



FINAL REPORT

Project title:

A Network for Global Sustainable Mountain
Agricultural Development.

Organization:

International Potato Center (CIP) / The Global
Mountain Program

Duration of the Project: July 1996 – June 1998

Date of Reporting:

May 17, 1999



A. OBJECTIVES

General Objective

The goal of this project, in the broadest of terms, is to improve the management of natural resources in mountain agroecosystems, thereby contributing to the well being of mountain populations through increased agricultural productivity. Its principal objective is to establish coordination mechanisms that would enhance research and development capabilities to promote sustainability and improve the productivity of selected mountain agroecosystems.

Specific objectives

- To promote global collaborative links between research and development endeavors, to facilitate decision-making and resource allocation.
- To provide a reliable and easily accessible information exchange system for the sharing of results, methodologies, scientific information, provide means for monitoring results, and integrate the participating institutions and the knowledge gained in a holistic manner.
- To develop proposals for funding by donors other than IDRC to support priority research for mountain agricultural development.
- To develop monitoring mechanisms to assist in research and development efforts, and resource allocation.

This final report summarizes the achievements of the project. It is important to note that as stated in the objectives and given the magnitude of the grant, the funds were used as seed funds to attract other donors to support the global network created, and denominated the Global Mountain Program.

B. GLOBAL MOUNTAIN COORDINATION

The dilemma facing sustainable mountain agriculture is that whereas natural resources have to be used to their optimum potential, the current knowledge and capacity for using these resources on a sustained basis is limited. Considering the degree of variations of the environmental conditions and carrying capacity limits, a careful assessment of the process at work in most of the mountain regions of the developing world, is required urgently to design approaches to contain the unsustainability trends. By joining hands institutions can facilitate systematic gathering of knowledge to deal with these concerns of sustainable mountain development. Based on these assumptions, the leading institutions for sustainable mountain development in Asia, Africa and in the Andes, viz.;



The International Potato Center (CIP), the International Center for Research in Agroforestry (ICRAF), the International Livestock Research Institute (ILRI), and the International Center for Integrated Mountain Development (ICIMOD) and others made a joint effort to set up in October 96 the global mountain initiative on sustainable mountain agriculture development, identified as The Global Mountain Program (GMP). IDRC funding has been effective in establishing such links.

The terms of reference of this de facto consortium are:

- The GMP is a global forum for promoting and supporting research in natural resources management and sustainable agriculture production in the mountain regions of the world.
- The GMP is an institutional mechanism created for increased exchange of knowledge and experiences about sustainable development of mountain agriculture, among the three mountain regions - Asia, Africa and Andes.
- The GMP is based on common concerns and issues that cut across all three regions, for which strategic research programs could be developed.
- Recognizing diversity and distinctness among mountain regions, GMP supports independent development of natural resources management research programs in the three regions, Hindi Kush Himalayan region (HKH) in Asia, highlands of eastern and central Africa (EAH) and the Andes, through the existing regional program convened by ICIMOD, ICRAF, ILRI, and CIP and then share the generated knowledge and information with other partners institutions of GMP.

For the first phase of activities, the partner institutions have identified the following priority areas of research:

- Characterizing mountain agroecosystems
- Intensifying land use and natural resource management
- Exploiting biological diversity in a sustainable manner for economic growth, and
- Stimulating productivity and enhancing resource conservation through policies and public-sector investment.

The terms of reference for the studies being conducted and a few concept notes presented to potential donors are shown in annex 1.

Based on these priority areas, within each mountain area, the corresponding Center was expected to develop its own program activities and mechanism for collaboration.

- ICIMOD has concluded and reported the study on land policies and their role in land degradation in the HK-H Himalayan region. This research was co-funded by ACIAR



and the European Union. The research on characterizing mountain agroecosystems is expected to be concluded in 1999. A CD-ROM for practitioners, combining the results and methods developed by the research groups at ICIMOD and CIP will be produced under ICIMOD leadership. Funds to complete the integrated nutrient management study are being sought by ICIMOD.

- CIP budgeted US \$ 800,000 for the GMP in its Medium Term Plan from 1999-2001. It is understood that ICIMOD, ICRAF, and ILRI as Co-Convening Centers can also attract additional funding for the program. In this case, henceforth overheads would accrue to the Co-Convening Center, if it were successful in generating the resources for GMP. Therefore total resources in the Medium Term Planning Horizon 1999-2001 for the overall GMP in all regions may exceed 1,000,000 annually.
- Funds from SDC and the EU for the GMP add up to US\$ 400,000 for 1999 to conduct research in the EAH, HKH, and the Andes.
- On the institutional mechanism for implementing/coordinating the GMP it was agreed that Coordination will take place through a technical Committee comprised of the GMP-Coordinator and representatives of ILRI, ICRAF, and ICIMOD. The first meeting of the Technical Committee was held in Nairobi, Kenya in October 1998. A copy of the minutes of the meeting is presented in annex2.

C. AN INFORMATION SYSTEM FOR GLOBAL MOUNTAIN DEVELOPMENT.

I. Background

During the Mountain Forum NGO Consultation in Lima, in 22-27 February 1995, 110 mountain NGO representatives from 40 countries came together in Lima, Peru in a meeting organized by CIP, and The Mountain Institute (TMI). As result from this meeting, the participants agreed to create a Global Mountain Forum of NGOs and interested organizations for information sharing and mutual learning about mountain development. The nodes identified of this information system are CIP/CONDESAN (Infoandina) for Latin America, ICIMOD for Asia and the Pacific, and TMI for the global and regional organizations, making use of electronic and printed communication tools, and strengthening the capacity of benchmark sites with the development of human resources.

InfoAndina activities between 96 - 98

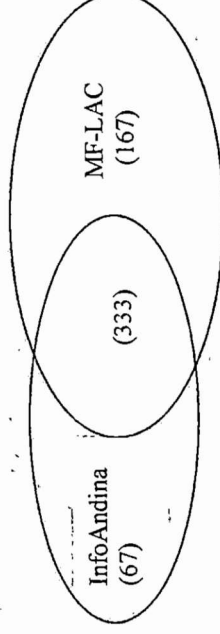
The Information arm of CONDESAN, InfoAndina, promotes exchange of information among its partners using low cost electronic communication facilities (E-mail, listservs and Internet).



Membership

InfoAndina uses moderated electronic discussion lists to facilitate the information exchange among partners: InfoAndina and MF-LAC.

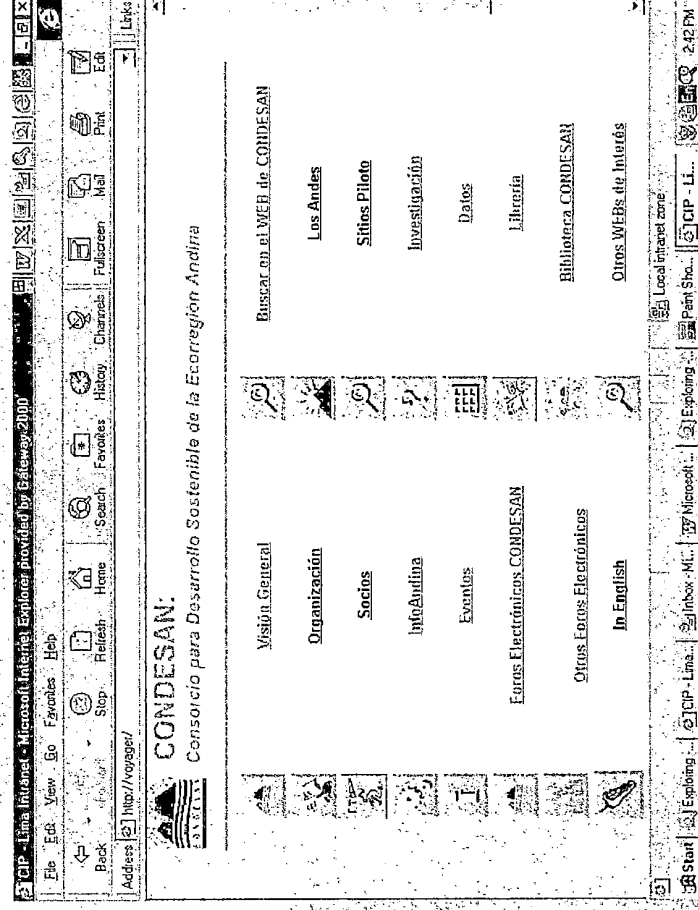
- **InfoAndina:** Used to disseminate electronic newsletters, InfoNotas and TechnoNotas to CONDESAN partners and people interested in sustainable development in the Andes (400)
- **MF-LAC:** This list hosts temporary electronic discussions among members registered to the Mountain Forum in Latin America (500 participants). The discussions are moderated by specialists in development and natural resource management issues.



WEB Page

InfoAndina is the Webmaster of CONDESAN. The WEB page includes the following sections:

- **General Overview:** This section stores the CONDESAN Brochure images and Text
- **Search Engine:** Allows full-text searching CONDESAN WEB
- **Organization:** Shows the organigram of CONDESAN
- **Partners :** This section lists CONDESAN partners by benchmark site
- **Benchmark Sites:** Includes a description of the location, research lines and partners working at each site.
- **InfoAndina:** Describes the activities developed by the Information Network of CONDESAN: Forums, bulletins, etc.
- **Data:** This section will contain georeferenced information from Benchmark Sites
- **Bookstore:** The main publications of partners supported by CONDESAN are exhibited here
- **Events:** A chronological list of regional events related to sustainable development in the region



- **Electronic Forums:** An electronic archive of the electronic conferences organized by InfoAndina
- **Other forums:** Links to other electronic discussions
- **CONDESAN Library:** A list of research results in articles edited by our partners at each Benchmark Site.

Electronic Conferences (Forums)

In order to facilitate the horizontal exchange of information (N to N) among partners, InfoAndina has organized electronic conferences since 1996. A methodology has been developed to conduct these conferences moderated by specialists in the main research lines of CONDESAN, who are located at different countries (e.g. Peru, Ecuador).

The electronic discussions are stored in the WEB pages and printed format. The subject moderators select the agenda, audience and contributors. The moderators receive technical support and training from InfoAndina to conduct the discussions.



Year	E-Conference	Moderator	Contributions	Participants
1996	Paramos & Punas Conservation	TMI-Huaraz	76	150
1997	InSitu-97 Conservation	CIP/CONDESAN	21	200
1998	Biosphere Reserves Conservation	CI-Peru	55	250
1998	Local Governments	AME-Ecuador	34	300

Table 1. Electronic conferences organized between 1996-98 by InfoAndina

Table 1 shows the title, moderator, country, number of submissions, and number of participants at the electronic discussions organized by InfoAndina since 1996.

Newsletters

InfoAndina promotes the edition of electronic newsletters to disseminate research results at CONDESAN benchmark sites. Presently, there are three newsletters edited in Cajamarca (El Cajachito), Carchi (Mesa de Concertacion) and Cochabamba (El Valluno) attached to this document. A sample is presented in annex 3.

InfoAndina edits six times a year an electronic newsletter of regional interest, and disseminates it to the 400 members subscribed to the InfoAndina-fm lists.

InfoAndina co-edits the Latin American section of the Mountain Forum Newsletter, published twice a year and disseminated to the registered members in the region.

D. SELECTED RESULTS FROM THE ANDES WITH GLOBAL IMPLICATIONS.

Incorporating indigenous knowledge in the research and development process

The incorporation of indigenous knowledge is of particularly importance in mountain settings due to their adaptation to such a diverse environment. A few studies have been conducted in the area to make comparable farmer's perceptions and scientific measures. The first study conducted in the Aroma Province of La Paz, Bolivia dealt with indigenous soil classification methods. This study, funded by IDRC and conducted by the Project "Sistemas de Producción en el Altiplano Boliviano" (SIPAB), showed a very close correspondence between farmer's classification and a physical-chemical characterization of the top layer of the soil. Farmers did not classify as accurately lower soil layers.

In a second study, financed by this project, farmer's knowledge on incidence and severity on risk in crop production was elicited. Direct elicitation gave comparable results to the



more tedious objective method of sampling yields over time. A summary of the risk study for potato production in the Altiplano is described in annex 4.

Using RS/GIS tools to make land management decisions

During the last three years the research teams at CIP and ICIMOD have been actively involved in developing tools to aid in the decision-making process for land management. Combinations of different tools are being tested in projects financed by different funding sources.

Two cases were selected to illustrate the progress in this area. Both summaries are described in annex 5. In the first case, software capable of integrating process-based crop and livestock models with GIS and remotely sensed data is presented. This user-friendly package allows researchers to evaluate land use option at different spatial scales and to ex-ante assess the expected outcomes in time.

The second case shows how the spatial data can be integrated into maps to make land management plans. The study presented constitutes an on-going effort of providing farmers and extension agents with a conflict resolution tool. A draft of an intervention plan as conceived by a development program or a local authority is presented to resource users for their discussions. Farmer's inputs are then incorporated into the plan and a new map is drawn and used to implement proposed changes.

Automated tools for land evaluation

A series of tools to support land management decisions have been either developed or adapted to the conditions encountered in mountain regions. The previous section referred to software being developed by our group to evaluate land use options and to monitor land use changes in data-scarce environments. These tools are greatly complemented with the automated land evaluation system an expert system developed by Cornell University (ALES) to evaluate land according to the method presented in the Food and Agricultural Organization "Framework for Land Evaluation"

Annex 6 presents a short description of the ALES program and describes an example of its use in the Andes. ALES uses the results obtained through modeling and remote sensing as technical coefficients to perform the land evaluation. ALES also has the flexibility of evaluating different proposed land-use systems. By combining ALES with a GIS e.g. IDRISI, the land suitability maps generated using different criteria (e.g. optimal management as appraised with models against farmer's beliefs) can be compared. It then constitute a powerful tool for the participatory management of natural resources.

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ANNEX 1. Terms of References for the Research Undertaken in the GMP and Concept Notes Presented to Selected Donors.

A. Characterization of Mountain Agro-ecosystem

Background

CGIAR-Global Mountain Program (GMP) convened by the International Potato Centre is a global research program for promoting sustainable mountain agriculture. As partner institution of this program the International Centre for Integrated Mountain Development (ICIMOD) based in Kathmandu, Nepal initiated some programs under GMP during 1996-98. Supported by Australian Centre for International Agriculture Research (ACIAR) one of the project activities focussed on developing methodology for characterising mountain agroecosystems. Taking the Hindu Kush Himalayan region as a test case. ICIMOD tried to develop the methodology both for regional and local use. The findings of the study are interesting and it was therefore decided by the Technical Committee of the GMP in Nairobi in October, 1998 that this work be widely shared in the form of a CD-ROM. In addition, TC-GMP felt that to strengthen it, similar work done by other agencies in Africa and Andes should also be included in this CD ROM.

Objectives of the study

Coordinated efforts to produce a CD-ROM on Experiences in Characterization of Mountain Agroecosystems. The aim is to document available methodologies used in different parts of the mountain regions.

Expected Outputs

Expected outputs are as follows;

- (1) Set of methodologies for characterization of mountain agriculture systems.
Outputs of these methodologies will be presented largely in series of thematic maps.
- (2) Outputs of the regional and local studies from the HK-Himalayan region.
- (3) Case studies from Africa, Andes.
- (4) CD-ROM

The Conceptual Framework of ICIMOD work

(Why work on characterizing mt agroecosystems?)

Mountain environment poses special challenges to the conventional development approaches, especially so for agriculture. The biophysical and socio cultural nature of mountains is characterized by extreme diversity. Remoteness and marginality of mountain areas further adds to data scarcity. The impact of vertical zones that shape agricultural resource management requires different analytical tools than the conventional two-dimensional analysis typical of flat land agricultural systems. The current knowledge and capacity for using these resources on a sustainable basis is limited. Therefore, a careful assessment is required for mountain areas in order to design approaches for sustainable use and management of resources for improving livelihoods of mountain farmers. Different institutions have been working in this direction, to gather knowledge and there may be scattered information available at watershed level and for local administrative use. But one more task is to evolve mountain specific methodologies, which can help capture potentials and constraints of agriculture development in specific agroecosystems. We know much about the work on agroecological zones but not much information is available about mountain agroecosystems. While the agroecozoning is and can be a part of the process to characterize mountain agroecosystems but agroecozoning of a region does not necessarily reflect all aspects of agroecosystems.

Many individual research projects have been carried out at different scales for characterization of mountain agroecosystems. Past experience in the research and data scenario is however summarized in the following realizations;

- The availability and collection of data is affected by historical, political, climatological, topographic and many other considerations.
- Sets of available and recorded data are often not comparable because of differences in scale and accuracy.
- The micro-scale differences are often more predominant than the macro scale differences.
- Heterogeneity of agro-climate and soil needs to be reduced to homogeneous region in broader scale.
- If not possible to map the extreme variability, then how to identify the range of characteristics encountered, is known.

These realizations lead to the following key questions:

1. How the agro-ecological diversity be described, measured, assessed and conceptualized to relatively homogenous region (the agroecosystem) where direct sharing of knowledge, experience, and technologies are relevant?

2. How does the biophysical and socio-economic condition shape the agro-ecosystems in mountains and how these relationships can be parameterized in a model?
3. How to determine the critical datasets needed for agro-ecosystem characterization and to bring them in compatible format?
4. What kinds of transformation of scale are available, to aggregate or disaggregate data in mountains?
5. What properties of physical and human systems are invariant with respect to scale and what are the problems that must be overcome in integrating data from different scales for characterization of mountain agro-ecosystem?
6. How can Geographic Information Systems (GIS) be coupled with other land resource to assess farming in mountains, as part of spatial decision support system (SDSS)?

Despite success of the classical land evaluation schemes in many cases, there still exist some fundamental problems while using them in mountains. The vast diversity of mountains both in terms of bio-physical and socio-cultural aspect make it extremely difficult to delineate homogeneous land unit where management and policy implications can be applied and compared. Those methods were implicitly developed as being scaled independent without taking into account at which scale the land use questions are most significant. While, in mountains, ecological 'homogeneity' is scale dependent phenomena requiring different data set at different hierarchical scale. Research questions (1) and (2) address this problem. Various statistical techniques are available which integrate GIS and Remote Sensing dataset to create cluster of homogeneous regions. Multivariate statistical/empirical models are available and developed to predict the contribution of various topographic and socio-economic conditions that shape the agro-ecosystems in mountains. The research should review these methodologies, which are currently practiced in different mountain regions. Moreover, although the importance of socio-economic conditions is acknowledged, little is done to take this condition into account. The classical procedure is entirely driven by land quality assessment techniques without allowing input from modern process-driven land research.

The methodological challenge in the process of characterization of mountain agroecosystems lies in the fact that there has not been one framework which identifies and correlates the different data sets available at different scales. Data for almost all aspect of mountain agro-ecosystems are heterogeneous in their scale, frequency of record, spatial coverage, and availability. The multi-scale data collection for the HKH region at different hierarchical levels is a complex process. Moreover, one of the problems in delineating agricultural systems in the mountain is the large number of interconnected variables that need to be handled, analyzed. The rigid classical procedure does not provide an alternative guideline for land evaluation in data scarce region. Question (3), (4) and question (5) will derive insights drawn from previous research questions particularly in this aspect. However, level of such study calls for substantial budgetary resources.

Land use planning at a macro level and its derivative recommendations appear to loose its significance when operationalizing the planning strategies in response to socio-economic demands of stakeholders. However, the problem becomes still complex when considered at the farm level. At this point it is important to study properties of physical and human systems that are invariant with respect to scale and the problems that must be overcome in integrating data from different scale for characterization of agro-ecosystems in the mountains. Any such study should aim at developing tools or system for decision-makers and planners. Traditional approach to rely on an empirical observation falls short of considering large number of factors that affects the homogeneity of the region and land suitability analysis. In order to meet this requirement an interactive spatial decision support system could be feasible for planning which gives multiple options to users in a graphic and spatial environment for land resource assessment. Question (5) relates the problems of scale with physical and human systems that are invariant with respect to scale. A logical flow in answering Question (5) would lead to Question (6), which identifies decision-makers, and stakeholders need in management practices and policy formulation.

ICIMOD's input in the CD-ROM

ICIMOD initiated work on methodologies to characterize the mountain agro-ecosystem in the Hindu Kush Himalayan region has collected large quantities of disparate spatial and attribute data of the HKH region., such as spatial units, projections, geographic coverage /formats needed for integrated projection. These baseline data have been assembled and then converted to 'value added' foundation through the processes of spatial interpolation, overlaying and simulations. In addition, experience from several case studies in different scale is assessed for multi scale characterization in the Hindu Kush-Himalayan region. The CD-ROM may include following things from it;

- Review of the agro-ecosystem characterization methodologies with specific application of multivariate statistical technique illustrated with different thematic maps e.g., Digital Elevation Model, Climatic and edaphic surface etc.
- Agricultural indicators for watershed or local administrative cum development unit which establish argo-ecological relationship with distribution of farming system variables.
- A predictive model for agro-ecosystem analysis in data scarce mountain environment.
- Case studies of specific issues critical in mountain regions e.g., site specific analysis of land degradation and poverty for understanding their relationships in the mountains.

Activities & Timeframe

<u>Activities</u>	<u>Q1</u>	<u>Q2</u>	<u>Q3</u>	<u>Q4</u>
1. Screening of past work in the respective regions to select few case studies relevant to the project				
2. Preparation of a review/position paper which will include details of the selected studies/especially maps				
3. GMP workshop to compare and assess the methodologies/ regional case studies				
4. Design and preparation of interactive CD-ROM in ICIMOD				
5. Beta-release of the CR-ROM for review				
6. Final release of CD-ROM for wider distributions				

Budget

GMP has allocated budget for ICIMOD to accomplish this task. The commissioned work in Africa and Andes will be seeking funds directly from CIP from CIP- GMP.

B. Intensifying Land Use and Natural Resource Management

Background

The Global Mountain Program (GMP) was created in 1997 as an umbrella institution within the CGIAR to coordinate research programs in the three major highland areas of the developing world. The GMP's goal is to enhance the ability to transfer technology within and across these mountain regions. It links the programs of CONDESAN in the South American Andes, ICIMOD in the Asian Himalayas, and AHL in the African highlands.¹

The sustainability of agricultural production in mountain settings is at the heart of the priority research area on "Intensifying land use and natural resource

¹ Acronyms: AHL = African Highlands Initiative; CGIAR = Consultative Group on International Agricultural Research; CIP = International Potato Center; CONDESAN = Consortium for Sustainable Development of the Andean Eco-Region; ICIMOD = International Center for Integrated Mountain Development.

management.” Central to sustainability is the role of human population growth. Two schools of thought offer opposite diagnoses and recommendations in the population – sustainability debate. The Malthusian school views population growth as threatening the limited capacity of arable land to produce food, shelter, and sustenance. By contrast, the adaptive intensification school (led by Boserup and Tiffen & Mortimore) views population growth as an impetus for technological and institutional change that can mitigate or even eliminate the effects of natural resource limits on economic well-being.

In order to design future research policy toward mountain regions, the GMP needs to evaluate the role of population growth and land use intensification in mountain regions. This note proposes draft terms of reference for coordinated research in this topic area.

Goal

To improve knowledge on land use intensification in mountain areas. Specific objectives include analysis of types, determinants and impacts of land use intensification. Lessons learned will be shared in the global context.

Expected Outputs

The following outputs will be generated by the time this research program is complete in 2001:

- (1) Case studies from two benchmark sites per region. Sites will have contrasting levels of population pressure and natural resource endowments in each of the three GMP regions.
- (2) A typology of land use intensification processes.
- (3) Impact analysis of how the types of land use intensification affect productivity, income, biodiversity, sustainability and equity.
- (4) Analysis of the driving forces causing land use changes.
- (5) Recommendations for research and policy initiatives to foster sustainability development of mountain regions facing demographic pressure.

Conceptual framework and methods

Key research questions are these:

1. What forms does land use intensification take in mountain areas?
2. What factors determine the form by which population growth affects land use?

3. What impacts does land use intensification have?

4. How sustainable are land use changes of different types?

5. What research or policy initiatives might mitigate problematic impacts?

Prior research has identified two general types of land use intensification (Reardon et al.). Labor-led intensification involves more intensive cropping and larger herd sizes with labor substituting for other inputs. In many areas, temporary increases in land productivity have been achieved at the cost of serious deterioration in quality of soil and sometimes water resources. Capital-led intensification involves capital investments in soil fertility, pest control, water management, and soil retention to increase crop yields. Analogous investments in forage quality, veterinary care, and breeding stock apply to livestock production. Examples exist of both sustainable and unsustainable capital-led intensification in land use.

Although individual research projects have been carried out in mountainous areas, no comprehensive lessons have been drawn across regions. The challenge to GMP research is to develop a research design capable of distinguishing between the particularities of individual benchmark sites and the common elements that can be generalized across mountain regions. Factors that should be controlled for (either by careful data collection or by formal stratification) include the following:

- Biophysical setting (elevation, slope, soils, climate, water availability)
- Prevalent farming systems (pastoral, agropastoral, crops; irrigation; traction power)
- Demographic pressure
- Asset availability and property rights (esp. physical & financial capital, including communal assets)
- Market access (inputs and outputs)
- Major environmental impacts (e.g., soil erosion, deforestation, water pollution)

Other underlying factors to account for include political stability and macroeconomic management.

Research questions (1) and (2) are best answered by statistical analysis of rural household survey data. By the nature of the research problem, a range of demographic pressures is important within each region (and ideally, within each benchmark site). GMP participants may wish to limit the variety of potential benchmark sites by agreeing upon a limited range of elevations, farming systems or natural resource problem types.

Research question (3) on intensification impacts may be addressed by statistical or biophysical simulation analysis (the latter depending upon the nature of the impact and the availability of suitable validated software). Impacts on income distribution and biodiversity lend themselves more to statistical analysis, whereas certain environmental impacts such as soil erosion or leaching of agrochemicals may be amenable to simulation.

Research question (4) on sustainability will be difficult to address. It implies a dynamic perspective to examine trends, their desirability and their reversability. These are best measured in a time series or panel study. In a cross-sectional survey they can only be inferred from recall data or else by simulation from the future projection current practices in a given biophysical setting. Remote sensing data may also be useful to identify changes over time, most especially in instances where it can be linked to natural resource management practices.

Clearly research question (5) on recommendations will derive from insights drawn from the previous research questions. If data collection practices can be sufficiently standardized across benchmark sites, it could be possible to conduct a statistical analysis of aggregated data from multiple sites. (However, the level of coordination required to do this would call for substantial budgetary resources.)

For research results to be compared and aggregated, common measurement units will be needed for both space and time. Management decisions on land use are taken at the household level. However, households control dispersed fields of varying size and quality. The ideal research design for linking household decisions to landscape changes is area frame sampling, which selects a geographic location and then identifies the decision maker who manages that piece of land. However, this procedure is costly, and will be feasible only if this GMP research area enjoys substantial supplementary funding.

However, with the limited funds currently available, there is little alternative to single-visit surveys using clustered list frame sampling. This procedure selects geographic clusters (typically villages) and then draws a sample from a list of village households, such as a village census. Although data gathered from this procedure can be aggregated up to a regional level, there is likely to be bias toward special characteristics of the villages sampled that are not shared across the region. Moreover, procedures for direct field observation must be carefully specified, especially in instances where households control too many fields to permit site visits and detailed measurements. In such cases, even a random field choice may be misleading, since field management often varies importantly with physical characteristics, distance from the homestead, and land tenure status.



Activities

- Electronic conference to choose benchmark sites based on demographic and natural resource management parameters.
- Initial characterization of benchmark sites in collaboration with local partners, based on literature review, secondary data, and rapid appraisal of study zone.
- Field survey of agricultural production, consumption and marketing systems and related natural resource management practices.
- Draft papers prepared testing the null hypotheses (1) that population growth has no effect on land use and (2) that land use has no effect on natural resource status.
- GMP workshop to compare effects of intensification across regions. Workshop may include participants doing relevant research outside the program for the sake of developing wider insights.
- Development of policy recommendations to the CGIAR on land use intensification in mountain regions.
- Publication and diffusion of best workshop papers and policy recommendations (via book or special journal volume)

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C. Defining Opportunities for Policy Research in the Global Mountain Programme²

Background

The Global Mountain Programme (GMP) is an umbrella institution that links together three distinct programmes operating in different highland or mountain areas: Condesan in the Latin American Andes, ICIMOD in the Asian Himalayas, and AHI in the African highlands.

The purpose of the GMP is to improve the efficiency and impact of scarce funds by disseminating relevant research results where possible between highland areas and by coordinating research of a strategic nature. The GMP is considering to implement strategic research in 4 broad areas: Characterizing Mountain Regions, Intensifying Land Use and Natural Resource Management, Agro-biodiversity, and Policy.

This note outlines terms of reference for a rapid appraisal study to determine the potential opportunities for policy research within the GMP.

Objectives

The related objectives of this activity are to determine whether there are opportunities for and expected impacts of cross site policy research/dissemination within the Global Mountain Programme (GMP) and if so, identify the priority global policy research agenda.

² This is to be considered as Phase 1 of policy research within the GMP

Expected outputs

The expected outputs are answers to the following:

- (1) What are the key NRM problems or policy problems related to NRM in the region?
- (2) To what extent has policy research addressed these key problems? What are the key lessons from the region for dissemination?
- (3) What other relevant policy research has taken place within the past 20 years? To be specified by topic.
- (4) What are the key gaps for further research?

Within highland areas, who is doing policy research related to NRM and what are their mandates and comparative advantages (government, universities, private firms, international organizations)?

Boundaries of the work

For the purposes of this note, policies are defined as rules, regulations, directives, laws and the like, enacted by formal or informal policy making institutions at different levels of administration. Thus, a policy could be embedded in a Land Registration Act passed by the parliament or a grazing management rule enacted by a traditional chief. They both have in common an effect on incentives for managing natural resources.

An argument could be made that nearly all policies at national or local levels ultimately have an impact on natural resource management practices by households. However valid this argument, it is not true that all policy research studies have relevance for natural resource management. Therefore, it is critical to distinguish that this activity is not about undertaking new policy research; it is about compiling and analyzing existing policy research. Further, the aim is to focus on studies that have an explicit link to natural resource management (more on this below), that are relatively recent (within the past 20 years), and that are relevant to highland areas.

It is necessary to define "relevance" in terms of a link to natural resource management. Policy research may be defined as relevant if it has an explicit reference to one of two areas:

- Inputs into, management of, and outputs from farming systems in the highlands. This would include policy studies related to seed and fertilizer input systems, on husbandry practices and cropping patterns, and on marketing and storage of outputs relevant to the highland farming systems.

- Management of off-farm rural natural resources in the highlands. This would include management of forests, woodlands, wetlands, grasslands and pastures, and water sources.

To ensure a degree of cohesiveness between the regional studies, it will be important to identify core subject areas for the literature review. The core subject areas will be defined along two dimensions. The first is natural resource management issue and the most important current or projected issues will receive priority (e.g. topics such as soil fertility depletion, soil erosion, loss of biodiversity, deforestation). The second is type of policy and to make this manageable we shall propose to initially exclude from the review studies focussing on macro-economic policies (trade, monetary, and fiscal policy) since the mountain programmes appear to have the little comparative advantage in addressing them. Other policy studies, for example relating to tenure, market access, of agricultural research, would be included, but they should provide information on the impacts of such policies on the priority natural resource management issues.

The core natural resource management issues will be identified through soliciting inputs from each of the mountain research/development teams. Each regional study will then include analysis of these issues. The study team may also add to the list of key natural resource management issues.

Activities

- Identification of regional core team(s) and consultant(s) to undertake the work. (3 weeks)
- Identification of key subject areas in consultation with research teams
- Consolidated literature search using accessible computerized databases for relevant subject areas and countries
- Regional meeting(s) to agree on additions to the core subject areas and to identify key sources of documents. (1 day)
- Visits to relevant government ministries, to research institutions, to private institutions, to universities, and to donor agencies. (3-6 weeks)
- Compilation of relevant research. (2 weeks)
- Brief overview and analysis of relevant research. (2 weeks)
- Draft synthesis of analysis. (1 week)
- Review of synthesis by core team. (2 weeks)

D. Concept Note³

Seeds for Mountain Development: Inter-Mountain Exchange of Agro-Biodiversity

Justification

The Global Mountain Program (GMP) was created in 1997 as an umbrella institution within the CGIAR to coordinate research programs in the three major highland areas of the developing world. The GMP's goal is to enhance the ability to transfer technology within and across these mountain regions. It links the programs of CONDESAN in the South American Andes, ICIMOD in the Asian Himalayas, and AHI in the African highlands.⁴

The agricultural economy and the farming systems of the mountains/highlands in the developing countries are closely related to the diversity of the physical and natural environment. However, with few exceptions, they are characterized by small holders, mixed rain-fed cropping and a predominantly subsistence economy.

The 1992 Rio Earth summit on global environment and development statement includes the use of biodiversity as a main factor for the agricultural sustainable development and establishes a special chapter for the mountain conditions, considering these ecoregions as fragile ecosystems but with diverse genetic resources.

Several public institutions and NGO's have oriented their activities -with variable results- to improve the rural standards of living in these areas in order to alleviate the actual poverty of the majority of more than 300 million people, depending on mountain agriculture. However, little attention has been oriented to promote the use of the mountain native crops that have been domesticated in each ecoregion; despite their potential to improve not only the level of human nutrition but also to promote these crops as sources of economic benefit.

Some examples of already introduced crops are quinoa, amaranths and tubers from the Andes to the Himalayas as well as millets and buckwheat from the Himalayas to the Andes; also tef, high altitude barley and forage species from the African Highlands to the Andes. Quinoa and potato varieties introduced in Asia have received little attention on nutritional and utilization aspects as well as the knowledge about the different uses of these food crops. At present, results show

³ Prepare by Mario Tapia and Roberto Quiroz (Project 14 & GMP)

⁴ Acronyms: AHI = African Highlands Initiative; CGIAR = Consultative Group on International Agricultural Research; CIP = International Potato Center; CONDESAN = Consortium for Sustainable Development of the Andean Eco-Region; ICIMOD = International Center for Integrated Mountain Development.

that the introduced crops are not properly utilized, due to the lack of special training about their preparation.

In 1987, the International workshop on mountain genetic resources was organized in Nepal by the International Center for Integrated Mountain Development (ICIMOD), and the International Development Research Center (IDRC-Canada). The attendants showed interest and discussed the potentials for a continuous exchange of crop varieties of several different species within mountain regions in the world. In 1990, on a seminar on sustainable mountain agriculture in Nepal, the possibility to create a **mountain to mountain project** - including the transfer of technologies as well as the exchange of species and their utilization in nutritional and development projects in the mountain environments of the world - was discussed. A 1996 visit to Andes of high officials from the Agriculture Ministry of Bhutan raised a special interest from this country to initiate these exchange processes with the Andes region.

The GMP offers a unique possibility to facilitate mountain to mountain cooperation, being the exchange of selected native crops only an example.

Expected Outputs

The following outputs will be generated by the end of the three-year period:

1. Case studies for at least three local communities in each mountain region evaluating introduced crops from other mountains.
2. The potential for intermountain transfer of promising crops assessed.
3. At least 30 scientist involved in the research process and more than 600 professionals informed of the characteristics of mountain crops.
4. Local meetings to divulge the results to farmers and professionals.
5. A publication documenting the process

Objectives

1. Initiate the process of information exchange between researchers, politicians as well as producers of mountain food crops.
2. Establish a research process in the introduction of mountain species and their utilization within pilot areas in the mountain ecoregions.
3. Promote the exchange among professionals from different mountain conditions.
4. Divulge the results in a wide context using different media, including electronics, publications and workshops in each ecoregion.

Activities

1. A moderated electronic conference to define the bases for the initial workshop.
2. A workshop of no more than 9 specialist from the three mountains to:
 - Review of the actual status on mountain species and environmental studies.
 - Define the genetic material required and legal aspects (See Table 1).
 - Design the introduction experiments.
 - Determine the strategy for the involvement of researchers, farmers, and research stations.
 - Design a web page.
3. Conduct the research proposed.
4. Analyze and compare results across mountain regions.
5. Publish and diffuse the results.
6. Increase public awareness on mountain biodiversity through regular newsletters and a video on the biodiversity of each mountain region.

ANNEX 2. Global Mountain Program: First Technical Committee Meeting.

Nairobi, Kenya
October 15,16 1998

Participants⁵

Ann Stroud - AHI/ICRAF
Tej Partap - ICIMOD
Mohammed Saleem - ILRI
Peter Ewell - CIP
Roberto Quiroz – CIP

A. Background

Mountain ecosystems are a major source of the world's biological diversity, water, energy, and forest products. About 80% of the planet's fresh water supplies originate in mountain areas. Many of the world's most important food crops evolved in the unique microecologies found in mountain valleys.

Mountains account for 20% of the world's landscape and are home to at least 10% of the earth's people. A global ecoregional program on sustainable mountain agricultural development should focus on the three most important mountain regions in developing-country agriculture in Asia, Latin America, and Africa: (1) the Hindu Kush Himalayas, (2) the Andes, and (3) the highlands of eastern and central Africa. More than 100 million people live in these mountain regions, and they are highly dependent on agriculture for their sustenance and income.

Complexity, diversity, and vulnerability are all widely recognized themes in mountain agriculture in the tropics and subtropics. Mountains are also frequently associated with grinding poverty. Some of the poorest people in Asia, Latin America and Africa live in the mountains. Given all the limiting factors in the mountains, improving natural resource management, in general, and land use, in particular, should be viewed as a mechanism for improving opportunities in the often densely populated tropical and subtropical mountain regions. Under these conditions, investing in agricultural research can significantly improve the odds of favorable outcomes for production and for the quality of the natural resource base. Conventional biological research can make a difference to the welfare of

⁵ AHI = African Highlands Initiative. ICRAF = International Centre for Research in Agroforestry. ILRI = International Livestock Research Institute. ICIMOD = International Center for Integrated Mountain Development. CIP = International Potato Center.

poor people. But research is also needed to better understand interactions among resources, technologies, institutions, and policies that ultimately shape favorable or unfavorable environmental consequences in response to rising population pressure.

The Global Mountain Program – convened by CIP - was created in 1997 to provide a focal point for the CGIAR system for research in support of Chapter 13 of Agenda 21. The goal is to enhance the ability to transfer technology within and across the mountain regions of the world. The proposed research topics, defined at a consultation meeting with participation of scientist from the three mountains (October 1995, CIP), were grouped as:

- Characterizing agroecosystems
- Intensifying land use and natural resource management
- Exploiting biological diversity in a sustainable manner for economic growth, and
- Stimulating productivity and enhancing resource conservation through policies and public-sector investment.

The technical committee, responsible for the implementation, and the monitoring and evaluation of the Program, met for the first time in Nairobi, Kenya (October 1998), with the following objectives:

- To revisit the original action plan in the light of the research activities implemented in the regions
- To define the action plan for the upcoming three years
- To identify mechanisms for an effective coordination of the Global Mountain Program

B. Research Topics

The participants agreed that the strategic research topics suggested in the GMP document are still the most relevant common concerns and issues that cut across all three regions. The committee decided to prioritize the topic on Intensifying Land use and Natural Resource Management, for the next three years. It was also agreed that the GMP funds would complement on-going research in the three regions, directed to assess issues of global relevance. These issues are also expected to be applicable at the regional level. The emphasis of the meeting was then focused on defining the expected outputs of each research topic and determining the mechanisms that would allow the committee to monitor and evaluate the Program.

Characterizing Mountain Regions

Responsible institution: ICIMOD

Goal

To provide researchers, decision-makers, and developers with suitable characterization methods and tools that enable them to: compare land use patterns, extrapolate technological options, select promising rural development project sites, and exchange experiences across regions.

Expected Outputs

- A state of the art publication on methodological guidelines for assessing and characterizing mountain regions based on spatial and temporal dynamics. The interactive use of remote sensing, GIS, and dynamic models is emphasized. New developments on the annexation of temporal and spatial dimensions of socioeconomic data are incorporated. The publication will include a critical analysis of available methods for use by researchers, decision-makers and developers; a description of available data sets, and examples of their application in data-scarce environments of the three mountain regions. Special emphasis will be given to mechanisms for making these methods useful for mountain research and development.
- CD-Rom for practitioners containing methods and databases.
- Terms of references for the contributing papers: November 1998
- Draft of papers by each region: August 1999
- Distributing papers to practitioners: October 1999
- Discussion meeting (global level) and design of CD-Rom: November 1999
- Regional meetings to test the products and give feedback: March 2000
- Publication , production of the CD-Rom, and guidelines for future work: July 2000

Intensifying Land use and Natural Resource Management

Responsible institution: CIP/CONDESAN

Goal

To improve knowledge on driving forces – e.g. land markets, changing markets, and political and economic stability - causing land use intensification, ascertain impacts, and share lessons learned in the global context.

Expected Output

A consolidated report on two contrasting areas in each region, focusing on processes, options, technologies, and policy impacts of land use intensification on productivity, income, biodiversity, sustainability, and equity. To guarantee global relevance, particular attention is given to pertinent issues such as: (1) the use a comparable framework of case studies; (2) reaching a compromise on a scale level that would allow a precise matching of socioeconomic and ecological data; and, (3) a careful identification and quantification (whenever possible) of the set of causal connections between demographic and land use changes. A closer look on the two contrasting paradigms on the subject is envisioned: is population growth a threat to the inherent limits to arable land to produce food, shelter, and sustenance? Or, can it be the impetus for technological and other changes that mitigates or even eliminates the effects of natural resource limits on economic well-being?

- Electronic conference to define the framework : March 1999
- Selection of the benchmark sites (defined in the electronic conference)
- 2 years field work (defined in the electronic conference)
- Full participation of local partners from the beginning

Agro-biodiversity

Responsible Institution: AHI

Goal

To identify opportunities for transregional transfer of crop and livestock species and indigenous knowledge on management of agro-biodiversity.

Expected Output

Identification of potentially promising crop and animal species for intermountain transfer. The documents will include a description of the species that have high potential for generating income for farmers and or environmental value. In

addition, there will be a description of the niches that might benefit from adapting exogenous species.

Phase 1

- Terms of Reference for the contributing documents : December 1998
- Selecting resource persons: March 1999
- Draft of papers by each region: March 2000
- Papers reviewed by local institutions: To be defined
- Discussion meeting: To be defined
- Publication; compendium which will also identify areas for future research:

Phase 2

Issues taken up under this task will depend on the results of phase 1.

Policy and Public-sector investment stimulating productivity and enhancing resource conservation

Responsible Institution: ICRAF

Goal

To synthesize and analyze information on policy research in the different mountainous regions to define global policy issues affecting land use intensification and scope for further studies.

Expected Output

A critical comparative analysis of the policy studies, related to intensification of land use, that has had either positive or negative impact on productivity, conservation of agro-biodiversity and equity. Policies related to tax incentives, decentralization, water legislation, and taxing the natural resource base, among others, will be considered.

- Terms of Reference for the contributing documents: Mid November 1998
- Draft of papers by ICIMOD, AHI, CONDESAN: June 1999
- Papers reviewed by local institutions: October 1999
- Discussion meeting: November 1999

- Publication: March 2000

C. Information Exchange

- A quarterly e-mail report by the coordinator, based on the reports of the members of the technical committee
- Extensive use of the Mountain Forum
- Technical committee meetings coinciding with technical meetings of the different research topics.

D. Technical Committee

Members of the committee

The GMP coordinator (CIP)

The AHI coordinator (ICRAF)

The coordinator of the highland project (ILRI)

The CONDESAN coordinator (CIP)

The representative of ICIMOD to GMP

Responsibilities

To develop the work plan

To organize and implement the work plan

To review proposals

To monitor regionally organized projects

To write quarterly e-mail update reports

To report to donors

To perform strategic reviews of technical and operational plans

ANNEX 3. INFOANDINA Electronic Newsletter



"EL VALLUNO"

Boletín informativo de la Asociación para la Investigación y

Desarrollo Andino y Amazónico (AIDAA) en apoyo a CONDESAN - COCHABAMBA

Nº1. Año 1. Abril 1999

En esta edición:

- AIDAA integra a CONDESAN-Cochabamba a las autopistas de la información.
- Visita del Dr. Josue Posner y el Dr. Jaime Tola a CONDESAN-Cochabamba.
- El Dr. Miguel Holle visitó "Candelaria".
- Reconocimiento al Centro Internacional de la Papa y al Dr. André Devaux.

AIDAA integra a CONDESAN-Cochabamba a las autopistas de la información.

Queridos amigos:

Un saludo electrónico muy fraternal y un sincero agradecimiento a INFOANDINA y CONDESAN por hacer realidad un largo anhelo de AIDAA; el integrarse a las maravillosas autopistas de la información, que día a día se hacen más imprescindibles en el interrelacionamiento de nuestras instituciones, nuestras regiones, nuestros países y en la realización de trabajos conjuntos en la ecoregión andina.

Con la circulación del boletín, CONDESAN-COCHABAMBA busca fortalecer y ampliar su vinculación interinstitucional, además de constituirse en un medio de difusión que permita expandir e intensificar la circulación de información de interés para los miembros de CONDESAN. Así, nos identificamos y hermanamos más con el noble objetivo de alcanzar un desarrollo justo y equitativo para la ecoregión andina.

Este es un momento de inicio, son los primeros pasos que se están dando pero no cabe duda que día a día iremos mejorando este servicio. Estamos dispuestos a recibir sus comentarios, noticias y anuncios para retransmitirlos al entorno de CONDESAN-COCHABAMBA a través de INFOANDINA y ampliar su difusión a CONDESAN, a nivel de la ecoregión, del continente y del mundo.

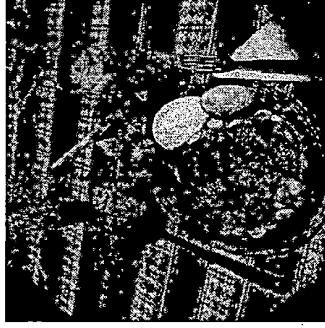
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Visita del Dr. Josue Posner y el Dr. Jaime Tola a CONDESAN-Cochabamba.

Los días 21 y 22 de abril visitaron la ciudad de Cochabamba el Dr. Josue Posner y el Dr. Jaime Tola, Coordinador y Presidente de CONDESAN respectivamente.

En tal oportunidad y con la presencia de ambos visitantes se realizaron diferentes reuniones sobre tres proyectos en gestión: MIACUCHA (manejo integral del agua en Cochabamba), ABIOPRO (aprovechamiento de la biodiversidad promisorio) y MICAMEL (Manejo de camélidos en los Andes altos de Cochabamba). Estos proyectos se trabajan con la participación de socios de CONDESAN-Cochabamba, que implica a más de 10 instituciones diferentes y sobresalientes de la región y el país.

Finalmente, el Dr. Posner y el Dr. Tola, durante su visita tuvieron la oportunidad de degustar el famoso plato andino Charke (de llama) que se encuentra ilustrado en la página 21 del folleto CONDESAN, editado en enero de 1999 por el Consorcio con base en el CIP - Lima Perú.



El Dr. Miguel Holle visitó "Candelaria".

El Dr. Miguel Holle, coordinador general del Programa Colaborativo de la Biodiversidad de Raíces y Tubérculos Andinos (RTAs), visitó la zona de Candelaria-Colomi el pasado viernes 23 de abril, con el objetivo de realizar un seguimiento a las actividades que se desarrollan en esta zona dentro del marco del Proyecto Integral Candelaria.

Las valiosas sugerencias realizadas por el Dr. Holle para mejorar los trabajos que se desarrollan en Candelaria fueron acogidas con mucho interés, lo que permitió plantear nuevas perspectivas a mediano plazo. Recordemos que el Proyecto Integral Candelaria es ejecutado por tres instituciones: PROIMPA, IESE-UMSS y el PAPN-UMSS.

Consortio Carchi

PROYECTO MANRECUR II La

PRESENTACIÓN

El Consortio Carchi-Ecoregión Río El Ángel, inicia sus actividades desde Agosto de 1995, en el marco de actividades del Consortio para el Desarrollo. Sostenible de la Ecoregión Andina o CONDESAN, el cual funciona como un Consortio abierto con instituciones socias de Venezuela hasta Chile.

El Consortio Carchi, es una "mesa de concertación" lo que significa que es un espacio de intercambio y negociación entre las instituciones nacionales e internacionales, que trabajan y participan voluntariamente desde sus capacidades y competencias para lograr su meta principal de largo plazo, que consiste en "promover el uso sustentable de la biodiversidad de la microcuenca del Río El Ángel, a través del manejo sostenible de sus recursos naturales".

Durante los primeros años del Consortio, se organizaron reuniones de los miembros de forma espontanea, de acuerdo al sentido de necesidad de uno o más de los participantes. Para los fines de comunicación e intercambio entre investigadores, esto funcionó muy bien, pero luego, en 1997, cuando miembros del Consortio empezaron a crear actividades colaborativas y de desarrollo, la mayoría de los miembros sintieron la necesidad de tener un esquema más regulador de contactos. Por eso, a fines de 1997 los miembros del Consortio decidieron formalizar sus reuniones y las fijaron para realizarlas el primer viernes de cada mes. Durante el 1998, se concentran sus reuniones principalmente en tres temas: Agua, Manejo de Conflictos Socioambientales y Futuro del Consortio. En cuanto al último, se decidió que ya era hora para "tomar el pulso de los logros y necesidades del Consortio", y usar esto para planificar los próximos pasos. Esto empató con la conclusión de ciertos proyectos de diferentes instituciones del Consortio, y les cayó bien poder identificar nuevos caminos para nuevos proyectos.

El proyecto MANRECUR I, de FUNDAGRO, era uno de los proyectos que en 1998 estaba concluyendo. Con el apoyo del donante y el Consortio, MANRECUR I financió un evento de planificación en Mayo de 1998 en el cual participaron todas las instituciones que forman parte del Consortio. Como resultado del evento, se identificó un conjunto de prioridades, las cuales fueron organizadas bajo la propuesta para una segunda fase del Proyecto, como MANRECUR II. Esta propuesta fue aprobada y arrancó desde enero 1999 y tendrá una duración de 2 años. Uno de los ejes del Proyecto es el apoyo para el fortalecimiento del mismo Consortio Carchi.



MEMORIA DE LA REUNIÓN DE LA MESA DE CONCERTACIÓN DEL 9 DE ABRIL DE 1999

La presente es la memoria de la reunión del 9 de abril de 1999 y con éste primer número se inicia la publicación en forma de noticiero que esperamos sea compartida en las instituciones y organizaciones a quienes representan y por quienes participan.

En el taller de planificación del Consortio Carchi, efectuado el 5 de marzo de 1999, se acordó como fecha de la próxima reunión el 26 de marzo. Sin embargo, la situación política y económica del país, llevó a que la sociedad civil realice paralizaciones en protesta, determinando que la reunión se la transfiera al 9 de abril, comunicando el cambio oportunamente.

La reunión del 9 de abril convocada para las 9h00 se da inicio a las 10h00 en vista de que las carreteras de la provincia del Carchi estuvieron en mal estado por las lluvias de los días anteriores que incluso paralizaron la circulación por los deslizamientos de tierra en las vías principales de llegada a El Ángel.

Susan Poats, coordinadora del Proyecto Manrecur II comienza la reunión con la bienvenida a los presentes y la presentación de la nueva facilitadora de la mesa de concertación, Susana Ricaurte.

Antes de iniciar el trabajo de la reunión, por moción de Hernán Valencia de la Asociación de Municipalidades del Ecuador (AME), se hace una ronda de presentación de los asistentes y las instituciones representadas.

La Agenda para la reunión propuesta y desarrollada se la conformó por los siguientes puntos:

1.- Plan Operativo del Consortio Carchi: revisión y concreción

El trabajo del Plan Operativo se basó en revisar lo realizado en el taller del 5 de marzo. Se dividieron los participantes en cuatro grupos y sobre la fotocopia del plan los grupos anotaron las sugerencias que luego fueron presentadas en plenaria. Las recomendaciones al plan están recogidas en un documento disponible en las Oficinas de MANRECUR II.

2.-Análisis de Relaciones Interinstitucionales del Consortio Carchi: Informe de Avance.

Joel Ulrich de Fundación CIMAS, informó que terminó con la elaboración de un cuestionario que permitirá obtener la información necesaria para llegar al análisis de

ANNEX 4. Risk Analysis of Potato Production in the Altiplano: Quantifying Farmers' Beliefs.

The Altiplano of Peru and Bolivia is home to many very poor farm families for whom agriculture is the main source of income. Potatoes are the staple food crop, and production risk, usually in the form of drought and frost, is pervasive.

The incidence and productivity consequences of risk are difficult to assess because historical data on the productivity of fields and farms are not available. Nonadoption of improved technologies is often attributed to risk, but both subjective and more objective information is usually lacking to document the relative riskiness of competing technologies.

Nor has the effectiveness of different methods to assess risk been established. In this study, yield and net revenue risk of native and improved varieties are examined in three ways: (1) estimated yields from samples taken in potato fields, (2) elicited information on farmer beliefs about varietal productivity, and (3) simulated yield estimates from process-based, crop-growth models.

A. Site and Methods

This research was conducted in Santa María, a community in the Department of Puno, Collao District, Peru. It is situated at about 3,900 m above sea level. Land is privately and communally farmed.

Potatoes are a dryland crop grown from October to April in the main growing season. Mixing native and improved potato varieties in the same field is common. Native varieties include bitter (Ruqui, Pinaza, Lok'a, Luki, and Ajanhuiri) and nonbitter (Ccompis, Imilla Negra, Sacampaya, Imilla Blanca, and Choquepito) cultivars. Improved varieties are represented by Andina, Tomasa Condemayta, Mariva, and Mi Perú.

Yield samples in farmers' fields were collected during six growing seasons from 1987 to 1992. Stratified sampling by elevation was used to generate estimated yields for native and improved varieties. About 10 fields were sampled in each of the 6 yr.

Farmers were interviewed in 1996 when information on the incidence and consequences of risk was canvassed. Farmers recognize four classes of years for potato productivity: bad, normal, good, and very good. Beliefs on varietal yield were assessed using a triangular method where the respondent provided information on the highest, modal, and lowest observations. By multiplying the frequency of the four productivity events by the results from the triangular elicitation procedure by varietal type, we generated yield distributions for native and improved varieties.

Daily weather data and soils information figured as inputs into a process-based, crop-growth model to simulate potato yield. Genetic coefficients on potential leaf and tuber expansion rate, degree of determinacy, photoperiod sensitivity, and temperature sensitivity for Imilla Negra and Andina were used to simulate the performance of the bitter and nonbitter varietal types.

B. Results

We determined risk by comparing yield and net revenue of native, improved, and mixed varietal groups.

Yield comparisons

Productivity of the native, improved, and mixed varietal groups is compared for each of the three methods of estimation (Table 1). The yield for the mixed varieties was calculated as the average field proportions of native and improved varieties across the 6 years.

All methods give productivity estimates substantially higher than the departmental average yield of about 5 t/ha for Puno. The difference between estimated and officially reported yields partially reflects the impact of technological change introduced by the Proyecto de Investigación de los Sistemas Agropecuarios Andinos in 1985. Healthier seed, improved fertilizer, and other crop management practices played a role in this change.

The simulated results in Table 1 are especially noteworthy because estimates from such models are often several orders of magnitude higher than yields in farmers' fields. In our case, the crop simulation accurately reflects reality.

The measured and elicited estimates are similar. Indeed, regressing the elicited on the measured yield data for the 6 years accounts for about 98% of the variation in the measured productivity estimates.

Improved varieties were also characterized by the highest mean yields. Differences between the improved and native varietal types were most apparent with the measured and elicited methods. In contrast, the simulated results gave more or less the same results for each varietal type.

Figure 1 shows the tradeoffs in risk and productivity and presents the estimated cumulative distribution function of yields by varietal type for each of the three estimation methods. The cumulative probability reflects the likelihood of obtaining a yield less than or equal to a stipulated level. For example, in Figure 1A, the chance that native varieties produce less than 4 t is only about 3%; the expectation of this very low yield for the improved varieties is 10 times more likely at 30%.

Crossing curves imply tradeoffs in risk, that is, native varieties are less prone to both low and high yields (Figure 1A). The crop-cut method gives results highlighting the stability of native varieties and the yield responsiveness of improved varieties to good weather. In contrast, the farmers' subjective beliefs (Figure 1B) show almost no conflict between risk and expected productivity. For almost all yield levels, improved varieties dominate. The cumulative probability for a stipulated yield level is everywhere higher for native compared with improved varieties. Hence, the two methods generate different results: in Figure 1A, risk matters; in Figure 1B, it does not.

The distributions of the simulated results are not that informative. Improved varieties dominate at almost all yield levels (Figure 1C) and the yield distributions are almost the same. This similarity suggests that the crop simulation model is not sufficiently well-developed to assess varietal-specific risk.

Net revenue comparisons

The higher productivity of improved varieties (Figure 1) does not necessarily translate into higher net returns. Native varieties command a higher price, and improved varieties are more intensive users of costly inputs. Price differences between native and improved varieties are sharper in better production years when the improved varieties give higher yields.

Figure 2 charts tradeoffs between risk and expected profitability. The measured and elicited results show a slight advantage of native varieties over mixtures and improved varieties in lower-yielding years. The opposite occurs in better years when pure stands of improved varieties are superior to native varieties or mixtures.

Conclusions

Direct elicitation of the subjective incidence and severity of risk in potato production was useful in incorporating farmers' knowledge. It also gave results comparable to the more tedious objective method of sampling yields over time. This result suggests that farmers' knowledge might be successfully used to estimate potato yields over time with acceptable precision. Moreover, the estimated variance of the reported yields appears to be reliable and useful for assessing production risk.

Simulation models also gave results consistent with mean levels of productivity, but such tools are still too immature to describe variety-specific risk, the subject of this study. Experimentation in both bad and good years is needed to recalibrate these models to reflect the reality of the harsh production conditions of the Altiplano.

More research is also needed to understand the dynamics of varietal mixtures in risk-prone environments. In general, our results suggest that risk is an important

issue for potato producers in the Altiplano. Native varieties are more profitable in lower-yielding years, and improved cultivars are more profitable in better years.

Table 1. Measured, elicited, and simulated potato yields in Puno, Peru, during the period 1987 through 1992.

Variety	Yield (t/ha)		
	Measured	Elicited	Simulated
Native	8.28 (0.85) ^a	9.77 (1.21)	8.76 (0.88)
Improved	12.04 (1.24)	13.23 (1.50)	9.80 (0.85)
Mixed	10.03 (0.84)	10.25 (0.61)	8.99 (0.85)

a: Numbers in parentheses are standard errors of means.

Figure 1. Estimated cumulative distribution of yield by estimation method. CIP, 1996.

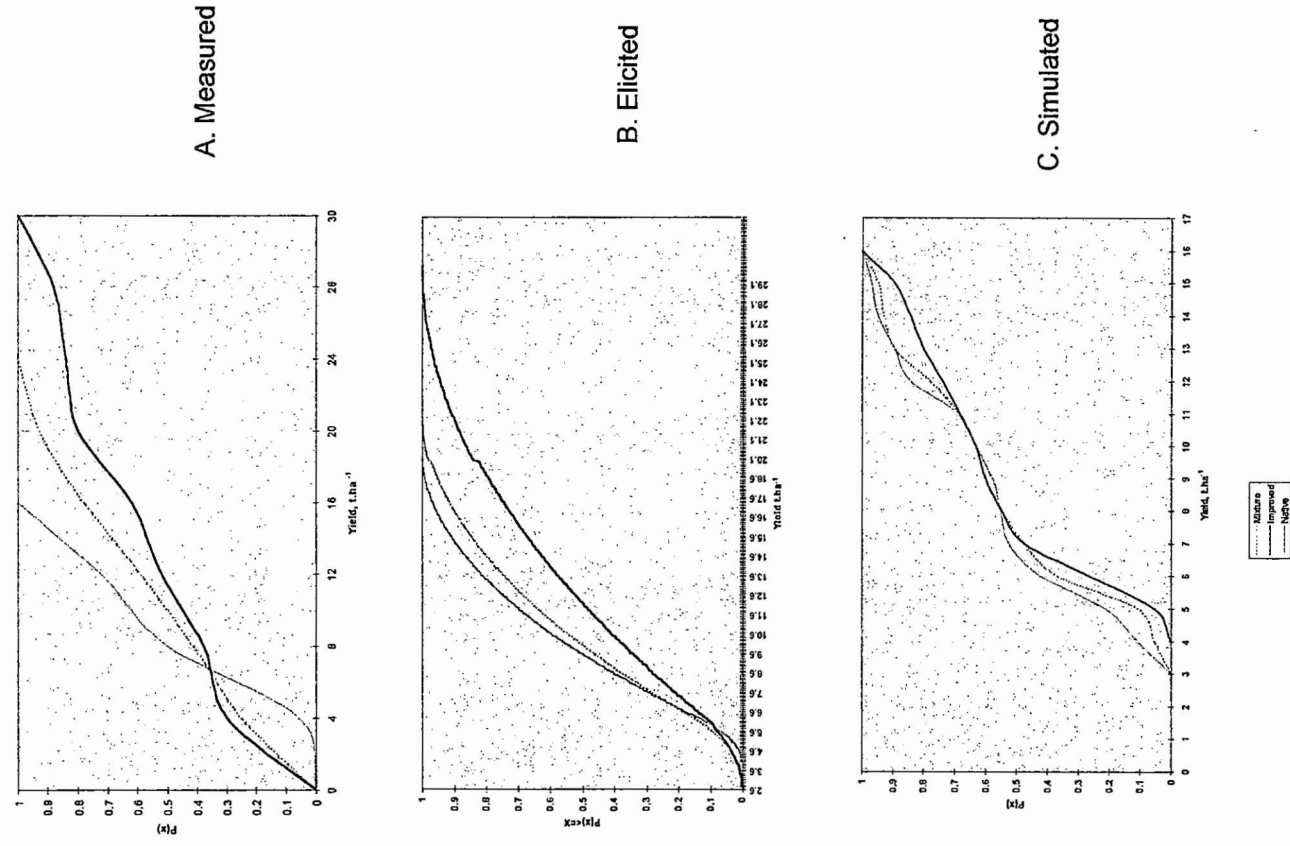
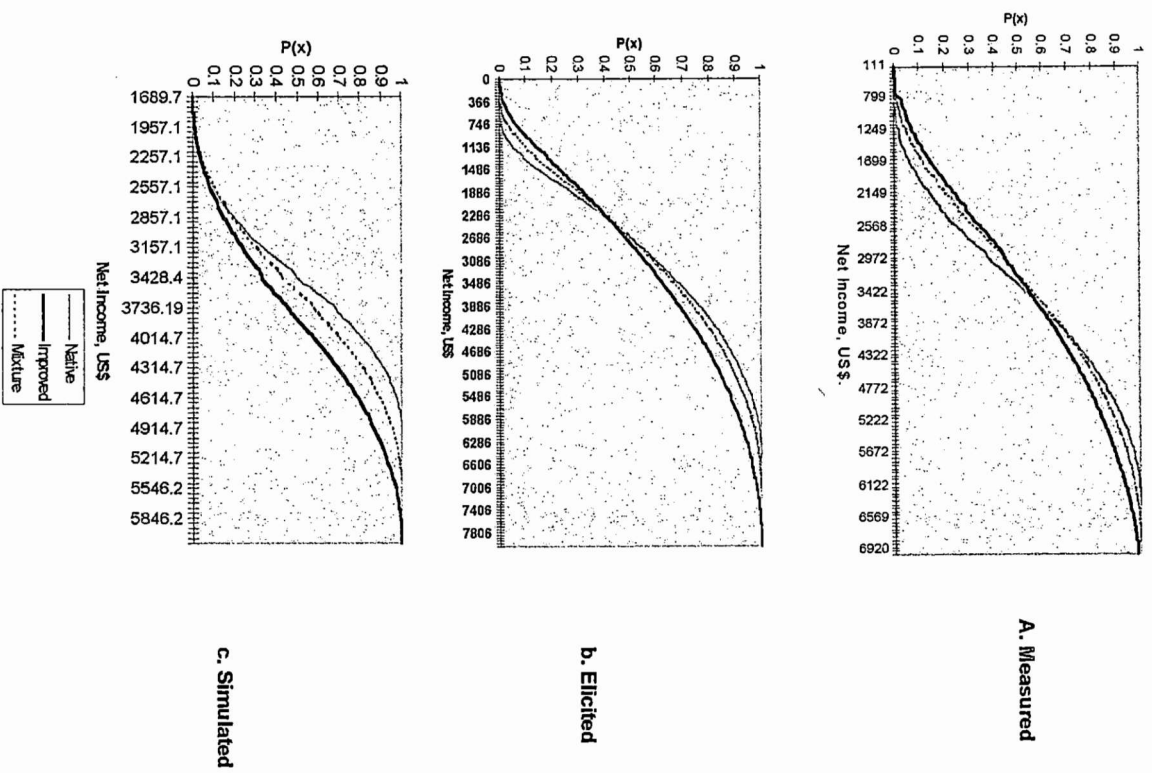


Figure 2. Estimated cumulative distribution of net revenue by estimation method. C/P, 1996.



ANNEX 5. Remote sensing and GIS tools for land management decisions.

A. A brief description of the Integrated Geographic Information and Modeling System to monitor land use changes⁶.

A preliminary version of an Integrated Geographic Information⁷ and Modeling System was completed. A brief description of the software, programmed in C++ Builder language follows. The screens are presented in Spanish, native language of the targeted users. The final product will include screen in both Spanish and English. The different subsystems are briefly described below.

Image input and processing

This subsystem includes basic image processing functions, analysis and display. A sequence of screens is shown in figure 1. In the sequence shown in panel A, the image is loaded, displayed and zoomed. A quick display of the range of values in the cells of the image being processed, together with the location of a selected pixel in both coordinates and row and column numbers in the image are shown in the bottom left part of the screen. Sub-images can be selected and saved for further processing.

Quick analyses can be performed using descriptive statistics on the different bands of the image or thematic maps. Panel B shows the numerical matrix of band 1(Vis) of NOAA-AVHRR over a part of the Altiplano. The range, mean, and standard deviation values of different sub-images are also shown.

Quick and dirty analysis can be accomplished with the histogram function. Selecting the bars of a particular band or thematic map can highlight areas of interest. This option allows for a visually guided classification and the flagging of areas that bias the classification using maximum likelihood methods (Panel C). This is a very handy procedure particularly when working in areas with high spatial diversity.

Specialized functions

This subsystem calculates the Normalized Difference Vegetation Index (NDVI), estimated primary biomass production, the Land Surface Temperature (LST) using two different split-window algorithms (Price, 1984; Ulivieri et al., 1992), and evapotranspiration. The calculation of the evapotranspiration is described in the

⁶ A project funded by the Ecoregional Trust Fund managed by ISNAR

⁷ Integrated Geographic Information System refers to a software where remote sensing and GIS technologies are combined.

annex 1. This subsystem will (not implemented yet) provide the user with user-friendly routines to locate and delineate major types of boundaries (e.g. land/water, vegetated/non-vegetated, vegetation with striking differences in spectral attributes).

The system additionally provides the user with an aggregation routine to aggregate pixels to conduct simulation studies on the effect of aggregation at different spatial scales. As an example, a power-2 grid pyramid based on 32.25m TM NDVI data was constructed (Richards, 1993). Treating the pyramid as a nested set - in which the variance at each resolution level consists of the variances of the levels above plus some new information- we calculated the nested variance . When little additional variance is found, a relatively spatially coherent feature may be detected; when considerable additional variance is found there is probably noise at that level (De Cola, 1997). Figure 2 shows an example of multiresolution analysis of TM NDVI. The breaking of the nested variance in level 4 (approximately 500m) indicates the existence of a coherent structure at that level.

Interface with GIS

In an electronic conference held in June-July 1998, all the team members agreed to use IDRISI as the GIS software. The reasons given for this decision included, the low cost and high-value of the software (meaning you get a lot for what you invest), and the widespread use of IDRISI in both developed and developing countries. If the Fund would like to include GIS functions in the software to end up with a stand-alone system, it would be possible but we would need more time to include it. All the modules within the subsystems work interactively and dynamically with the integrated data base (IDB). They retrieve from the IDB the information when needed and archive the results generated in the process. There is a default structure for the archiving of the data generated, but the user can also defined his/her own structure.

Interface with Process-based models

There are two different interfaces with the process-based models. DSSAT is coupled to the system in a similar manner as IDRISI. The Livestock models are programmed in the same environment (Figure 3). The sheep model is fully functional within the system and the alpaca and LINPAS will be shortly re-programmed in C++ Builder. There are several options to run the sheep model. It can be run independent from the system. Under this option the user must introduce the input data on pasture availability and quality if LINPAS is not active. It can be run in conjunction with LINPAS. In this case LINPAS simulates both pasture availability and quality. The third and fourth options include the use of satellite imagery to identify grassland types and biomass on offer. In the first case, the user can assign the spectral characteristics defining pasture types and the model simulates animal production by clusters of pastures and their combinations in rotational grazing systems, given a herd structure. In the last

Figure 1. Selected screens of the Integrated System

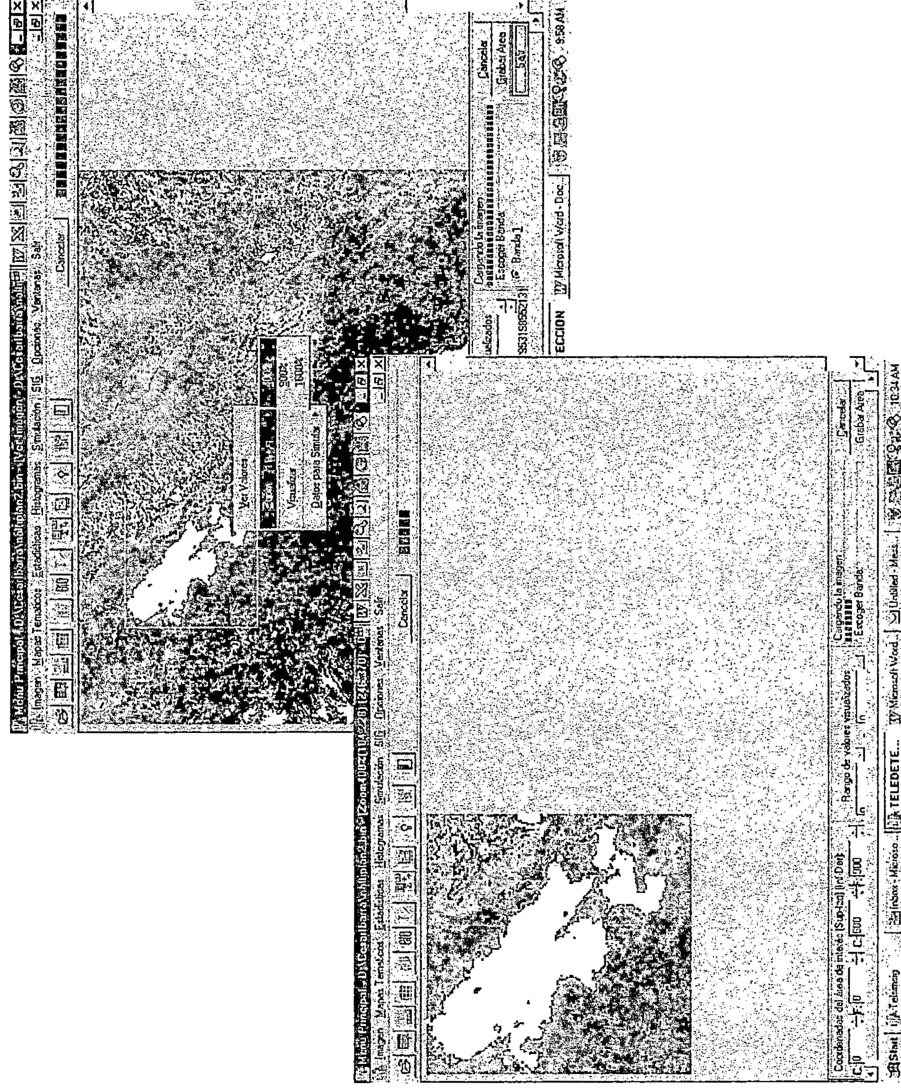
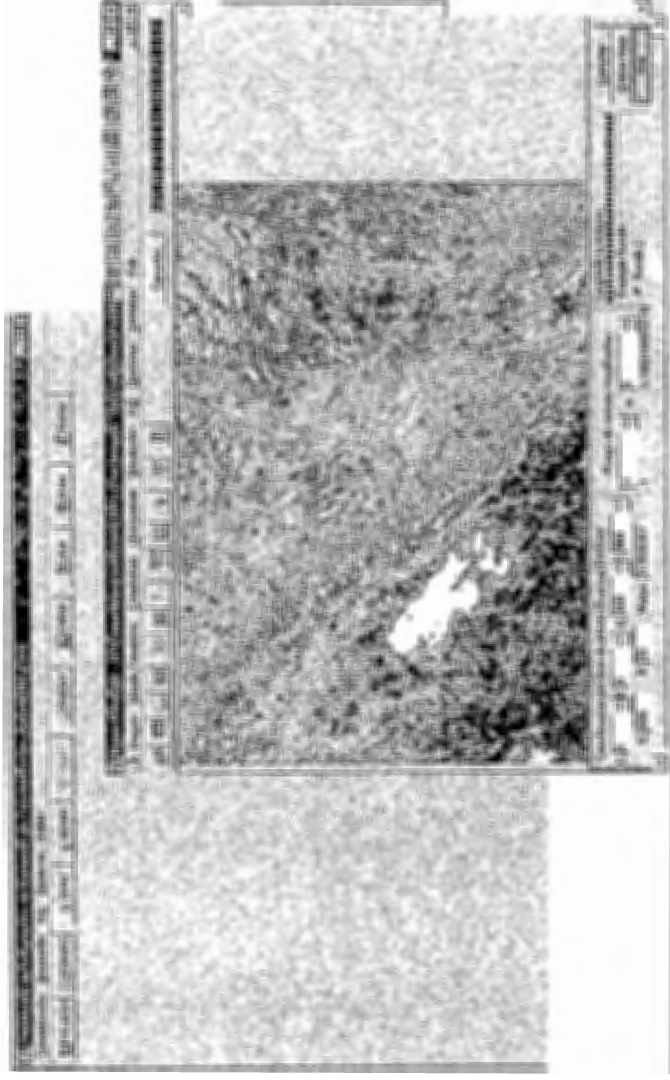


Figure 2. Multiscale Analysis: Effect of the aggregation level on the Mean, the Standard Deviation and the Scaled Variance on the TM NDVI.

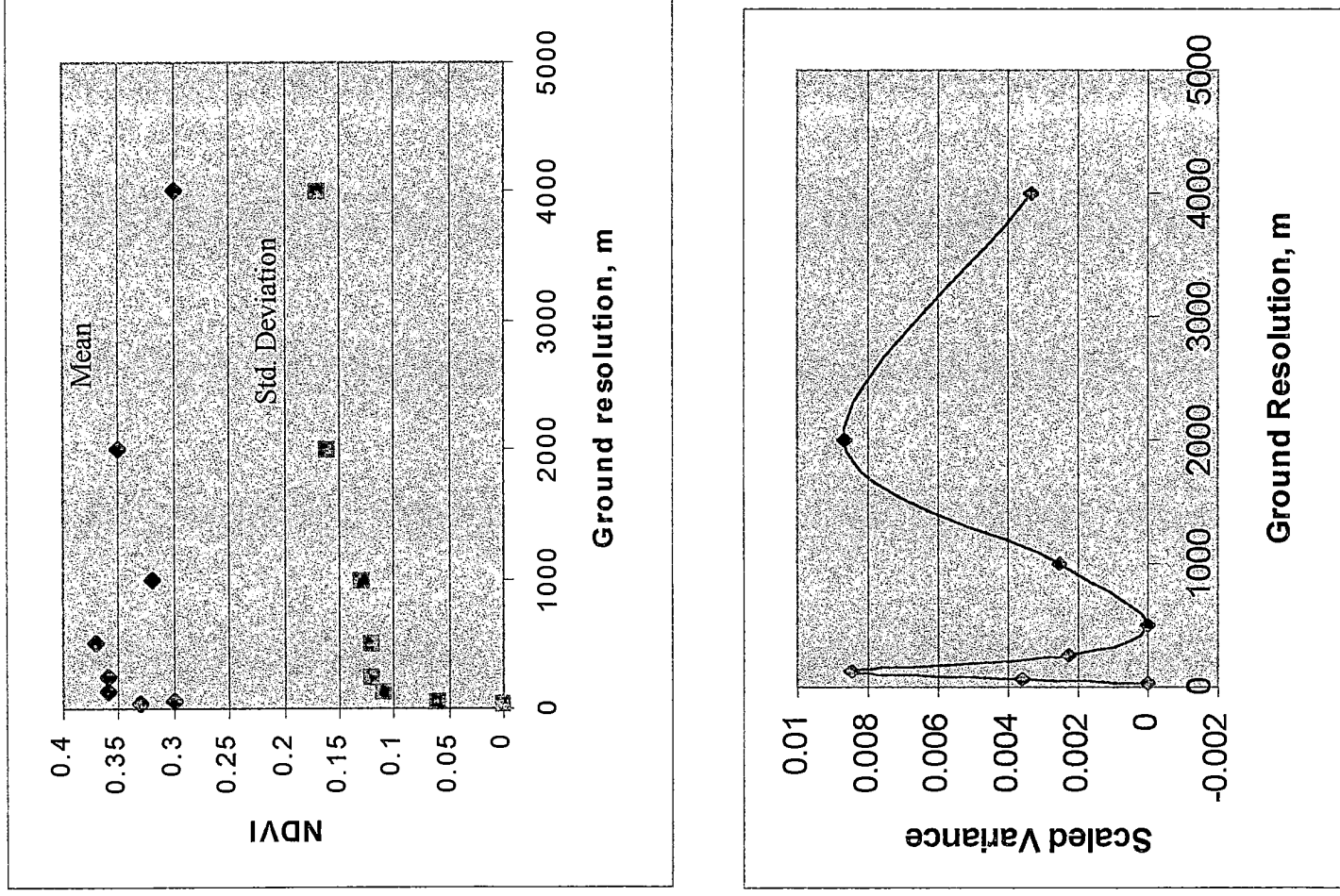


Figure 3. Some illustrative components of the Sheep Model.

Inicio del Año: 1/1/99

Fin del Año: 31/12/99

Verificar: Verificar

HATO INICIAL

Cantidad (nº) de animales: 1.4

Categoría Animal:

Peso Promedio (Kg):

Hembras adultas (mayores a 1.5 años):	100	34
Machos adultos (mayores a 2 años):	10	35
Borrégas (entre 1 y 2 años):	10	25
Borrégas (entre 1 y 1.5 años):	100	23
Corderos (menores a 1 año):	100	14

Área de la Pradera

Forrajes:

Tipo de forraje: ALFALFA

Extensión (Hec): 10

Indicadores de Reproducción y Mortalidad

Indicador de Producción (%)	75	Indicador de Mortalidad (%)	5
Indicador de Producción (%)	85	Peso Hembras adultas (%)	5
Indicador de Producción (%)	85	Peso Machos adultos (%)	5
Indicador de Producción (%)	85	Peso Borrégas (%)	6
Indicador de Producción (%)	85	Peso Corderos (%)	8
Indicador de Producción (%)	85	Peso Corderos (%)	20

Embarazo:

Fecha de nacimiento: 1/1/99

Período de Gestación (días): 150

Período de Lactancia (días): 150

option the model simulates on a pixel by pixel basis, using the biomass estimates with the sensor and the changes in time.

Examples of the type of assessment that can be done with the process-based models incorporated in the Integrated System are given in annex 1.

A few of the lessons learned

Working in data-scarce settings, such as the Altiplano, demands creativity to collect and systematize the limited existing information. In the project, the training in the use of the simulation models as a tool to systematize the field information collected by researchers and to explore options that were difficult to test otherwise proved very useful.

The aggregation problem must be well defined in order to be correctly assessed. The scaling range, the optimum resolution (scale below which the phenomenon is homogeneous) and its multiscaling dimension – the law function of the spatial resolution (usually power law) – may vary from one phenomenon to the other. The integrated system developed in this project provides some tools that allow researchers to approach the aggregation problem in a more systematic way. The next step is to study selected important phenomenon in different ecological settings to compare scaling ranges, optimal resolution, and the multiscaling dimension as well as describing the process to be followed.

The integrated system being developed constitutes an outstanding analytical tool for researchers. Nonetheless, as expressed by a few development projects managers, there are two elements that would be most helpful as a planning and M&E tool for them; the integration of the analysis into a Land Evaluation System (an Expert System that summarizes the results of the scenarios tested) and the incorporation of farmer's perception. These elements ought to be incorporated into the system if massive use is expected among decision-makers.

B. Plan de Intervención en La Encañada – Cajamarca

La Encañada es uno de los sitios de Cajamarca en donde se han realizado muchos estudios a diferentes escalas y/o niveles de detalle, siendo privilegiada en ese aspecto, sin embargo los planes de intervención han utilizado sólo parte de la información existente, de otro lado muchos lugares del ande, no poseen tal caudal de información que permita delinear planes o políticas de uso y conservación de los recursos que poseen.

Existe mucha necesidad de los pobladores del ande para utilizar sus recursos en forma adecuada, pero no tienen los recursos económicos para realizar este anhelo, ó los que la tienen, requieren de información en plazos perentorios a costos efectivos.

Esta necesidad ha llevado a plantear la búsqueda de un grupo mínimo de datos que permita por un lado caracterizar los espacios, en tiempos cortos, de otro conservar la base de recursos que sustentan a esa población y de metodologías que permitan integrar esa información.

La intervención en un espacio, requiere además la concertación de los pobladores con las instituciones del lugar bajo criterios orientados por los factores biofísicos que caracterizan la microcuenca

Objetivos

Seleccionar parámetros para evaluar las tierras de la Encañada con fines de protección de las tierras

Establecer una metodología que permita la intervención en la Encañada, con un grupo mínimo de datos

La Intervención en el Espacio Agrícola

Los planes de intervención en los espacios agrícolas requieren de información a un nivel de detalle que muchas veces no es disponible ó el costo de obtención es muy alto y pocas veces existen instituciones en la zonas a intervenir con recursos para solventar el costo que demanda su elaboración; por otro lado los organismos encargados de tal labor se dedican a labores de construir infraestructura de riego u otras obras, con pocas posibilidades de investigar las diferentes opciones o escenarios que podrían servir para tomar la decisión de realizar la actividad x o z a fin de aumentar la productividad de los cultivos y a la vez conservar los recursos que la sustentan.

Se entiende como Conflicto de Uso de la Tierra a la discrepancia que se presenta cuando las tierras con determinada Capacidad de Uso Mayor, se utilizan con cultivos ó coberturas que están acordes ó no, a la aptitud que tienen; como resultado de esto las tierras son clasificadas dependiendo si se utilizan en forma Adecuada ó Inadecuada, en este último caso, cuando son Sobreutilizadas ó Subutilizadas.

Area de estudio

El área bajo estudio se localiza en el Distrito de la Encañada, Provincia de Cajamarca, Departamento de Cajamarca. Abarca 6399 ha, ubicadas en la microcuenca de la Encañada, y parte de la cuenca del río Tambomayo.

Altitud y Clima

La zona de la Encañada se halla entre 2944 y 3956 msnm; la precipitación promedio a 3020 msnm es de 10.7 con extremos de 15.9 y 5.6 °C con una precipitación anual de 554 mm; a 3320 msnm en la estación de Usnio el promedio de temperaturas es de 10.1, con extremos de 14.1 y 6.0 °C,

precipitación anual de 683 mm y a 3590 msnm; en la estación meteorológica de La Toma se tiene como temperatura promedio 6.5 °C, con extremos de 10.5 y 2.4 °C, y precipitación total anual de 662 mm.

El uso de la Tierra

En la cuenca del río Cajamarca se ha realizado el estudio de caso de Cambios de Uso de la Tierra en Cajamarca, en el que se establecieron las categorías de Cereales, Tuberosas y raíces, Pastos cultivados, Pastos naturales, Bosque, y otros.

Materiales

Equipo y Programas

Se utilizó una computadora Pentium de 133 MHz

128 Mb RAM

Los programas que se utilizaron fueron:

Arc/Info v 3.4.2

Idrisi W95 v2.0

Arc/View v.3.0

Métodos

La información del uso de la tierra fue reclasificada en dos categorías: 1. Tierras agrícolas y 2. Otros usos, a través del programa Idrisi .

El mapa de pendientes fue generado con el Programa Arc/Info, para su elaboración se utilizó la Hoja catastral a la escala 1:25000, con curvas a nivel cada 50 metros habiéndose digitalizado con el programa Arc/Info e interpolado los datos con el mismo programa, para obtener un modelo digital del terreno, el mismo que se utilizó para obtener los rangos de pendientes en grados, operación que se realizó en el programa Idrisi, convirtiéndose posteriormente a porcentaje.

- | | | | |
|----|------|---|----|
| 1. | 0 | - | 5 |
| 2. | 5.1 | - | 15 |
| 3. | 15.1 | - | 40 |
| 4. | | > | 40 |

A fin de establecer los Conflictos de Uso de la Tierra para definir si los usos eran adecuados, respecto a las pendientes en las que se hallaban, se superpuso la información de las Pendientes sobre Uso de la tierra utilizando el programa Idrisi.

Las reglas de decisión para definir cada una de las categorías de Conflicto de uso de la tierras de tienen en el Cuadro 1.

Para utilizar la información del Uso de la tierra, las clases fueron agregadas en dos categorías: Uso agrícola y Otros usos, las cuales fueron superpuestas sobre las pendientes.

Cuadro 1. Reglas de decisión para hallar los conflictos de uso de la tierra

Pendiente	Uso de la Tierra	Conflicto de Uso de la Tierra	
		Clase	Categoría
A	1	1	Adecuado
B	1	2	Liger. Inadecuado
C	1	3	Liger. Inadecuado
D	1	4	Muy inadecuado
A	2	1	Adecuado
B	2	2	Adecuado
C	2	1	Adecuado
D	2	1	Adecuado

Pendientes:

A. 0 - 5
 B. 5.1 - 15
 C. 15.1 - 40
 D. > 40

Uso de la tierra

Uso Agrícola

Otros usos

Conflictos de Uso de la Tierra vs. Profundidad de los suelos

La información de suelos de Cajamarca fue derivada del estudio de suelos de la cuenca de Cajamarca realizado por Landa *et al* (1978) y completada para La Encañada por Jiménez (1996).

Para fines del estudio, los suelos fueron clasificados en base a la profundidad de los mismos, en los que se consideró dos categorías: 1. Suelos con profundidad menor a 60 centímetros y 2. Mayor de 60 centímetros

En base a la combinación de estos parámetros, cuyas reglas de decisión se presentan en el Cuadro 2, se establecieron recomendaciones de intervención. La información obtenida fue graficada a través del programa Arc/View

Cuadro 2. Reglas de decisión para obtener las recomendaciones de Intervención en la Encañada

Profundidad de suelos (cm)	Conflictos de Uso de la tierra	Intervención
< 60	1	No intervención
	2	Recomendable terrazas
	3	Zanjas de infiltración
	4	Bosque de protección / Zanjas de Infiltración
> 60	1	No intervención
	2	Recomendable terrazas
	3	Recomendable terrazas
	4	Bosque de producción/ Zanjas de infiltración

Resultados

La Encañada presenta un paisaje en el que predominan las pendientes entre 15 y 40 %, casi un cuarto de la superficie entre 5 y 15 %, pendientes mayores al 40 % se presentan en el 15 % del área y en menor proporción las áreas planas (Cuadro 3), las mismas que están graficadas en el Mapa respectivo.

Cuadro 3. Pendientes en la Encañada

Clase	Pendiente (%)	Superficie (Ha)	Porcentaje (%)
1	0 - 5.0	678	10.5
2	5.1 - 15.0	1515	23.4
3	15.1 - 40.0	3281	50.5
4	> 40	1014	15.6
Total		6488	100.0

El uso de la Tierra en la Encañada se caracteriza por tener casi el 50 % del área dedicada a los pastos naturales, incluyendo una 100 ha. de bosque y el otro 50 % cubierto por cultivos; la distribución de los usos en forma desagregada se presenta en el Cuadro 4 y está graficado en el Mapa de Uso de la Tierra.

Cuadro 4. El Uso de la tierra en la Encañada

Clase	Uso de la Tierra	Superficie (Ha)	Porcentaje (%)
1	Cereales	1911	29.5
2	Tuberosas y raíces	391	6.0
3	Pastos cultivados	864	13.3
4	Pastos naturales	3139	48.4
5	Bosque	77	1.2
6	Sin información	106	1.6
Total			6488

Las extensiones según los Conflictos de uso de la tierra, obtenidos en base al mapa de Pendientes sobrepuesto al de Uso de la Tierra se presentan en el Cuadro 5, en el, se observa que el uso adecuado es el predominante, sin embargo se presenta 38 % del área el uso es de ligeramente inadecuado a inadecuado, predominando este último y 5.3 % del área tiene un uso muy inadecuado. Los criterios de decisión para asignar a cada clase se han basado en observaciones realizadas por técnicos de la zona y observaciones de campo.

Cuadro 5. Conflictos de uso de la tierra en la Encañada

Clase	Conflictos de Uso de la Tierra	Superficie (Ha)	Porcentaje (%)
1	Adecuado	3692	56.9
2	Lig. Inadecuado	779	12.0
3	Inadecuado	1676	25.8
4	Muy inadecuado	341	5.3
Total			6488

En la Encañada 58% del área tiene suelos con menos de 60 cm de profundidad y 42% mayores a 60 cm. (Cuadro 6)

Cuadro 6. Profundidad de los suelos en la Encañada

Clase Profundidad de Suelos (cm)	Superficie (Ha)	Porcentaje (%)
1 <60	3779	58.2
2 >60	2709	41.8
Total	6488	

Los resultados de la combinación de las características de uso de la tierra, pendientes y profundidad de los suelos obtenidos se presentan en el Cuadro 7, en el se detalla la superficie según el tipo de intervención requerida. La distribución espacial de las categorías, se presenta en el Mapa de Conflictos de Uso de la Tierra

Cuadro 7. Distribución de la superficie según tipo de intervención en La Encañada

Clase	Tipo de Intervención	Superficie (Ha)	Porcentaje (%)
1	No intervención	3688	56.8
2	Recomendable terrazas	1572	24.2
3	Zanjas de infiltración*	889	13.7
4	Bosque de protección/ZI	243	3.8
5	Bosque de producción/ZI	96	1.5
Total		6488	100.0

*Dado que se trata de tierras de cultivos, estas serían base para iniciar terrazas de formación lenta

ZI: Zanjas de Infiltración

A modo de conclusión

Como resultado del análisis de la información disponible de la Encañada y de otros espacios se ha determinado que los datos mínimos que deben obtenerse, son las Curvas de nivel, disponibles en las cartas fotogramétricas u hojas catastrales, de las cuales se pueden obtener los mapas de pendientes, sea en forma analógica o a través de programas para tal fin, de las cartas también se obtiene la información hidrográfica pudiendo complementarse con trabajo de campo el levantamiento de los manantiales u ojos de agua, y las vías carrozables o carreteras. El mapa de Cobertura y Uso de la Tierra, el cual puede obtenerse de la interpretación de fotografías aéreas o de imágenes de satélite de recursos terrestres.

La combinación de las variables consideradas restrictivas o limitantes al ser comparadas con el uso que se da a la tierra, proveen del mapa de Conflictos de uso de la tierra de acuerdo a si son utilizadas adecuadamente o en forma inadecuada (sobreutilizadas o subutilizadas). El factor climático (Precipitación y Temperaturas) definirá finalmente el grado en el que los conflictos detectados van a afectar el espacio a intervenir.

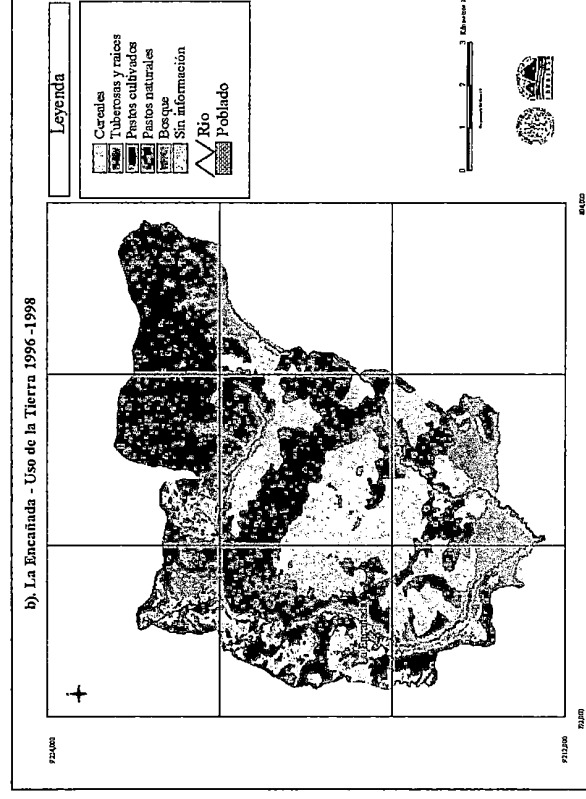
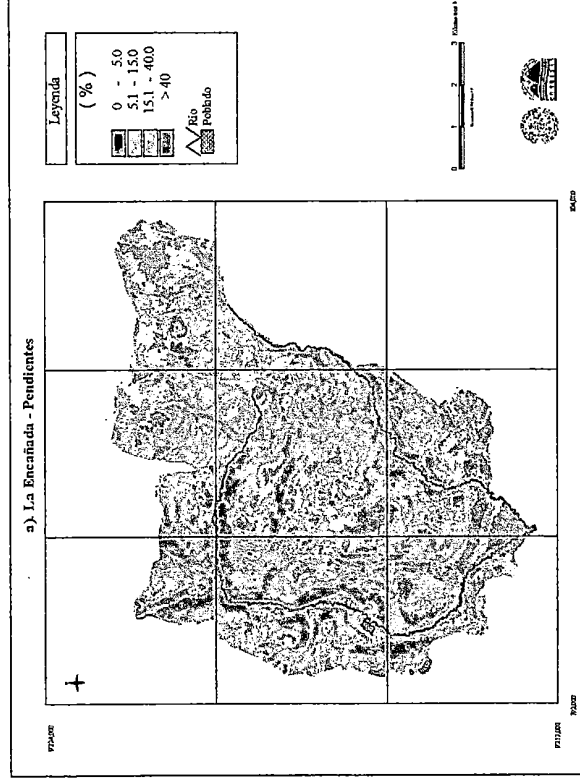
Si se decide intervenir a nivel de unidades físico-políticas se requerirá información de los límites, como en el presente caso de los caseños.

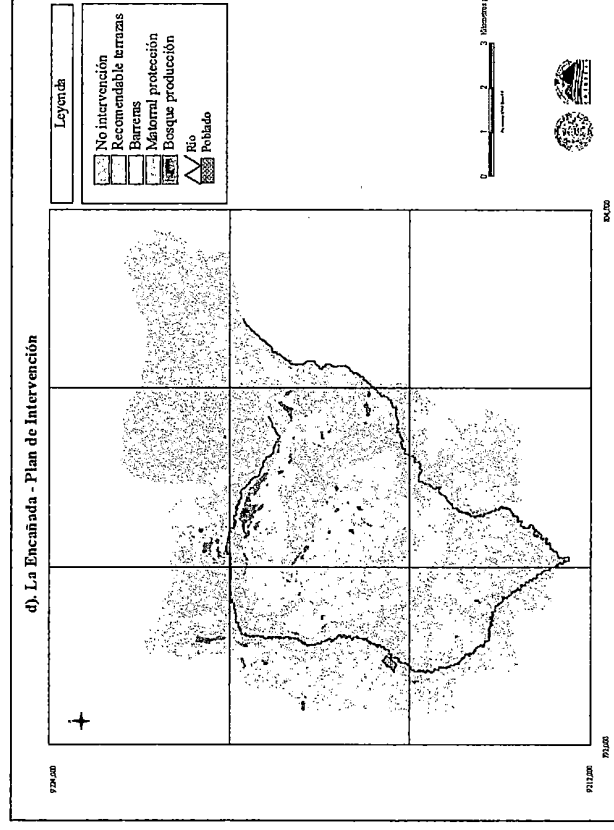
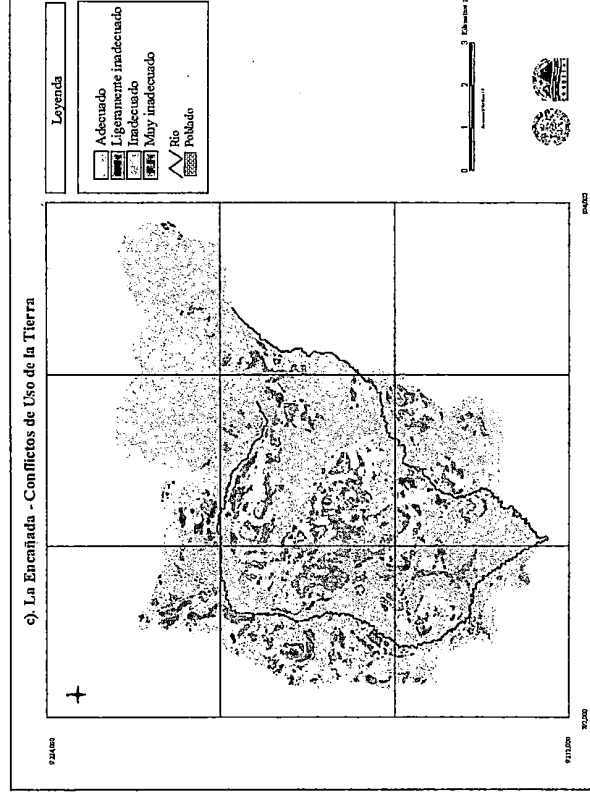
El mapa de conflictos generado así, sirve de elemento de diálogo sobre el cual los pobladores del espacio a intervenir pueden concertar el uso ordenado del territorio, y sugerir las modificaciones pertinentes al documento cartográfico, tanto en la ubicación de los atributos del espacio como en las recomendaciones de intervención.

Bibliografía

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ANNEX 6. Automated tools for land evaluation.

CIP has invested heavily in a number of tools to enhance its natural resource management research capacity. A prototype decision support system (DSS) that integrates remote sensing, geographical information system and computer simulation models has been developed. Under the present grant, two new potential components for the DSS were tested. The Automated Land Evaluation System (ALES)⁸ and an optimization procedure through linear programming. The rationale behind the process is to use the results of scenario evaluation with simulation models, at different geographical scales – possible with the integration described above – as technical coefficients for both the knowledge base and the database of ALES. An expert system is built to create land suitability maps. This output from ALES is in turn used to find optimal options for farmers through linear programming.

This short report is divided in two sections. The first section is a summarized description of ALES; and the second one, a short example of an application in a case study in La Encañada, Cajamarca Peru.

A. The ALES program

The Automated Land Evaluation System (see Figure 1), is a computer program that allows land evaluators to build expert systems to evaluate land according to the method presented in the *Food and Agriculture Organization "Framework for Land Evaluation"* (FAO 1976). It is intended for use in *project or regional scale land evaluation*. The entities evaluated by ALES are *map units*, which may be defined either broadly (as in reconnaissance surveys and general feasibility studies) or narrowly (as in detailed resource surveys and farm-scale planning). Since *each model is built by a different evaluator to satisfy local needs*, there is no fixed list of land use requirements by which land uses are evaluated, and no fixed list of land characteristics from which land qualities are inferred. Instead, these lists are determined by the evaluator to suit *local conditions and objectives*. Evaluators build their own expert systems with ALES, taking into account local conditions and objectives. ALES is not by itself an expert system, and does not include by itself any knowledge about land and land use. ALES is a *framework* within which evaluators can express their own, local, knowledge.

⁸ A commercial software developed by Cornell University. Rossiter and Van Wambeke, 1994.

ALES components

The last version of ALES has seven components:

1. a **framework** for a **knowledge base** describing proposed land uses, in both physical and economic terms;
2. a **framework** for a **database** describing the land areas to be evaluated;
3. an **inference mechanism** to relate these two, thereby computing the physical and economic suitability of a set of map units for a set of proposed land uses;
4. an **explanation facility** that allows model builders to understand and fine-tune their models;
5. a **consultation mode** that allows a casual user to query the system about one land use at a time;
6. a **report generator** (on-screen, to a printer, or to disk files); and
7. a **import/export** modules that allow data to be exchanged with external databases, geographic information systems, and spreadsheets. This includes the **ALIDRIS** interface to the IDRISI geographic information system.

Note that ALES is not a GIS and does not itself display maps. It can, however, analyze geographic land characteristics if map units are appropriate defined, and it can directly reclassify IDRISI or Arc/Info maps with the same mapping unit legend as the ALES database.

Land Evaluation with ALES

The result of a land evaluation is a prediction of the potential use of land for several actual or proposed land-use systems. In other words, land evaluation predicts how each land area would behave if it were used according to each of these systems. Its main purpose is to inform the process of allocation of land uses to land areas by individuals, collectives, or governments. As such, it is a tool for strategic decision making. A complementary purpose of land evaluation is to describe the limitations to land use, and based on these, appropriate management methods. (Rossiter, 1994)

ALES defines the Analysis unit as a "**Land Mapping Unit**" (**LMU**) which are matched with land uses, termed "**Land Utilization Types**" (**LUT**), this relation determines the relative suitability of each area for each use. **LUT's** are a set of "**Land Use Requirements**" (**LUR**) which are the necessary conditions for the successful and sustained practice of a LUT. Each Land Unit is defined by the values of a set of "**Land Characteristics (LC)**" (measurable or estimable land attributes), which are combined into levels of **Land Qualities (LQ)** (complex

attributes of land which influence the suitability of land in a semi-independent manner).

In this sense, land use requirements express the demands of a land use, whereas land qualities express the supply. The suitability of each *Land Mapping Unit* for each *Land Utilization Type* is calculated by:

1. *Determining* (measuring or estimating) the actual Land Characteristic values for the land unit, by field survey, laboratory measurements, remote sensing, etc.;
2. *Combining* these Land Characteristic values into Land Quality values (i.e., inferring the LQ from the set of LC's);
3. *Matching* the Land Quality values with Land Use Requirements;
4. *Combining* these Land Quality values into *land suitability classes* (i.e., inferring the suitability from the set of LQ's). There are two kinds of Suitability:

Physical suitability. Expresses the degree to which the sustained implementation of a given LUT on a certain land unit is feasible without unacceptable risk to the human or natural community; and

Economic suitability. Based on a calculation of the economic return which may be expected if the given LUT in question is implemented on the land unit. Several economic metrics might be obtained and include the predicted gross margin, the Net Present Value (NPV) of a LUT, the Benefit/Cost ratio and the Internal Rate of Return (IRR).

The land Process with ALES is summarized in the Figure 2. ALES could be easily incorporated to an integrated Land Evaluation System as it is shown in the Figures 3a & 3b.

B. Land use evaluation for selected sites in La Encañada, Cajamarca

In annex 5b, An intervention plan for the Encañada watershed was presented. The intervention plan was constructed as a base for the implementation of a soil and water conservation project in the area. The maps developed are used as a tool for participatory planning with local farmers.

In this study, a more in-depth land use evaluation was performed in five neighboring caserios where CIP project 14 and CONDESAN are directly involved. From each caserio a land-mapping unit was selected. The land uses considered were maize, potato with farmer's seed (Potato A), potato with certified seed (Potato B), wheat, cultivated pasture, and cabbage. The data required, described in the previous section, were from the on-going household survey or

secondary data. Expected yields were simulated (except cabbage and pasture) with DSSAT 3.5. Cabbage is a recently introduced crop with potential for areas close to markets.

The ALES framework was used to find the most suitable uses of the land and its maximum expected production when properly managed. The outputs were exported to BLP88, a linear programming software, to maximize gross income at the farm level. In the maximization exercise market restrictions for each product and access to market expressed as transport cost, were added to the model. A small area of Potato A was forced into the solution for self-consumption. The minimum area for Potato A was defined for each mapping unit using real data from the survey. By using the production estimated with ALES as the upper boundary, the sustainable management of the land was assumed to be maintained.

Optimization results for prototype farms in each cartographic unit are shown in table 1. The comparison of the proportions allotted to each land-use is depicted in figure 4. The Gross margin per farm varied, as expected, according to farm size and land characteristics. Even though ALES solution for Magmamayo and Sogorón included cabbage, when the market restrictions were imposed, these cartographic units showed no competitive advantage.

The farm size in Sogorón is too small to generate enough income for the food security of the family, even with an optimal management. Non-agricultural income, coming from migration to the city of Cajamarca, handicraft, or as hired labor for agriculture, complement the family income. With the low carrying capacity of the land it is evident most of the area will either continue or become a source of migration to other areas of the department of Cajamarca or the country.

Table 1. Optimized land uses and expected gross margin of prototype farms in La Encañada.

	Maize		Pasture		Potato A		Potato B		Cabbage		Wheat		Total		Farm Gross Margin \$
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	
La Victoria	0.5	12.5	0.3	6.3	1.0	25.0	1.0	25.0	0.3	6.3	1.0	25.0	4.0	25.0	7,153
Magmamayo	1.0	14.3	0.5	7.1	1.0	14.3	1.0	14.3	0.0	0.0	3.5	50.0	7.0	50.0	8,263
Quinuamayo	1.0	7.7	6.0	46.2	2.0	15.4	1.0	7.7	0.4	3.1	2.6	20.0	13.0	20.0	19,181
Sogorón	0.0	0.0	0.0	0.0	0.5	41.7	0.3	25.0	0.0	0.0	0.4	33.3	1.2	33.3	1,725
Usnio	1.0	27.0	0.5	13.5	1.0	27.0	0.5	12.2	0.3	6.8	0.5	13.5	3.7	13.5	6,253

The two components tested add flexibility and complementary features to the DSS being tested. They will be implemented as an interactive part of it in the near future.

Figure 1. ALES Program Flow .

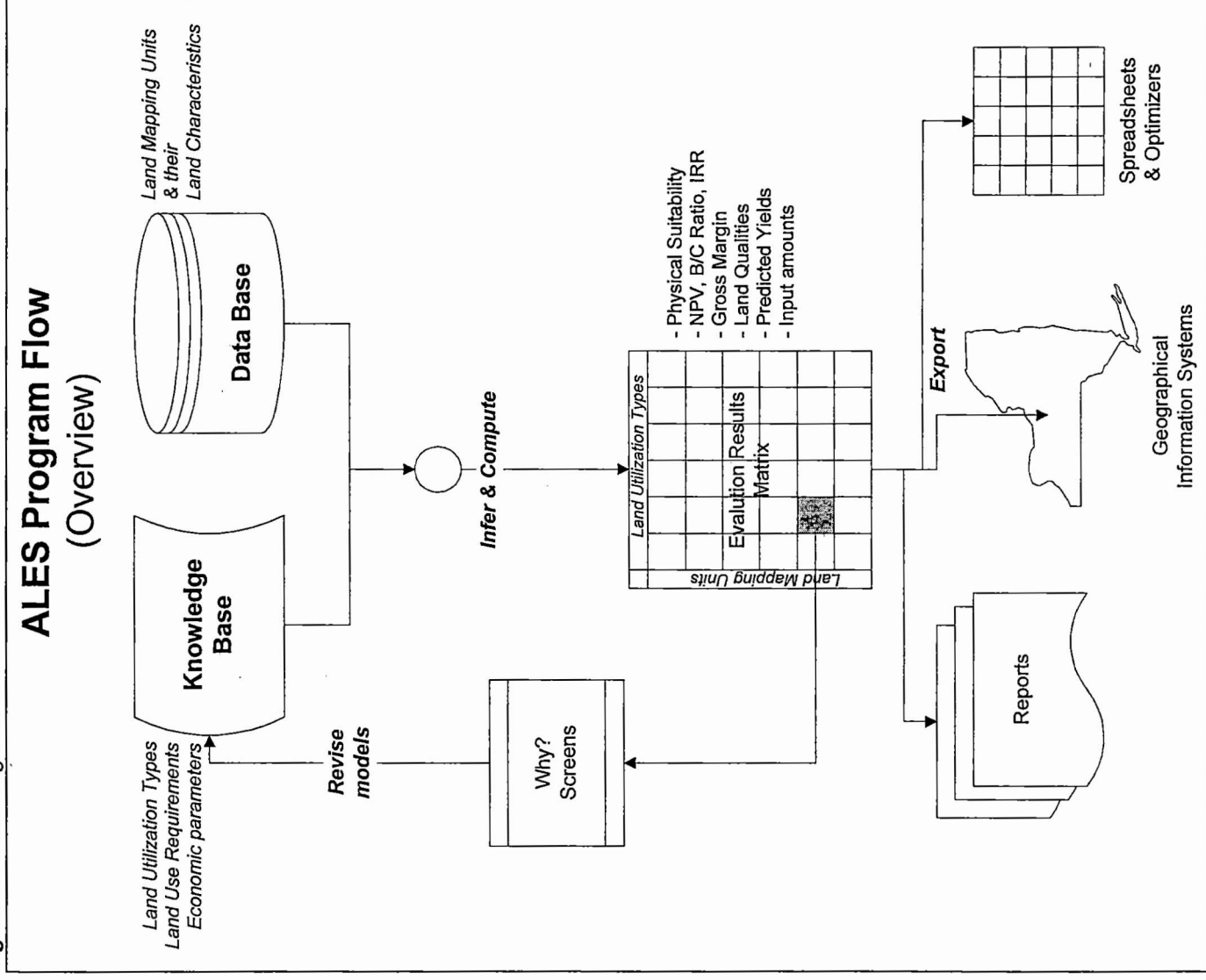


Figure 2. Land Process Evaluation with ALES. Notice that in steps from 7 through 11 ALES software is used directly.

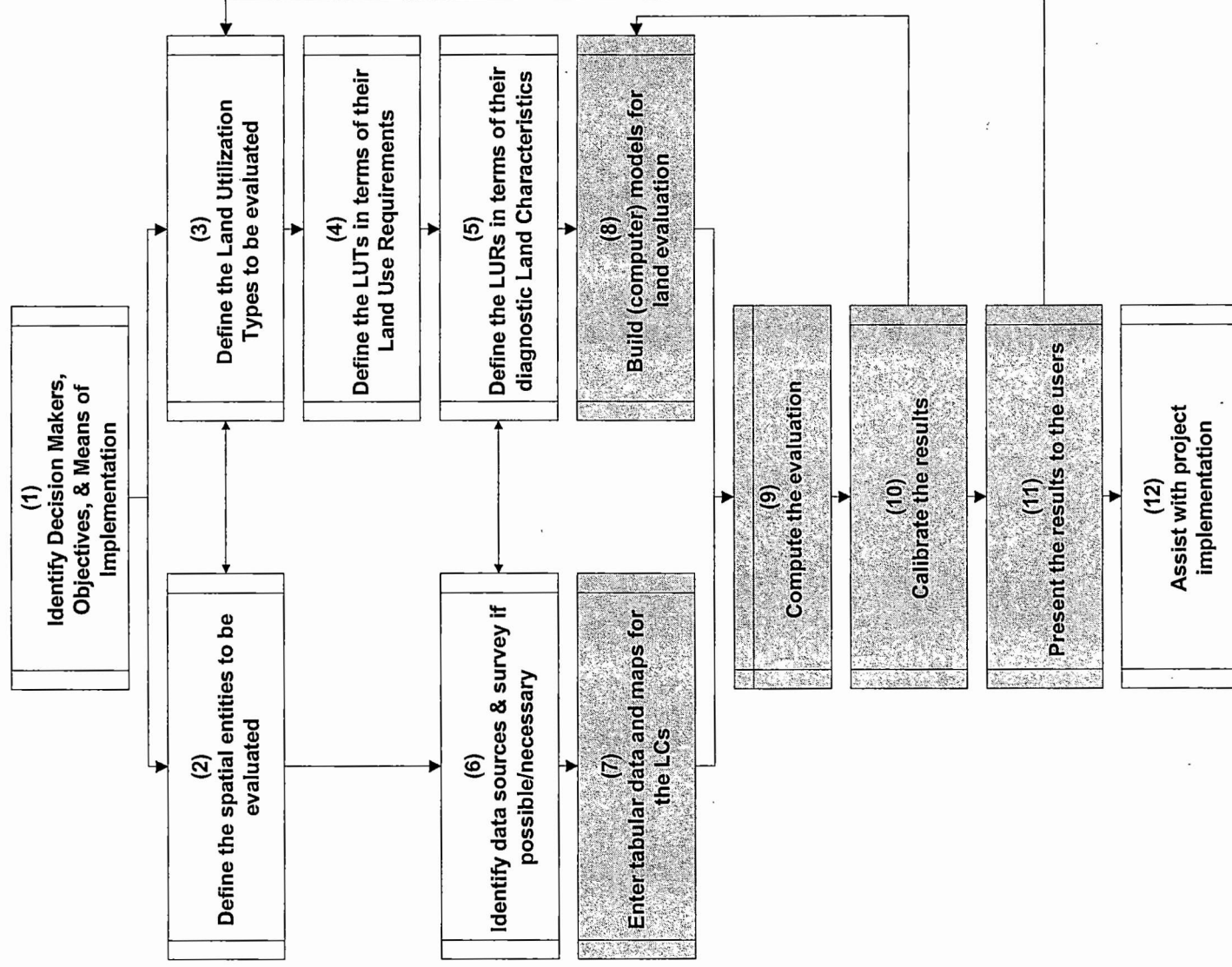


Figure 3b

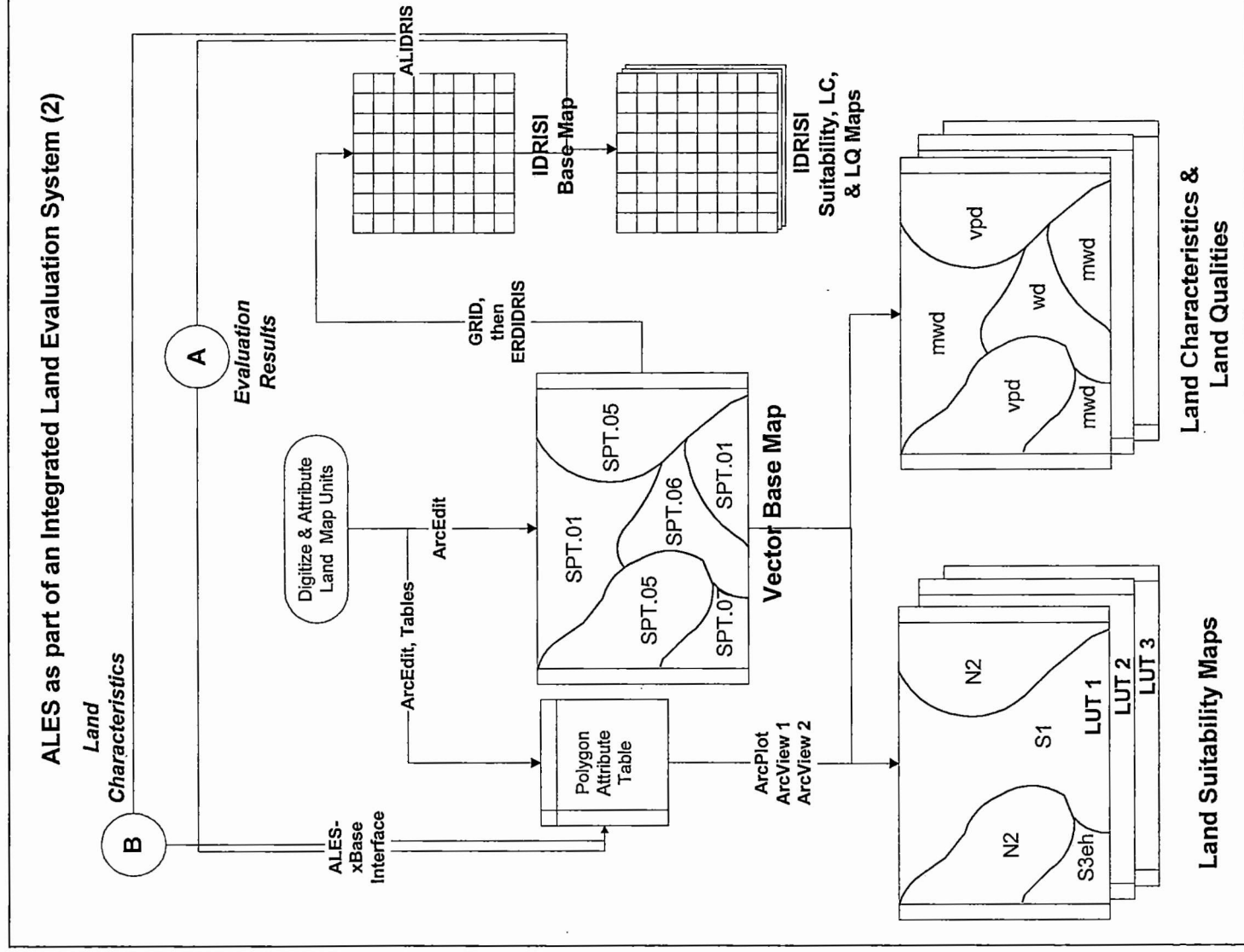


Figure 4. Land use evaluation in La Encañada, Cajamarca: Optimized allocation for six land-use options.

