upon the use of natural resources.
- State or NGOs entering or leaving the stage can have had influence upon the use of natural resources
- Major plant diseases (pests) or natural catastrophes can have lead to significant changes in agriculture.

3.3 Social Status and Local Knowledge

- Preparing for Understanding the Relationship Between Socio-economic Status and the Development and Maintenance of Local Knowledge While Enabling a Check for Bias

It is not always easy to divide people by socioeconomic status, because by which criteria do we categorize and divide? In the following, a rapid appraisal technique (Grandin 1988) will be presented with the intention of understanding and ranking people according to local criteria for well-being. The results of this ranking exercise will enable the selection of local persons by level of well-being and thereby serve as an instrument for controlling bias for or against particular social categories in the selection of key informants.

Undertaking a well being ranking using cards

Conducting a well-being ranking requires the identification of a well-defined community or neighborhood, small enough for people to know about each other's level of well-being and large enough to encompass differences (between 40-100 'units', e.g. households). Within the selected community, the households to be ranked should be properly defined. A list including all households in the community should be prepared, taking great care that it is exhaustive. Three to five local persons are then asked independently to rank the households by placing slips of paper, each representing an identified household, in piles according to differences and similarities in well-being. The local person is asked to make at least three piles. If one pile should contain more than roughly 40 percent of the households, the local person should try to divide it. When the local person feels satisfied with the piles, he or she is asked to characterize each pile of households — the ways in which households in the pile resemble each other and the ways in which they differ from households contained in the other piles. These criteria are carefully written down. The piles are numbered from 1,2,... to 'P', where P is the total number of piles made by the local person, in descending level of well-being so that pile 1 includes the households enjoying the highest level of well-being, etc. For each household, the pile to which it has been allocated is noted in order to allow for later comparison between the individual rankings. A score, 'S', is calculated for each household indicating its position on the 'well-being scale'. S is calculated as the average of the scores obtained in each of the individual rankings, $S_1...S_x$, 'x' being the number of rankings. These scores are calculated by taking the number of the pile to which the household is assigned, 'p', and dividing it by the total number of piles made by the local person, 'P'. To avoid operating with decimals, this figure is multiplied with 100. The formula for calculating the scores $S_{1...}S_x$ is then $S_{1\rightarrow x} = p_{1\rightarrow x}/P_{1\rightarrow x} * 100$.

On average, a ranking with one local person takes about half an hour. Within each community, it is advisable to carry out at least three rankings with different local persons in order to allow for later comparisons both with respect to how each household has been ranked and the criteria used by the local persons to describe the categories.

Obviously, the most crucial stage in the well-being ranking is the explanation of its purpose and a proper translation of the term 'well-being' which is a neutral concept in the sense that it does not imply any specific components or elements. In explaining the idea, general phrases like 'living a good life' can be used whereas giving specific examples of what *could* define the level of well-being must be carefully avoided. On the basis of the individual rankings, an average well-being score is calculated and the final well-being categories are established (Ravnborg 1996).

The ranking enables us to ensure that all levels of well-being are included to help selecting local persons for the subsequent exercises. Selecting the local persons from the top, middle and bottom end of the well being ranking makes the researcher more independent from the contact- or support network. It is often seen that the local leadership is held by the those who have wider intellectual and/or economical capacity, the local elite. When someone from the outside (a researcher, for instance) approaches the community via formal links, it is probable that he/she will be lead around the leaders network. This underlines the importance of being able to check whether such leadership represents the agendas, and in this case different production and knowledge systems, of the different interest groups within the community, or may indeed exclude particular groups (Ashby et al 1995)

3.4 Production Systems - Farm Walks with Selected Local Persons

The aim of undertaking the farm walks is **first** to make an inventory of significant use-categories and useful plants according to local perspectives and criteria. The information is organized according to use-category and level of well-being in a matrix format which provides an overview of production. **Secondly** the aim is to gain insight into the organization of production and to identify knowledgeable people on plants contained in different use-categories e.g. farmers, charcoal burners, midwives, etc. **Finally** we intend to establish a picture of the historical flow of significant plants according to local criteria.

For the farm walks local persons from different households are selected from each village based on differences in age, gender and socioeconomic status.

During the walk around the fields and house gardens of each of the farmers, he or she is asked to explain the name, use and variation within and among the species. Particular problems in the cultivation of these plants must be addressed open-ended concerning pests, soil and water conditions and/or place and method of acquisition (e.g. market, neighbors, family, forest etc.). Furthermore, we explore the organization of production at household level with questions such as: Who collects plant material? Who sows? Who weeds? etc. Where are these work functions taking place? When during the week and over the year are they performed? etc.

3.5 Local Knowledge Related to Use-categories In-depth Interviews with Selected Local Persons

The criteria for selecting use-category will principally be determined by the research objective. In this particular project where changes in knowledge generation and maintenance are in focus, it is important to choose a use-category that includes households from both of the two different knowledge systems. We also need to ensure that the choice of use-category provides possibilities for estimating the influence of the other mentioned dimensions to the development of knowledge.

The objective of this last exercise of in-depth interviews are:
(a) to further understand how people seek, generate and use knowledge for a particular purpose and (b) to further understand what motivates rural people to develop this knowledge?

a. In order to try to understand how people seek, generate and use knowledge about the plants within the chosen use-category, the following topics and questions are to be addressed:

Questions into the actions

- What is the name and use of this plant?
- When you are in need of a plant with a certain effect, and you don't have it in your garden, where do you seek it? (Which concerns the flow of plants to and from the use-category, among farmers and between farmers and market).
- Who collects new plants for such a particular purpose?
- Which problems arise growing this plant?
- Who deals with such problems?
- What do you do to the plant from when the seeds are collected and sown till the plant is finally harvested and used?

Open-ended questions are used to ensure that ideas are not imposed upon the local person (Patton 1990). In order to make the situation as concrete, comfortable and precise as possible, these questions should be asked at the local person's farm, while he or she is handling the specific plant. The interviews can either take place where each plant is grown, or in order to save time, at the farmers house provided he or she has brought samples of the plants to the house. Sometimes repeated questions and visits are required to produce a complete inventory of useful plants within a use-category.

b. Understand what motivates this use and generation of local knowledge?

Questions into the reasoning

- Why do you grow this plant? (Which criteria are important for breeding and domesticating, i.e. choosing one plant variety or species and not another).

- Of all the plants you grow for the same particular purpose (the use-category), which do you like the most, and why?

- How do you deal with problems in growing this plant?

- If the problem cannot be solved by you, what do you do?

- Can you get products from the market with the same effect as this plant?

- If yes, why then do you grow it? (Which is the competition between products/technologies being "science-based" and/ or brought from the market on one hand and traditional products/technologies on the other hand).

The questions should to the extent possible be asked in relation to experiences/problems farmers have, enquiring about how they deal(-t) with these.

4. *Local Knowledge in La Cocha, Colombian Andes*

As mentioned, studying local knowledge should be undertaken in the context where knowledge is being developed. Therefore it has been the intention to employ the developed research strategy in a suitable area influenced by contrasting livelihood- production- and knowledge-systems. In our case, Laguna La Cocha was found to satisfy these conditions, due to the presence of two interwoven production systems; one being primarily an extractionary, forest-based production system and the other primarily being an agricultural production system.

The aim with this chapter is thus, to present insights gained during fieldwork concerning the processes of developing and maintaining local knowledge using the above methodology. But rather than drawing the attention to the data in the following tables[3] the intention is to indicate conclusions while pointing towards interesting correlations.

Fieldwork was undertaken during 4 visits of 2-10 days duration between november 1994 and february 1995.

4.1 *The Study Area and Sites*

The hydrographic watershed (basin) of Laguna La Cocha, also referred to as Lago Guamuez forms part of the grand basin of the Amazon. La Cocha lies 23 km east of the city of Pasto, capital of the Department of Nariño, in the southernmost of the Colombian Andean mountains.

At the time of the Spanish conquest, the area was inhabited by some 600 Quillasinga people (Calle 1994). The present inhabitants do not consider themselves indigenous and speak only Spanish. Because of the homogeneous population, ethnicity wise, this potential dimension can be considered constant. We will therefore not look into the role of ethnicity for the development of knowledge.

Within and around the Andean forest margins[4], where Laguna La Cocha is situated, the livelihood- and production systems, as well as areas with high both wild and cultivated biological diversity are not only relatively more threatened by population pressure, road construction and the rapid expansion of the agricultural frontier, than in for instance in the lowlands. Such montane forests may also be the home of most of the biological diversity of the neotropical countries even though they cover much smaller extensions than those of the lowlands (Forero, 1993).

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[3]The sample is limited to 12 cases in the tables. This amount does not statistically justify such correlations.

[4] Forest margins, in this context, include both the agricultural frontier and the standing forest bordering this.

Out of the 18 villages bordering La Cocha two were chosen. Santa Teresita, with a significant number of the households involved in forest-related activities, thus frequently accessing the forest, and Romerillo, with next to none working on a daily basis in the forest.

Santa Teresita has 68 households and a total of 347 inhabitants. More than half of these families (about 40) work full time burning charcoal and cutting wood. The rest are mainly dedicated to agriculture, including milk production.

Romerillo has 45 households, comprising a total of 215 inhabitants. Most households are dedicated to milk- and other agricultural production (mainly onion and potatoes). Previously people mainly lived from the forest i.e. timber and charcoal production (Calle 1994). Today there is only one family left in Romerillo which dedicate almost all its time to extraction of forest products.

4.2 Local Knowledge over Time in La Cocha

In the case of La Cocha, we learned, from local elders that the demographic pressure on the regions natural resources is related to both political and economic changes occurring during the last century. Large parts of the area belonged to the University of Nariño who were contracting people for selective timber extraction. The legislative action of declaring land surrounding Laguna La Cocha "public uncultivated land", coupled with the scarcity of land in the neighboring villages led to a continuous flow of farmers and forest exploiters starting at the beginning of this century. The agricultural technologies the settlers brought with them have had a serious impact on the state of the natural resources. The lower parts of the land bordering the lake are principally used for agricultural production i.e. cattle, potatoes, onions and cabbages while the upper parts (the moors) serve principally for forest-related activities (timber and charcoal). As the forest, at that time reached the edge of the lake, the first type of agriculture was "slash and burn". When the agricultural frontier moved upwards, some people intensified agriculture close to the lake by applying increasing amounts of inputs including labor, while others remained in the forest related activities. Many of the latter brought crops and other plants with them into the forest, to be planted in the clearings.
The forest resources become scarcer, and there seems to be a process of transition from the very hard work in the forest, towards the "lighter" but risk prone agriculture. Local NGO and state rural development organizations have also had an impact on the utilization of the natural resources, although more in agricultural production-based villages like Romerillo than in the forest extraction-based villages like Santa Teresita.

4.3 Social Status and Local Knowledge in La Cocha

In La Cocha this exercise provided us with a broad understanding of key socio-economic differences within each of the two villages as well as a ranking of all the households. Both has been useful for selecting local persons for the following exercises, avoiding social biases.

The purpose with this exercise was to provide the instrument to understand whether local knowledge is distributed broadly or if it specific to different social categories. It is still premature to make such conclusions.

4.4 The Production Systems in La Cocha

In the case of La·Cocha, the interest was mainly, via this exercise, to obtain enough information concerning how mentioned dimensions (age, gender and socioeconomic status) influence upon the organization of production and into which use-categories production can be divided. The principal aim being to prepare for depth studies. Therefore only eight farm walks were carried out.

The result of these farm walks, in terms of overview of production and plant-use-categories enable us to make an extensive inventory of significant use-categories and plants from local perspectives. Although we did acquire information about the origin of the most significant plants it was not possible to establish a picture of the historical flow of these by this technique.

By choosing the eight households according to mentioned dimensions, it was possible to get some insights into differences and similarities with respect to the state of knowledge between the different segments of the population concerning the management, conservation and flow of plants. But these are not more than hints so far. It was difficult to separate the information, as only well being and village were controlled. This emphasize the need to focus on a limited part of production - in this research strategy the use-category.

4.5 Knowledge Related to Use Categories in La Cocha

In La Cocha, half the population in one of the villages depend on charcoal production, and many of them don't have access to agricultural land apart from a small house garden, or they have land of very poor potentials. For this reason, it was necessary to choose a use-category which was relevant both to households dependent on the agricultural production system as well as households dependent on the forest-based production-system. From the farm walks we experienced that all households seemed to be using medicinal plants. The latter exercise also showed that the management of this use-category is largely the domain of women. This provides a good opportunity to hold the gender variable constant by only interviewing women during this final phase. As mentioned ethnicity is considered a constant by people in the area around Laguna La Cocha. The interview schedule for the last stage can now be set, including young (20-35 years) and older women (36-) from each of the well-being categories and villages. We chose to conduct 12 in-depth interviews (that is with 2 young and 2 old from each well-being category, 6 from each of the villages). From the fifth step we have a close to complete inventory of significant plants used for remedial purposes by the 12 local persons. These amounts to 78 different plant species[5]

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[5] Both in the farm walks and the in-depth interviews in step five, we only requested information concerning the used plants situated within the fields and house gardens of the household. This might cause a bias in terms of number of plants per informant. After the farm walks were carried out we understood that people having daily access to the forest, collect plants there when they need them instead of domesticating these, because they don't have time or proper land, or as explained "the plants

(Table 5).

We have collected information concerning the most important uses, each of the local persons have for each plant, according to local criteria. These amounts to 43 remedial sub-use-categories and 5 additional use categories[6] (Table 6).

We also know whether the plant was domesticated or not. And if it was domesticated, we know more about from where or whom these plants were collected (eg. from the forest, the pastures, their grandparents, from other family, the neighbors, from a local herbal doctor or marketplace)(table 6).

Apart from the local person's gender and village we know their approximate age and where they currently are in their "life cycle"[7].

The data obtained via step 5, organized in the following tables, is based on ordering every local person (case) by every medicinal plant, its use(-s), whether it was domesticated and if so, where it was collected, into a matrix (Lotus), after which the cases are arranged according to age, village and well-being category[8] and finally worked on with a statistical processing package (SPSS).

Reasons to maintain and develop local knowledge on cultivated plants

Let's first look at a few examples from the study area which highlight several of the central motives and processes leading to generation and maintenance of local knowledge.

The first example is a farmer from Romerillo. When he experienced some stomach problems, he went to a doctor in town, and was send to buy some pills. The medicine helped, but after a month he had taken all the pills. He couldn't afford another trip to town nor the medical expenses, and the pain returned. His daughter took advice from her girl

are jealous" which means that they can't be domesticated, presumably for ecological reasons. The bias is thus more likely to affect the results in favor of the farmers who have no or little access to the forest (farmers from Romerillo and farmers from the higher well-being category of Santa Teresita who were found not to work in the forest).

6 This is an extraordinary high number of plants and sub-use-categories compared to similar places (Padoch and Jong 1990).

7 Life-cycle group 1 are women from 20-35 years of age who live with their parents.
Life-cycle group 2 are women from 20-35 years of age living in own household.
Life-cycle group 3 are women above 36 years of age.

8 WBC1 is the higher well being category, WBC2 the middle well being category and WBC3 is the lower well being category.

As the wbc-data are collected on a context-specific basis, it is actually not possible to compare these, or even construct a common wbc category across the two villages (without taking further steps, see Ravnborg 1995), because the wbc2 of Santa Teresita might be more similar in level of well being to wbc3 of Romerillo than it is similar to wbc2' of Romerillo.

friends, upon which she collected plants from her garden and the grazing fields, and started experiments with some different blends of herbal tea. The father got better, and the girl learned from her social networks and from experimenting.

The second example[9] is from Santa Teresita where two wood cutting/charcoal burning families helped each other out, drawing on experiences developed in two different knowledge-systems. Family "A" has been working in forest related activities for several generations. Family "B" has recently settled in Santa Teresita, coming from a densely populated agricultural community, with a highly diverse agriculture. The families work close by each other, about one and a half hours walk from Santa Teresita. Due to lack of money to send their children to school, they have to bring even small children to work. The two families have become friends.

Family A have lived from the income of a purely extractionary economy, so they buy almost everything they need for food etc. They feel trapped in a debt bondage, as forest resources are getting scarcer, their income is decreasing and prices on the food items have increased. Family B introduced cabbages and onions to family B, to be planted in the remains of the charcoal production. Here the soil is fertile and all pests are burned away.

Family B is, as mentioned, now living and working in an area with very different ecological conditions and a different production system, than the agricultural land they, due to scarcity, had to abandon. They are contracted laborers, have very little money, and are not used to the cold misty mountains they've entered. So the children are often sick, and in need of remedies. The family know very little of useful plants in the forest, and had it not been for their friendship to family A, who uses a wide range of medicinal plants from the forest, they would have needed to buy expensive medicine.

Plants that in this way substitute goods from the market seem to be preferred by many, even when these goods are within (physical and economical) reach.

Though one general motive revealed in the two communities for maintaining or increasing biological diversity is related to economic gains or constraints linked to the conditions of risk prone agriculture or the extractionary and labor intensive charcoal production, it became clear, during fieldwork that the motives were manifold. People would collect and/or domesticate and/or breed species with purposes as varied as taste, nutrition, remedial effect, drought- or flood resistance, pest control etc.

I noticed a very broad basic knowledge concerning the useful effect of many plants across gender, age, well-being and village, particularly within the different knowledge (in this case production-) systems. What seem to determine how this knowledge is put into use rather depend upon money; social relations or physical access (or no access) to plants or substituting goods from: the market place; the forest; at the pastures or from elsewhere. Limits to these types of access (i.e. monetary and physical) is often dealt with through social networks, such as friends and family, as we can see in the above examples.

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9 The example was in fact collected during a farm walk, and should have been presented there. But it serves well to discuss the processes of developing, transmitting, changing knowledge, which is why I've chosen to use it here.

We've seen that people from La Cocha handle several knowledge systems at the same time. Socioeconomic and cultural conditions seem to be important factors when people make a decision. They might employ knowledge generated from one or another knowledge system.

The ability to always be able to tackle unforseen events, such as shortage of monetary means or food supply, human and plant diseases etc., with a large variety of species is highly treasured in both Romerillo and Santa Teresita. Diversity is thus, by several of the persons interviewed at La Cocha perceived as a means of flexibility to safeguard a continuous flow of plant genetic resources.

So what do people do at Laguna La Cocha to obtain, develop and maintain knowledge concerning plant genetic material?

Considering the results from the fifth exercise, it turns out that most women collect plants for domestication. From the interview we learned that successful domestication of plants depends upon experience with and/or access to information concerning soil quality, -humidity and -structure as well as exposure to light/shade, pests, inter-cropping and water. To exemplify this point we could mention that a few women from the case area have covered nurseries above ground, where they control light/shade, water and nutrients.

It seems that more plants are being domesticated from the forests close to Santa Teresita, which is no surprise as half of the population have daily routines around and in the forest, than it is seen from the forests around Romerillo.

The importance of close personal relations to obtain plants and information which was stressed during almost every interview and farm-walk, is also supported by the information in Table 4. About half of the plants are collected from relatives, and almost two thirds from relatives and neighbors combined.

It seems that the highest number of plants are being used by the younger women. This could be explained by the presence of the local NGO "Asociacion Para el Desarrollo Campesino", which undertakes workshops on use and conservation of genetic resources. These women, as opposed to the elder generation, collect their plant material to a higher degree from herbal doctors, pasture fields and (quite obviously) from their grandparents. The older women (over 36 years of age) domesticate more plants from the forest, in percent of their total amount of domesticated plants than the younger generation. This can be explained with the apparent move from the forest related activities towards agriculture which necessitate domestication to save time on transportation.

The case generally showed that the women treasure their knowledge (every woman has several plants although many has no significant land (some only 3 by 3 meters!). The knowledge on medicinal plants seem to be very persistent, it is not influenced in a significant degree by external agents of change, and is furthermore enhanced frequently by the younger women.

An interesting observation is that it seems that people from the region collect plants for domestication, while undertaking other activities, such as while visiting friends, on the way from work etc. A point for further research could be mapping these activities over time to explore whether the plants will be collected even though the other activities ceased. This should say something of the "consciousness of the act", the necessity of the plants and sensitivity to societal changes.

Table 1. Description of local persons according to village, well-being, life cycle, number of medicinal plants used and number of uses per plant

Local person	Village	Well-being category	life- cycle category	Number of medicinal plants	Number of uses
1*	Romerillo	high	1	18	39
2*	Romerillo	high	1	34	61
3	Romerillo	mid	2	15	16
4	Romerillo	mid	3	16	29
5	Romerillo	low	2	12	14
6	Romerillo	low	3	14	16
7	S.Teresita	mid	1	15	29
8	S.Teresita	high	3	4	9
9	S.Teresita	high	1	9	12
10	S.Teresita	low	3	7	8
11	S.Teresita	mid	3	10	10
12	S.Teresita	low	2	8	12

*There is one factor that distorts the picture a bit. To of the local persons, cases #1 and #2 have been actively engaged with a local NGO, working with conservation and development. This work has inspired them to, in their private life, explore the medicinal plants of the region. They rank both clearly the highest in the number of plants used, and the number uses they dedicate to each plant. They both fall into life cycle category 1 and well being category 1 and thus represent both a social- and life cycle-category with better time and resources than other categories to participate in activities, such as working for the ngo. As they both live in village 1 they influence heavily on the results as seen in this and the following tables.

Table 2. Average number of medicinal plants used, uses and uses per plant by village and life cycle
Number per local person

	Romerillo	S. Teresita	LC1	LC2	LC3	Total
Average number of plants	17.3	8.0	17.5[10]	13.0	9.0	12.7
Average number of uses	27.3	12.0	29.3	20.0	12.0	19.7
Average number of uses per plant	1.5	1.5	1.7	1.5	1.3	1.5

[10] Because of a high standard deviation and the few cases it is not possible to draw conclusions of correlation neither in this case nor in the ones to follow.

Table 3. Medicinal plants collected to be domesticated in percent of medicinal plants grown by village and life cycle

	Romerillo	S. Teresita	LC1	LC2	LC3	Total
Plants collected	71	98	85	68	94	85

Table 4. Place of origin of domesticated medicinal plants in percent of used medicinal plants by village and life cycle

	Romerillo	S. Teresita	LC1	LC2	LC3	Total
Forest	9	29	13	18	33	23
Pasture	11	4	15	4	0	6
Grandparents	26	8	25	18	4	15
Neighbors	23	7	15	8	13	11
Other family	20	41	6	45	47	34
Herbal doctor	11	11	15	9	4	11

Table 5. Local and scientific names of medicinal plants, from Romerillo and Santa Teresita, Nariño, Colombia.

1.-	AGUANUCO	40.-	HIERBABUENA
2.-	AJENJO	41.-	HORTENCIA
3.-	AJO CIMARON, *A. Sativum*	42.-	LENGUA DE VACA, *Rumex crispus*
4.-	ALCACHOFA, *Cynara scolymus*	43.-	LLANTEN, *Plantago ecuadorensis*
5.-	ALCAPARRO	44.-	MALVA ALTA
6.-	ALFALFA, *Medicago sativa*	45.-	MALVA DE MONTE
7.-	ALTAMIRA	46.-	MALVA O. (Hoja)
8.-	AMAPOLA BLANCA, *Papaver somniferum*	47.-	MALVA TENDIDA
9.-	APIO, *Apium vulgare*	48.-	MANZANA VERDE
10.-	ARRACACHA, *Arracacia xanthorryza*	49.-	MANZANILLA C., *Anthemis nobilis*
11.-	BERBENA	49.-	MANZANILLA D.
12.-	BERRO	50.-	MANZANILLA PEQ.
13.-	CALENDULA	51.-	MARIHUANA, *Canabis Sativa*
14.-	CEBOLLA BLANCA, *Allium cepa*	52.-	MEJORANA, *Origanum majorana*
15.-	CEDRON	53.-	MENTA, *Menta crispa*
16.-	CHILLACUAN, *Carica candamarcensis*	54.-	MENTA CHICLE
17.-	CHOCHO (Pepa)	55.-	MORA DE CASTILLA, *Rubus glaucus*
18.-	CHOCLO (Pelo de)	56.-	OREGANO, *Origanum vulgare*
19.-	CHULCO	57.-	PACUNGA
20.-	CHURILLO	58.-	PAICO, *Chenopodium ambrosoides*
21.-	CILANDRO	59.-	PEREJIL, *Carum petroselinum*
22.-	CIPRES EXTRANJERO	60.-	POLEO, *Satureja brownei*
23.-	CLAVEL BLANCO	61.-	REMOLACHA
24.-	COL (Zumo de)	62.-	ROMERO, *Rosmarinus officinalis*
25.-	COL DE CABALLO	63.-	ROSA BLANCA
26.-	CRESPO	64.-	ROSA ROSADA
27.-	DEDOS DE NIÑO DIOS	65.-	RUDA, *Ruta graveolens*
28.-	ENELDO	66.-	SALVARIAL
29.-	ESCANCEL	67.-	SEGUIDORA, *Peperomia fraserii*
30.-	ESCORCONERA	68.-	SIEMPRE VIVA, *Peperomia spp.*
31.-	ESDRAGON	69.-	TEMBLADERA
32.-	FLORIPONDO	70.-	TOMATE DE ARBOL, *Cyphomandra betacea*
33.-	FRAYLEJON, *Espeleti sp*	71.-	TOMILLO, *Thymus vulgaris*
34.-	GALLINAZA	72.-	TORONGIL, *Mellisa officinalis*
35.-	GERALDIO	73.-	TORONGIL / CASTILLA
36.-	GONGONA	74.-	UVILLA, *Physallis peruviana*
37.-	GUAYAVILLA	76.-	VALERIANA, *Valeriana sp*
38.-	HABA (Flor de)	77.-	VERANITA (Flor de)
39.-	HABA (Hoja)	78.-	VIOLETA, *Viola odorata*

5. *Concluding Remarks*

The main points of this last part of the paper is to evaluate, to what extent the chosen research strategy can contribute to the understanding of how local knowledge is linked to local livelihood systems, and whether the methodology employed has provided in-sight into the processes of developing and maintaining local knowledge. Additionally, these general conclusions will be related, when appropriate, to the specific case study of two communities bordering Laguna La Cocha in the southern Andes of Colombia.

a. What did we learn from the research strategy?

The site selection exercise proved useful in the case of La Cocha as it provided a rapid appraisal of the management of natural resources in the area. Choosing the two villages, Santa Teresita with two present production systems i.e. agriculture in a forest extraction based economy and agriculture in an agriculture based economy, and Romerillo as a next to purely agriculture based economy gave ground for the exploration of local knowledge in different livelihoods with different dominant production systems. For further studies it would be useful with the inclusion of a village with only forest related activities. This would, other sources of "knowledge-system-intervention" being constant, help estimating the influence between the two production systems, concerning the generation and maintenance of local knowledge.

Having mapped the biophysical environment, including baseline data concerning size and dominant production system, the next step was to ensure that the role and impact of significant actors and developments upon management of natural resources were not misinterpreted or left out. Therefore local notions of significant changes over time are investigated with old people. As mentioned, working in La Cocha these interviews provided us with valuable information on changes in livelihood- and production systems, interventions from state- and non-governmental institutions. This has, needless to say, had major impact on the way natural resources have been managed. A more concrete way of interviewing, as in steps 4 and 5 are necessary to cross-check information given on plants and other sides of production, and in order to obtain the specific knowledge.

The third exercise is focussed on the question "who should be interviewed, and who should not". Employing the ranking technique is essential to estimate the potential importance of social status, or well being, for the development and maintenance of local knowledge. This serves as an instrument to assess whether knowledge is broadly distributed, or if it is specific to different social categories, as well as to age categories and gender. If it is broadly distributed, then the in depth interviews can be undertaken with any key informant, if not, then the interviews need to be directed at the relevant segments of the population.

In the case study we found that the knowledge of how to use plants (medicinal) did not vary much according to differing social status among women pertaining to the same production system. It rather seems that actually **using** this knowledge depends upon conditions such as lack of or access to monetary means, market and/or social relations (family, friends etc.). As in the example with family "B" who, due to scarce land resources, knew how to grow a highly diverse field for self-consumption, but when the conditions changed, and they moved to an extractionary economy, they stopped using a high diversity production strategy in favor of using family labor resources for the production of charcoal, thereby not using the knowledge they formerly obtained, developed and used. This is an important point, and a new variant of the distinction between what, in the introduction, was called "active and passive local knowledge". The active knowledge is by far the most easy to access, and is mainly what has been focussed on in this paper. Thus, in the case of La Cocha, social status might not be related to the **development** of local knowledge, but there might be some relationship between the **maintenance** of local knowledge and the social status, as this process seems closer related to the actual, continuous use of a plant.

The farm-walks provided a reasonable framework for choosing a central use-category giving hints on the role of the gender, age and well-being dimensions in the organization of production. More farmers (cases) would be needed interviewed to say something significant. The historical flow of plants sought for in this exercise proved too ambitious and time consuming, and is more appropriate in the last step of the research strategy. It can be argued that if the researcher is set on a particular use-category, crop, or other pre-determined focus on the use of plant genetic material, then this exercise might not be necessary.

The objective of the last exercise was to further understand how people seek, generate and use knowledge for a particular purpose and to gain insight into what motivates rural people to develop this knowledge?

Having found that local knowledge in La Cocha is as broadly distributed as it seems, which is a conclusion with the modification that it might change with use-category and place, there it might not be necessary to put such emphasis in level of well being, when it comes to investigating the development of local knowledge.

Using open-ended questions focusing on at particular plants revealed much about these processes and the reasons for doing so. This is discussed in more detail in section 4.5, and further examples of such processes are included in the video mentioned in footnote 1, and in the references.

b. And how can the research strategy be improved or modified?

Several questions springs to mind when it comes to improving the research strategy. Some has already been mentioned so I'll limit it to three.

One question is for example: Are the users and cultivators necessarily the most knowledgeable concerning the management and use of these, even when we limit ourselves to the local environment, or put in another way; **does use equal knowledge?** This is quite important as we are only asking into the problems of the plants people have in their productive area and refer to the mentioned problem of active and passive local knowledge.

This might be dealt with using the cards with all the names of the households made for the well-being exercise. It provides an opportunity to rank or identify knowledgeable people in a similar exercise, though with another focus. Thereby one can identify farmers who specialize in certain, knowledge developing activities, such as: green fertilizers; traditional pest control; farmers having many varieties of a certain crop; or persons having particular interest in medicinal herbs.

Another question which we haven't dealt with, mainly because of time constraints, is the communication of knowledge between production systems, i.e. **does the forest based system have an impact on the management of resources of the agriculture-based production system and vice versa?** As mentioned in the example with families "A" and "B" (see section 4.5) there is plenty of reasons to believe that they do have an impact on each-other, which is also in the spirit of both Long and Long (1992) and the post-structuralist emphasis on relations within and between structures. A closer focus on the different social networks people participate in would probably have contributed to the understanding of the networks importance between/across local knowledge system.

A third point for further studies is related to focusing on different work functions. It was originally meant to **conduct focus group interviews with farmers from the different work functions,** by which the use category was organized. This might, for example have shown that some men have a vital function in bringing back plants from the forest, and bring about a more comprehensive gender perspective to the study of medicinal plants in step 5.

TABLE 6. REMEDIAL PLANTS USED BY 12 WOMEN FARMERS IN ROMERILLO AND STA. TERESITA, THEIR USES, IF THEY WERE COLLECTED AND WHERE.

REMEDIAL PLANTS LOCAL NAME	HAS THE PLANT BEEN COLLECTED? X - NO Y - YES NUMBERS CORRESPOND TO NUMBER OF INFORMANT	WHERE WERE THE PLANTS COLLECTED? A FOREST B FIELDS C GRAND PARENTS D NEIGHBORS E MARKET F OTHERS FAMILY G HERBAL DOCTOR H OTHER I DON'T KNOW	1 ANAEMIA	2 ARTHRITIS	3 VAGINAL Bath	4 BRONCHITIS	5 CANCER	6 BRAIN	7 COLIC	8 COLIC MENSTROUS	9 PREGNANCY DIET	10 DIARRHOEA	11 HEADACHE	12 HEARTACHE	13 STOMACHACHE	14 BONEACHING	15 LEGS HURTING	16 EPILEPSY	17 FEVER	18 MOUTH BURNING	19 THROAT	20 BRUISE	21 FLU	22 LIVER	23 INFLAMMATION	24 NAVEL	25 WOUNDS	26 NERVOUSNESS	27 HEARING	28 EYESIGHT	29 PARASITES	30 STOP BLEEDING	31 SNAKE BITES	32 PNEUMONIA	33 PROSTATA	34 BURNMARKS	35 STOPS THE CHILL	36 RHEUMATISM	37 COUGHS	38 ULCER	39 VENA VARICE	40 WINDS	41 VITAMINS	42 ANIMALS	43 AROMATICS	44 SPICES	45 REST	46 MARKET
1 HUANUCO	2Y	2C																							2																								
2 ALIENTO	8Y - 8Y																									8																							8
3 AJO CIMARRON	12Y	12H													12								12								12																		2
4 ALCACHOFA	4Y - 8Y - 9Y - 12Y	4F - 12H	12						12						4,12																																		8,9,12
5 ALCAPARRO	2Y				2																															2													
6 ALFALFA																																																	
7 ALTAMISA	6Y	6D																																								6						
8 AMAPOLA BLANCA	1Y	1D											1				2								2																					2	2	
9 APIO	2Y	2C								2																																				2		
10 ARRACACHA																																																	
11 BERBENA	1Y - 10Y	1E - 10B																	1									10																					
12 BERRO	2Y - 6Y	2B													2								6																										
13 CALENDULA	1Y - 2Y	1F D - 2D			2		1			2												1																											
14 CEBOLLA JUNCA	1Y - 3Y	1F - 3C											3																				1						1							1,3		
15 CEDRON	5Y - 4Y - 10Y - 2Y - 7Y - 8Y	4I - 2D - 8C													6													2,8,10																	8,9			2,7
16 CHILLAQUIAN	2Y																														2															2		
17 CHOCHO (Pepa)	3Y	3D																																															
18 CHOCLO (Pelo de)																												2																					
19 CHULCO	2Y	2B																		2																								4				
20 CHURILLO	5Y - 4Y - 7Y	5H - 4F - 7C											4						4,5												7																	6
21 CILANDRO	2Y - 7Y	7C													2																7																	
22 CIPRES EXTRANJERO	7Y	2F																																							2							
23 CLAVEL BLANCO	3Y	3D											3																																			
24 COL (Gorro de)	3Y	3C																																						3								
25 COL DE CABALLO	1Y	1B																																															
26 CRESPO	11Y	11A - 12A																																															
27 DEDOS DE NIÑO DIOS																																				3													
28 ENELDO	5Y - 4Y - 8Y - 7Y	4F													4,5,8																											7						
29 ESCANCEL	5Y - 11Y - 4Y - 7Y	4C - 7C																	4,5,7																		6								11			
30 ESCORCONERA	6Y																																															6
31 ESTRAGON																																																	
32 FLORIPONDO	2Y	2B														2									2																						2	
33 FRAYLEJON	11Y - 2Y	2A - 11A													2														2								11											
34 GALLINAZO	8Y	8H																																								8			8			8
35 GERALDO	1Y																				1																												
36 GORDOBA	3X	3C																																															
37 GUAYAVILLA	11Y - 7Y	11A - 7A													11																																		
38 HABA (Flor de)						2											3																																
39 HABA (Pepa)						2																																											
40 HIERBA LUISA	5Y - 4Y - 10Y - 8Y - 12Y	4F - 10I - 12H													4,10,12													10			3,5,7,12														4	7		6
41 HORTENCIA																									2																							12
42 LENGUA DE VACA	2Y	2A																				2																											
43 LLANTEN																																							2						3			
44 MALVA ALTA	11Y - 3X - 7Y	3C - 11H - 7C																	3,7																													
45 MALVA DE MONTE	7Y	7A																																														
46 MALVA O. (Flor)	4Y - 8Y	4G - 8H													6													4																	4			
47 MALVA TENDIDA	11Y - 7Y	11H											7									7			7												7											
48 MANZANA VERDE																																																	
49 MANZANILLA C.	4Y - 8Y														3,8																																	6
50 MANZANILLA D.	1Y - 11Y - 4Y - 8Y - 12Y	8D - 11H - 12H							1	1	4				1,9,12		4						6		1	4				6												1						
51 MANZANILLA PEQ.	2Y																																				2							2	2			
52 MARIHUANA				2																																													
53 MEJORANA	5Y - 4Y - 8Y - 7Y																																												3,5,7	6		4
54 MENTA		8H													8,10																																	
55 MENTA CHICLE	2Y																								2																				2			
56 MORA DE CASTILLA	2Y	2C																																			2											
57 OREGANO	11Y - 4Y - 8Y - 6Y - 7Y - 8Y	4F - 11H - 8C									2				8,8,11,12								6																						3,5,7			2,8,9,12
58 PACUNGA	11Y	11H									11																																					
59 PAICO	5Y - 3Y - 10Y - 8Y - 7Y	5F - 3C - 10I													7,10													10			3,5,8,7															3,7		
60 PEREJIL																																8																
61 POLEO	1Y - 3Y	1B - 3B										1			1																														1	1		
62 REMOLACHA																																																	
63 ROMERO	5Y - 2Y - 8Y - 6Y	2C - 5DJ															2											2,3									2,4,5									3		1
64 ROSA BLANCA	1Y - 3Y	3D																										2		1							2									4		
65 ROSA ROSADA	1Y - 2Y	2D																										1,2																				
66 RUDA	5Y - 10Y - 6Y - 7Y - 12Y	7C																																				8,12				6,7,10,12					2	4,12
67 SALVARIA		7C																																			7											
68 SEGUIDORA	1Y - 2X - 6Y	2G													1													3																	7			6
69 SIEMPRE VIVA															3												2		2							2												
70 TEMBLADERA	6Y	6A																					12																									
71 TOMATE DE ARBOL	2Y				2																																											
72 TOMILLO	1Y - 3Y - 6Y	3C - 6H																																	1										3,7	1,3,7		6
73 TORONJIL	1Y - 5Y - 10Y - 2Y - 8Y - 7Y - 6Y - 12Y	1F - 10I - 2C - 6H - 12H			2,12				1,12				5,8															10																	1,2,3			
74 TRONGIL / CASTILLA	7Y - 8Y	8C																										7,8																				
75 UVILLA	11Y - 12Y	11H - 12A													12																																	
76 VALERIANA	8Y - 8Y	8I - 8D														8												2	5,8																			
77 VERBANITA (Flor de)	1Y - 2Y	1D - 2C																			1																		2									
78 VIOLETA	8Y																						6																									

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