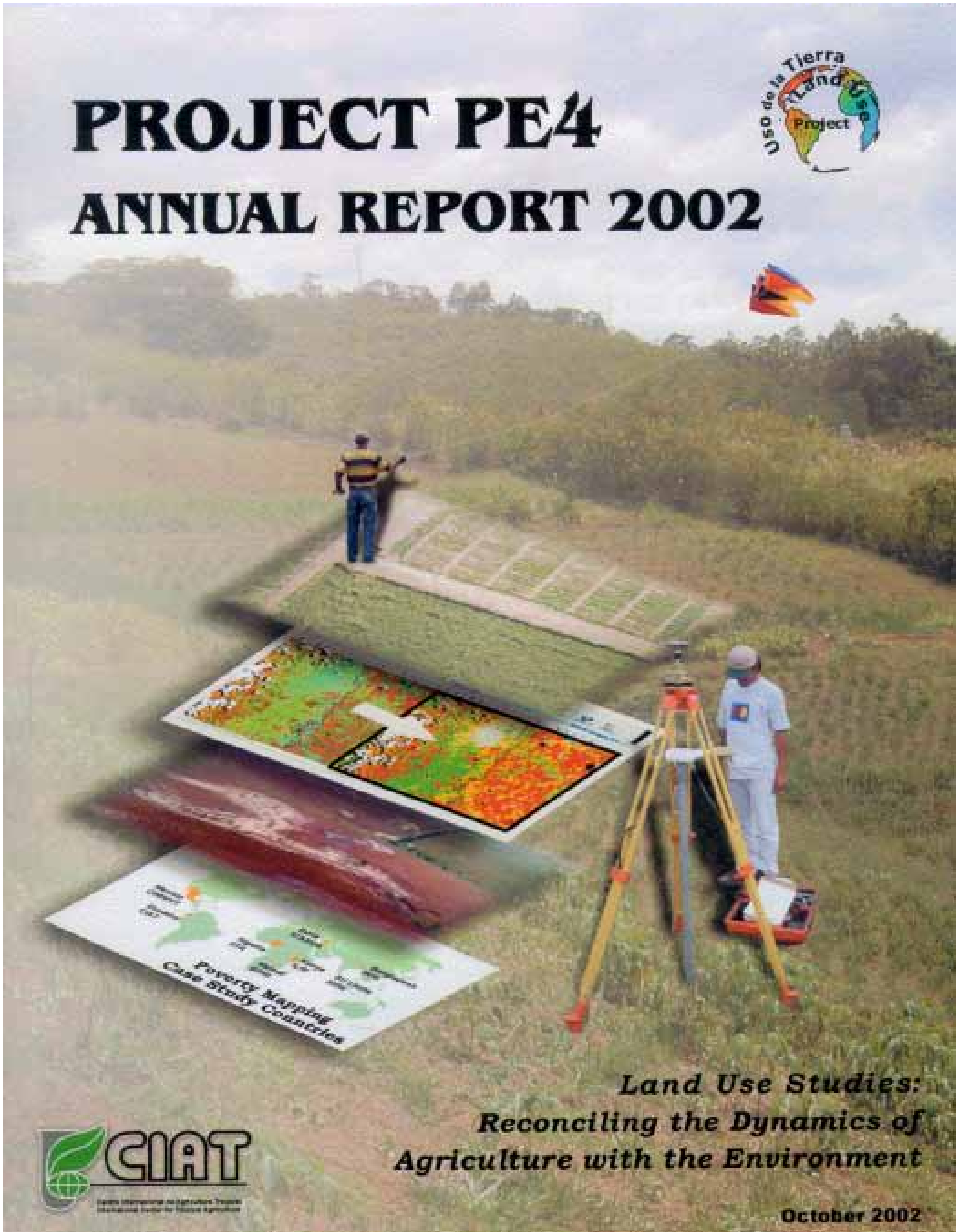
PROJECT PE4
ANNUAL REPORT 2002

Uso de la Tierra Land Use Project



Land Use Studies:
Reconciling the Dynamics of Agriculture with the Environment

CIAT

October 2002

PROJECT PE-4

LAND USE STUDIES: RECONCILING THE DYNAMICS OF AGRICULTURE WITH THE ENVIRONMENT

ANNUAL REPORT 2002

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

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Project PE-4: Land Use Studies: Reconciling the Dynamics of Agriculture with the Environment

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Executive Summary

This project addresses the need for spatial information by developing tropical agriculture. It does so by providing maps, insights, analytical methods, and software tools that enable people to use spatial information to make better decisions at a range of scales, and for a range of issues. This report summarizes activities over a wide range of interests that have been grouped into the following clusters:

(1) Generation of spatial data and effective methods with which to manage it;
(2) Analysis of biological drivers that underpin agricultural and landscape function;
(3) Analysis of socioeconomic variation to elucidate the linkage between land use and poverty at national to local scales;
(4) Identification of vulnerability and risk to natural hazards, which are significant constraints to development;
(5) Development of methods to link farmer and scientist knowledge; and
(6) Land Use planning as part of Convenio Colombia.

Clusters 1-4 are predominantly concerned with top-down process of delivering data, methods, and tools to policymakers, normally operating at global to sub-regional scales. Cluster 5 is bottom-up, and tries to develop knowledge that would be used by farmers. Cluster 6 focuses mainly on the process of land use planning within municipalities.

The main report describes 44 separate activities in over a 12 countries with 60 collaborating institutes. Clearly these cannot all be represented in this summary, which selects one or two from each group to illustrate how they contribute towards outputs described in the logframe.

Output 1: Baseline and time-series data for subsequent analysis

A major outcome of work this year has been the development of MarkSim v1.0, a method that generates simulated detailed daily weather data for the entire pan-tropical region from a relatively sparse network of weather stations. The method is the culmination of over 25 years work. It has been tested rigorously and is now available as a Windows-based tool that responds simply by pulling up a map and pointing at the location for which information is desired. Further work has been completed to streamline the handling of vast data files using advanced data-compression methods. A wide range of potential applications exists for this data, some of which have been explained in detail in this report. Paramount amongst these are those that take advantage of MarkSim's capacity to generate weather data in 25 and 50 years' time, by combining broad-scale predictions from global models with detailed simulation from MarkSim.

A second thrust of data generation work is the development of global data exchange and analytical capability, through the Consortium for Spatial Information (CSI) and through the application of ArcIMS software. In collaboration with the United States Geological Survey (USGS), the project carried out the Geospatial Applications to Support Sustainable International Agriculture (GASSIA) Workshop to establish inter-center data exchange capacity through the use of dynamic Internet map servers. An immediate application of Web-based technology was

the CONDOR2 Project, which enables researchers and policymakers in Andean countries to use the Internet to access and analyze spatial data on infrastructure, environment, and society.

Output 2: Information and insight of biological limitations and drivers of land use change

FloraMap is one of CIAT's best-known products. It has completed its first print run of 500 and we estimate is used by over 200 active researchers. A new manual has been produced and climate grids improved ready for release of FloraMap 2.0. We showcased the method this year with two applications: The first was with the United States Department of Agriculture (USDA) and the International Plant Genetic Resources Institute (IPGRI) to focus *ex situ* collection of wild plants within large field study areas in Mexico and Paraguay that were predicted (correctly) to contain selected gene pools. Spatial analyses resulted in the conservation of these important genetic resources, and provided a dataset for validation of predictive models. The second was to predict the catastrophic loss of wild bean germplasm because of climate change, hence the need for pre-emptive conservation, which was guided accurately to suitable locations in Central America. Spatial analysis of climatic variation was also used to predict the likely distribution in Latin America of *Bemisia tabaci*, and hence determine the extent of susceptibility to Whitefly. Careful analysis of climatic variables indicated that a very simple, but effective, rule could be applied at regional scale—areas susceptible to whitefly have 4 or more months of dry season with rainfall less than 80 mm.

Output 3: Analysis and prediction of socioeconomic factors influencing land use development

The joint CSI-Food and Agriculture Organization (FAO)-United Nations Environment Programme (UNEP) food security and poverty mapping project (www.povertymap.net) has established a CG system-wide initiative to map the distribution of poverty and its modifiable drivers at national scale. Work commenced this year in eight countries, which together represent the CG's first coordinated attempt to apply state-of-the art spatial analysis to this basic problem. In addition to acting as overall coordinator, this project also launched research in Ecuador with workshops to establish working partnerships with collaborators and to assess their capacity and needs (http://www/ecuamapalimentaria.info). Maps of *basic needs indicators* were produced for Central American countries. Basic needs maps have never been seen in this format before, and enable decision makers in the region to overlay socioeconomic data with maps showing underlying biophysical limitations.

It is at the farm level that socioeconomic and biophysical factors interact in land use decisions, yet information at this scale is difficult to acquire. Working with the Forages Project, a prototype has been developed to take expert knowledge (more available than hard information in developing economies), and develop a tool for extension workers and researchers to show where specific forages are likely to thrive, or what range of forages is likely to thrive at a given location. This work is highly complementary to the biophysical mapping from FloraMap.

Output 4: Analysis and prediction of vulnerability of land use systems to significant external events

Climate change is expected to present a significant threat to tropical agriculture. But how serious are the effects likely to be, and how will they vary within countries? By applying MarkSim to the outputs from Global Climate Models (GCMs), it was possible to derive synthetic daily input data for the DSSAT crop simulation model, and thereby estimate spatially variable maize yields in 25 and 50 years' time. We have completed the final runs of the trial modeling of maize for the whole of Latin America and Africa. The results show complex effects of climate change. In a few areas yields increase. In many areas, yield decreases moderately enough to be handled by varietal change and breeding for increased stress. In some, the prospects for continued agriculture are poor and major changes in the agricultural system seem evident. Overall the yield decrease could be 10%, or $2 000 000 000's worth of maize crop.

Following from the earlier successes of Indicators for Central America, these tools were packaged within interactive distance learning programs, organized through the World Bank for decision makers and technicians within six Central American countries. Experience with this will assist CIAT to develop similar learning methods for widespread dissemination of products.

Further work was completed on the assessment of landslide risk in Honduras. Two methods were used to predict the incidence of landslide, and tested against actual events that were triggered by Hurricane Mitch. Both methods underestimated the risk of extreme events

Output 5: Methods of capturing farmers' knowledge in land use decision support

Farmer's knowledge about their land remains a major untapped information resource. The value of farmers' knowledge about their local environment has been acknowledged for some time, and its power is unquestioned—farmers will always trust other farmers before so-called experts. But how can this knowledge be tapped and generalized? This participatory research is developing novel ways of capturing farmer's knowledge in geographic information systems (GIS), using intrinsically spatial attributes of landform and location, which farmers are known to be able to articulate well, and which scientists can quantify. The research has so far identified three research areas: First is identification of crossover points between farmers and scientists – what both agree on. This has been quantified using soil biology. Second is the mechanism for farmer-farmer and farmer-scientist dialogue. This is the method of participatory 3-dimensional terrain modeling, which has been developed with local communities in several workshops, and is being written up as a manual (see <http://gisweb.ciat.cgiar.org/sig/local-knowledge.htm). Third is the development of robust and cost-effective means of capturing hard data at the resolution which farmers like. A method using kites and balloons is being developed. This information is georeferenced so that it can be merged with other information in GIS, and enable spatial and temporal monitoring of genetic and biophysical resources. An immediate application for on-farm crop trials is being explored.

Collaboration with Agropolis and La Maison du Télédétection, Montpellier

This 2-year out-posting aimed to stimulate bonding with scientists of French institutions, joint methodological research, the elaboration of joint special projects, and transfer of capacity to CIAT support staff and to partners in Colombia. Valuable contacts have been established, which provide CIAT with access to specialist science. A scientist from the Institut de recherché pour le développement (IRD) will be seconded to CIAT in early 2003. The posting of Manuel Winograd to the Centre de cooperation internationale en recherche agronomique pour le développement - Département territoires, environnement et acteurs (CIRAD-TERA) will continue this link.

Work conducted within the scope of the Convenio Colombia

As part of the Convenio Colombia, this work has developed a framework and mapping tools to lead towards the development of long-term (POT) and shorter-term (PDM) land use plans. While remaining strongly participatory, this framework entrains a number of technical contributions, including a multiple-scale vision-actions-request framework, multi-temporal classified satellite imagery, GEOSOIL, “Arboles de Decision” and *ex ante* assessment of agricultural products. With CIAT’s support, the municipality of Puerto López developed a concerted plan that will guide its activity and expenditures over the next 3 years. The “PLAN DE DESARROLLO 2001-2004, *“Por la Reconciliación y Unidad de Puerto López”* will be an instrument to apply the “*Plan Básico de Ordenamiento Territorial*” of Puerto López. The plan, ratified earlier this year, will officially be launched on CD-ROM at the end of the year. About 100 professionals have already been trained in plan development and the use of MapMaker software.

Other activities

Proposals: Continued emphasis was required this year on developing proposals for donors. Special project funding had dropped as a result of low activity with donors during previous years, during which the project was without a full-time manager.

Water Challenge Program: CIAT was invited by the International Water Management Institute (IWMI) to develop the theme “Multiple Use of Upper Catchments” for the Challenge Program. Simon Cook was nominated Theme Leader for this large program, which has been recommended for approval by the ExCo, and has led the development of a significant research agenda, due to start officially on 1st November 2002 with a 1-year inception phase.

Project Overview

Project Description

Objective: By providing relevant information about land use change, the project aims to help decision makers, ranging from farmers to World Bank investors, reduce the uncertainties of development.

Outputs:
1. Baseline and time-series data for subsequent analysis performed.
2. Information and insight of biological limitations and drivers of land use change developed.
3. Analysis and prediction of socioeconomic factors influencing land use development performed.
4. Analysis and prediction of vulnerability of land use systems to significant external events performed.
5. Methods of capturing farmers' knowledge in land use division support developed.

Gains: Detailed georeferenced databases on land use, ecological, and socioeconomic factors. Environmental and sustainability indicators of land use, networking on the environment, land use, sustainable agriculture, and indicators. A blend of theoretical, methodological, and field-based inquiry for decisions on sustainable agriculture. Upscaling and extrapolation tools available for a variety of uses.

Milestones:

2002 Germplasm targeting tool completed (Beta version). World climate surfaces upgraded to 1-km grid. *FloraMap 2.0* released. *Dynamic Land Use Model* (Beta version) released. Indicators for sustainability at the municipality level published for Andean countries.

2003 Strategic databases on agricultural, environmental, social, and economic issues maintained and updated. Environmental and sustainability indicators routinely distributed to decision makers in the region at different levels. Remote-sensing information on land use changes in tropical America routinely collected and available for different purposes. Integrated GIS and mathematical models to support land management decisions by national organizations. National and local institutions from tropical America strengthened to use information, analysis, and tools.

2004 Data, analyses, and tools for natural resource management disseminated throughout tropical America and other tropical areas of the world.

2005 Delivery of second-order information products (e.g., policy guidelines, analytical methods, or information exchange networks) that will reduce the risks associated with specific land use changes that might otherwise threaten the well-being of significant numbers of rural people in the tropics. These will address specific issues such as water productivity, climate change, and application of new germplasm.

Collaborators: ICRAF, CIP, ILRI, ECLAC, Univ. Guelph (Canada), IICA (Costa Rica), IILA (Italy), IIASA (Austria), WRI (USA), RIVM (Netherlands), TCA (Amazonian Cooperation Treaty), Earth Council (Costa Rica), World Bank; NARS, GOs, and NGOs in Latin America: DNP, IGAC, MinAmbiente, IDEAM, CARDER (Colombia); Ministry of the Environment, EMBRAPA (Brazil); IVITA, INIAA (Peru); INIAP (Ecuador).

CGIAR system linkages: Protecting the Environment (60%); Improving Policies (20%); Enhancement and Breeding (10%); Saving Biodiversity (10%). Contributes to the Ecoregional Program for Tropical Latin America.

CIAT project linkages: GIS studies assist SB-1, SB-2, IP-1, and PE-2; model development with PE-3, PE-5, and BP-1.

Project Work Breakdown Structure

Project PE-4: Land Use Studies: Reconciling the Dynamics of Agriculture with the Environment: 2002

Project Objective
To reduce the risk of agricultural development in the tropics by providing spatial information about significant opportunities and risks of natural resource management

Output 1

Baseline and time-series data for subsequent analysis

1.1 Population, crop, and selected databases generated

1.2 Rainfall model available to collaborators in the tropics

1.3 Detailed climate data sets developed for modelers

1.4 Detailed future climate data sets used for prediction of climate change effects

Output 2

Information and insight of biological limitations and drivers of land use change

2.1 Threats of global climate change (GCC) to regional crop production defined for entire regions

2.2 Threats of climate change to plant generic resources defined

2.3 Models developed for defining the impact of GCC on the potential productivity of a range of crops

Output 3

Analysis and prediction of socioeconomic factors influencing land use development

3.1 Spatial processes driving land use change identified

3.2 Impacts of policy, external forces or physical geography improved

3.3 Distribution of poverty and its causes identified more accurately using spatial information

Output 4

Analysis and prediction of vulnerability of land use systems to significant external events

4.1 Indicators of vulnerability adopted by policy agencies

4.2 Spatial information on vulnerability used to reduce investment risks in at least one country case study

Output 5

Methods of capturing farmers' knowledge in land use decision support

5.1 Respective roles of farmers and scientists identified in the local decision-problem

5.2 Correlation identified between farmers and scientist knowledge

5.3 Farmer-farmer decision support network established

Project Logframe - Workplan 2002-2005

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Goal To reduce the risk of agricultural development in the tropics by providing spatial information about significant opportunities and threats of natural resource management.	Risk recognized as a reducible factor. Information adopted by decision makers. CIAT, CGIAR, or other collaborating research institutional activities enhanced by the ability to target activities.	Policy, projects, or funding strategies modified identifiably to include spatial information. Research portfolios modified identifiably by targeting or pre-selection. Risk management strategies, based on spatial information, included in development projects.	
Purpose To enable decision makers, ranging from farmers to World Bank investors, to reduce the uncertainties of development by providing relevant information about land use change.	Decision makers use spatial information to reduce risk.	Documented case studies at farm, national, and regional scales. Published methods of generalizing improved decision making, using spatial information of land use.	That uncertainty significantly obstructs land use decisions at a range of scales. That spatial variation introduces significant uncertainty to these problems. That relevant spatial information can be generated in a cost-effective manner.
Output 1 Baseline and time-series data for subsequent analysis performed.	Population, crop, and selected databases generated. Rainfall model available to collaborators in the tropics. Detailed climate data sets developed for modelers. Detailed future climatic data sets used to predict climate change effects.	Information available at CIAT. Selected information downloadable at CIAT Web site.	Information can be delivered to analysts and decision makers.
Output 2 Information and insight of biological limitations and drivers of land use change developed.	Threats of global climate change (GCC) to regional crop production defined for entire regions. Threats of climate change to plant genetic resources defined. Models developed for defining the impact of GCC on the potential productivity of a range of crops developed.	Maps and databases completed. Models developed, calibrated, verified, and published. Projects developed to apply models.	Sufficient data are available to generate insights.

Narrative Summary	Measurable Indicators	Means of Verification	Important Assumptions
Output 3 Analyses and predictions of socioeconomic factors influencing land use development performed.	Spatial processes driving land use change identified. Impacts of policy, external forces, or physical geography improved. Distribution of poverty and its causes identified more accurately, using spatial information.	Published explanations of the improved accuracy of explaining land use change. Spatial drivers of poverty explained in published case studies by June 2004. Information used to direct poverty alleviation policy. Information used to target further research activity.	Sufficient data are available to generate insights. Links exist with governmental and NGO partners to enable implementation of poverty alleviation policies.
Output 4 Analyses and predictions of vulnerability of land use systems to significant external events performed.	Indicators of vulnerability adopted by policy agencies. Spatial information on vulnerability used to reduce investment risks in at least one country case study.	Methods of vulnerability assessment published with case study at national or regional scale by June 2004. Ex ante analysis of the benefits of risk reduction published.	Sufficient data are available to generate insights.
Output 5 Methods of capturing farmers' knowledge in land use decision support developed.	Strengths and weaknesses, overlaps and gaps identified between farmer and scientist knowledge with respect to locally (e.g., declining soil fertility) and globally rooted resource-base management problems (e.g., climate change). Respective roles of farmers and scientists identified in local decision problems about locally and globally rooted resource-base problems. Farmer-to-farmer decision-support network established that tackle selected locally and globally rooted resource-base problems.	Case study documented of farmers generating information and merging with "hard" data on natural land resources. Network of farmer support initiated, including a minimum of 200 users at second-order organization level. Generated methods and tools documented and disseminated.	Sufficient data are available to generate insights. Local structures enable network establishment.

Research Highlights 2002

Output 1

- Release of MarkSim™. After almost 25 years of research, the Windows® commercial version (1.0) of MarkSim™ is released on CD-ROM with a 96-page users' manual.
- An index structure devised to accelerate access to records with a given climate for a FloraMap-type algorithm by a factor of 500 000. Work is now proceeding on constructing a structure-transparent application.
- CSI: Annual meeting and GASSIA workshop. Participated in live, real-time demonstration of distributed GIS. Developed CIAT spatial data clearinghouse node, including 74 digital maps in a metadata catalogue. Increased CSI membership from 9 to 14 CGIAR centers. Negotiated new agreement between CGIAR centers and the Environmental Systems Research Institute (ESRI) for GIS software and training. Discharged CIAT's responsibility as CSI coordinator.
- Some 7000 maps from around the world, mostly in the tropics, documented in an ISIS database for CIAT's internal use, and for consultation outside of CIAT. Satellite imagery of 6 years was georeferenced and their classification initiated.
- A Central America ListServer was established
- A GIS developed for CIAT Field Operations and Maintenance to document the present and historical land uses, topography, and soil conditions. The final product is designed to provide researchers and field workers with detailed information on the conditions within the fields they use for agricultural research.
- Land use change in San Dionisio, Nicaragua: A diagnostic baseline study of accuracy and utility of spatial information for the San Dionisio benchmark area completed.

Output 2

- FloraMap GIS and modeling used to target four different collecting missions of wild peanuts, wild chili, and wild "tomatillo" (husk tomato) in Mexico and Paraguay. The spatial analyses saved field effort and enabled the conservation of these important genetic resources, and provided a dataset for the quantitative validation of predictive species distribution models.
- Completed field collection of biological and environmental data within and around the Tiputini Biodiversity Station in Napo, Ecuador, and in Reserva Tambito, Cauca, Colombia. Some 602 species collected in Tiputini, and some 245 species in Tambito.
- A simple set of climate rules derived to predict the susceptibility of an area to infestation by whitefly. These can identify areas of potential spread of the pest and its associated viruses.
- QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) principles applied in an interactive ArcView GIS tool

Output 3

- Poverty mapping: First year completed. Spatial analytical methods workshop organized in Rome (April); funding secured for 8 country-level studies of the geographic dimensions of food security and poverty.
- Ecuador Poverty Mapping Case Study workshop in Quito identified likely driving forces of food security/poverty, scenarios for possible futures, needs and case study areas. Data inventory completed, key data sources identified, and efforts started to obtain data. Food security variable defined and process started to create disaggregated maps of food security and potential driving forces.
- With Forages Project, a prototype developed to use expert knowledge and generally available spatial information of biophysical and socioeconomic conditions to produce maps that show where specific forages are likely to thrive, or what range of forages is likely to thrive, at a given location.
- Basic needs map for Central America created.
- Values of spatial interaction produced for milk producing farms in five regions of Colombia.

Output 4

- Impacts of 25- and 50-year climate change on maize yield estimated for the whole of Latin America and Africa. The results show complex effects of climate change. Yields increase in a few areas. In most, yield decreases slightly. In others, significant decrease is predicted, the prospects for agriculture are poor, and major changes in the agricultural system seem imminent. Overall, the yield decrease could be 10%, or $2 000 000 000's worth of maize crop.
- Rural Sustainability Indicators for Central America developed for World Bank Distance Learning projects for six countries in Central America.
- Landslide distribution in San Dionisio, Nicaragua mapped exhaustively and compared with predictions from deterministic SINMAP algorithm and the probabilistic WofE algorithm. Masters thesis submitted at the University of Hohenheim, Germany.
- Impacts identified of nine cassava-based land use options on soil structural variation as an indicator for system resilience.

Output 5

- Kites and balloons-based aerial photography developed to provide cost-efficient, high-resolution (spatial and temporal) monitoring of genetic and biophysical resource systems at field and farm scale.
- A method developed to analyze jointly local and scientific perceptions of genetic and biophysical systems at farm to catchment scales (up to 50 000 ha).
- A clear relation shown at catchment scale between local land quality classification and measured biodiversity of the soil macro-fauna. Also shown that land use influences soil chemical and physical conditions that impact soil biodiversity at catchment scale. These provide a basis for practical, diagnostic soil quality indicators.

- Preliminary framework of knowledge assessment based on uncertainty and risk management established. Submission of the publication “Helping soil scientists and Andean hillside farmers to see the obvious about soil fertility management” to Journal Agriculture, Ecosystems and Environment

Collaboration with Agropolis and la Maison du Télédétection

- A collaborative project between IRD and CIAT (Integrated Regional Development Approach, AIDeR) planned for Bolivia and Colombia; with IRD’s Hubert Mazurek out-posted to CIAT.
- Rule-based method developed in collaboration with CIRAD- Département d’élevage et de médicine vétérinaire (EMVT) to classify time series of satellite images.
- Participatory planning, monitoring, and adaptive management methods will be applied in the Brazilian Amazon in collaboration with CIRAD-TERA and EMVT.
- CIAT included in a Research network for territorial development.
- Juan Gabriel León, a Colombian student, completed a Diplôme d’études approfondies (DEA) in water sciences with the Ecole nationale du génie rural des eaux et des forêts (ENGREF).

Work done within the Convenio Colombia

- A framework conceptualized to link image analysis to the processes of planning and adaptive management.
- A method formalized of radiometric normalization of image time series, and calculation of meaningful indices from the images, to allow national institutions to provide local users with products. A method developed to derive land use classifications and maps of potentially degraded lands from times series of multi-spectral images.
- An ex ante economic analysis of different agricultural strategies conducted with farmers of five villages in the municipality of Puerto Lopez. In the village of El Turpial, an economic analysis of a variety of strategies was conducted under contrasted scenarios, aiming at finding robust strategies. The “regret” criteria of Savage can be used with other indicators to indicate the economical robustness of agricultural production strategies, and can be incorporated in a multi-criteria analysis.
- Decision trees developed in the Soils Project adapted to a database decision support tool in GIS.
- With CIAT’s support, the municipality of Puerto López developed a concerted plan to guide activity and expenditures over the next 3 years. The “PLAN DE DESARROLLO 2001-2004, *“Por la Reconciliación y Unidad de Puerto López”* will be an instrument to apply the “*Plan Básico de Ordenamiento Territorial*” of Puerto López. The plan, ratified earlier this year, will officially be launched on CD-ROM at the end of the year. Training provided on how to develop a “*Plan de Ordenamiento Territorial*”, and, in this context, how to use the MapMaker software and the visions-actions-requests participatory planning methodology (VAR) developed in CIAT. About 100 professionals trained in plan development and the use of MapMaker software.

Progress Report

Output 1. Baseline and time-series data for subsequent analysis

1.1. MarkSim v1.0

Objectives

Researchers using dynamic crop models or trying to assess climatic risk in agriculture in the tropics are severely hampered by a lack of good daily weather data for this purpose. Weather stations are few and far between, and the length and reliability of the record is sometimes not what they would wish. Interpolated monthly mean climate surfaces are of great use to some climate applications such as FloraMap®, but fall short where daily weather is required. MarkSim™ is designed to fill this gap by simulating daily rainfall from the climate surfaces.

Materials and Methods

A third-order Markov model was fitted to daily rainfall data from 9162 weather stations with longer than 10 years of record. These were distributed throughout the world, but predominantly in the tropics. The climates (monthly rainfall, temperatures, and diurnal temperature range) of these stations were used in a modified leader cluster algorithm to group word climates into 709 clusters. Within each cluster, derived climate variates were used in a stepwise regression process to find a model for the 117 parameters of the complete daily simulation model. The stepwise process was modified to exclude variates that produced regression coefficients that could extrapolate results beyond the range of the data when used to reconstitute the parameters. This provided built-in stability for the models. Added to that, a set of bounding functions was developed to double check the validity of the parameter predictions.

MarkSim™ uses the interpolated climate grids to provide the driving data. It identifies the climate of the point requested, classifies it into its relevant cluster, applies the cluster regression models to generate the Markov parameters, and then stochastically simulates as many years of daily data as required. The standard Markov model underestimates tropical rainfall variances considerably. We therefore devised a method that stochastically re-samples the Markov parameters to bring the annual variance in line with reality.

Results

The method has been rigorously tested and the results have been reported in a series of papers over the years (Jones and Thornton, 1993; 1997; 1999; 2000[1]).

We have developed a sophisticated user interface with mapping capability to run under Windows®. This allows the user a great flexibility in how s/he requests the data. The basic method is by simply pointing at a map. This identifies the point to be simulated and the user is led through a series of questions on what sort of output is required. For power users that require large files of data on multiple points, there are options for various types of batch processing, all controlled through the MarkSim™ user interface. Output data can be requested in a simple calendar format of daily rainfall data, or in DSSAT file format with daily rainfall, maximum and minimum temperature, and radiation for direct input to the International Consortium for Agricultural Systems Application (ICASA) suite of crop models.

The 96-page manual includes a tutorial, a users' guide, a chapter on the theory of the model, and a comprehensive index. The same information is available online as a Help accessible during an interactive session.

The print run for Manual and CD-ROM is 500, and we are confident of selling this quantity over the next year or so at US$75 per copy.

Contributors: Peter G. Jones (consultant, CIAT); Philip K. Thornton (consultant, ILRI)

1.2. Climate database project

Objective

The Land Use Project has an extensive climate database. This is used continually by the project in the course of many of the analyses and in the development of the climate application tools. For many years, this database was available to CIAT researchers from the Conversational Monitor System (CMS). When this system was scrapped, we moved to a UNIX-based system, with Oracle as the database software. The climate database was transferred to Oracle, but there has never been a simple user interface for the scientific user. This project is to create an interface visual-friendly type GIS for the climate database with functions for data validation and checking. The database will be redesigned to make use of the advantages of the relational databases (Oracle).

[1] Jones, P.G.; Thornton, P.K. 1993. A rainfall generator for agricultural applications in the tropics. Agric For Meteorol 63:1-19.
Jones, P.G.; Thornton, P.K. 1997. Spatial and temporal variability of rainfall related to a third-order Markov model. Agric For Meteorol 86:127-138.
Jones, P.G.; Thornton, P.K. 1999. Fitting a third-order Markov rainfall model to interpolated climate surfaces. Agric For Meteorol 97:213-231.
Jones, P.G.; Thornton, P.K. 2000. MarkSim: Software to generate daily weather data for Latin America and Africa. Agron J 93:445-453.

Materials and Methods

This information was compiled over about 22 years; work begun by Peter Jones in 1978. The data originate from government organizations such as the Instituto de Estudios Ambientales (IDEAM) in Colombia, and from data sets bought from nongovernmental organizations (NGOs).

The data contained correspond to over 20 000 stations for the tropics of the continents of Asia, Africa, and Latin America. Each station has its own parameters—name, latitude, longitude, and elevation—with its corresponding monthly data (from January to December) for the different meteorological variables—precipitation, evaporation, temperatures, relative humidity, and evapotranspiration.

The present project began in August 2002, and expects to finish in December 2002. Taking advantage of the experience obtained with the Activex controls (ESRI MapObjectsLT utilized in the products FloraMap and MarkSim, which is Royalty free, we seek to provide an application for the consultation of climate data in CIAT.

Results

The climate data of this database have been used for different investigations, presentations, articles, and posters (e.g., Jones and Thornton, 1999[1]; 2000[1]; Jarvis et al., 2002[2]; Jones et al., 2002[2]). and in present production. They have also been the source of information for the production of climate surfaces and the FloraMap and MarkSim tools.

Contributor: William Díaz

1.3. New data structures for climate applications

Objectives

The present form of data storage and access severely limits the size of climate grid that can be handled by FloraMap, MarkSim, and other CIAT climate applications. It is intended that all of these should be able in the near future to handle grids calculated from the 30-arc second elevation model GTOPO30. However, if the present grid coverage were translated to 1-km precision, under the present FloraMap structures they would occupy over 100 Gb and would be impossible to work with.

The aim is therefore twofold. To create an index system that will allow fast access from very large files to only those records relevant to a given problem, and to compress the climate grid data files as much as possible without losing access time and precision. I have previously achieved compression rates better than 98%, but will report here the latest work on index development.

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[2] Jarvis, A.; Guarino, L.; Williams, D.; Williams, K.; Hyman, G. 2002. The use of GIS in the spatial analysis of wild peanut distributions and the implications for plant genetic resource conservation. Plant Genet Res Newsl 131.

Jones, P.G.; Guarino, L.; Jarvis, A. 2002. Computer tools for spatial analysis of plant genetic resources data: 2. FloraMap. Plant Genet Res Newsl:1-6.

Materials and Methods

I made a test climate grid by adding all the pixels from the FloraMap and MarkSim grids plus a set of pixels from the MarkSim calibration set. This yielded a complete coverage of all world climates in a set of 504 000 pixels of varying sizes. I used this to construct the variance/covariance matrix, and extracted the principal components for the world climates.

I then wrote bit interleave routines for 32- and 64-bit Morton key indices using 2, 3, and 4 key components. I also had to provide the inverse routines to extract the key components from a Morton key. I constructed the Morton keys for latitude and longitude, attached these to the climate grid records, and sorted the file in ascending order. I then compressed the data to 2-byte integers, and created a direct access file ordered by Morton key. This, on the average, puts geographically adjacent records close together in the file, and therefore they stand a good chance of falling into the same block.

I then constructed six climate indices using the 32- and 64-bit Morton key routines. To do this, I transformed the first four of the world climate principal components to probabilities, and multiplied by the largest integer necessary to provide a key component for the bit interleaves. This depended on the number of key components and the size of the Morton key.

The next step was to develop search algorithms for the indices, both geographic and climatic. I originally considered a simple binary search, but this, although highly efficient, adds an iteration each time the file size is doubled. The indices, although fractals, appeared to be well behaved on a large scale and showed remarkable linearity (Figure 1). I therefore decided to try for a more efficient algorithm. I tried the regula falsi method, relying on the large-scale linearity to allow me to approximate quickly to the key position. This worked well, but of course fails locally where the linearity breaks down. I therefore devised an algorithm to use the regula falsi method to home in on the locality of the key, but switch to the more reliable binary search once this was determined.

Results

All six of the climate indices were well behaved and, apart from locally, largely linear. Figure 1 shows the graph of the index using the first four principal components in a 64-bit key. I found that the 64-bit key could be handled as a real value, avoiding the problems of 64-bit integer manipulation.

I timed the search routines for each of the six options and compared them with the times for an exhaustive search of the file. I repeated this for various file sizes. Figure 2 shows the timing results.

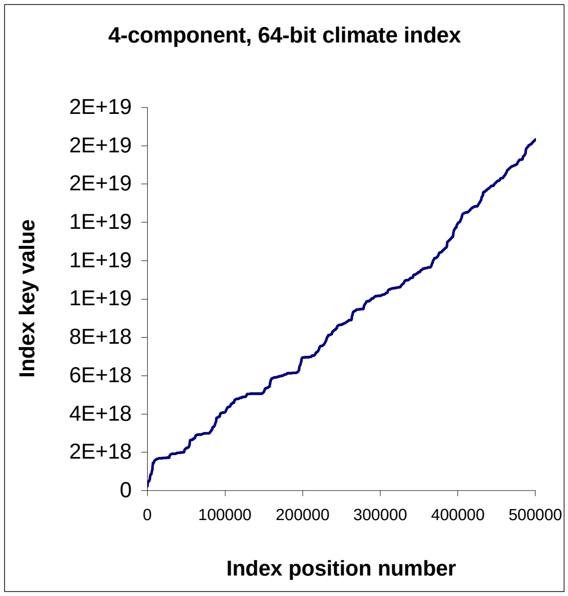

Figure 1. The index values for the 4-component, 64-bit climate index plotted against index position.

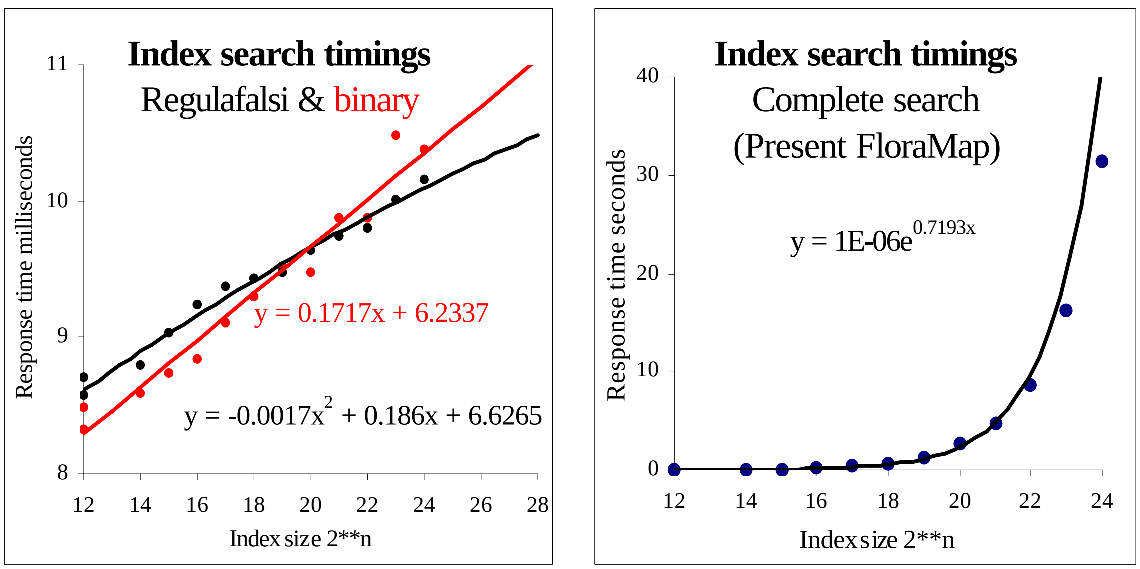

Figure 2. Search algorithm timings.

Note that the response time axis is in seconds on the right-hand graph, but in milliseconds on that at the left. I have extrapolated the timing to a file size of 2^{28} on the left-hand graph. This is the file size we will eventually be handling. Obviously, the right-hand graph would go off the page if extrapolated to this level. The regula falsi method is clearly of benefit for large file sizes. However, because we will probably be handling the index in blocks rather than a single array, the binary search may still be the optimum. Now we have the figures to make an informed decision. Extensive tests have indicated that the correct index to use will be the four-component, 64-bit index.

Once we have found the target record, the next step is to deliver the keys of all the records to the user in order of descending similarity until s/he is satisfied that all relevant records have been recovered. Assuming a user is measuring climate similarity with a simple Euclidean distance measure, how is that distributed along the index from a target record? Figure 3 shows the average of results from 20 runs using 20 random target records. We can see that, on the average, very few points need to be read to include all records to a similarity of, say, 25 units. This, in practice, would be a realistic target for many applications. In fact, because the users' distance measure is not identical to the Morton key, some records would be missed occasionally unless the search was extended to some extent. Finding the rule for this stopping point is the subject of current research.

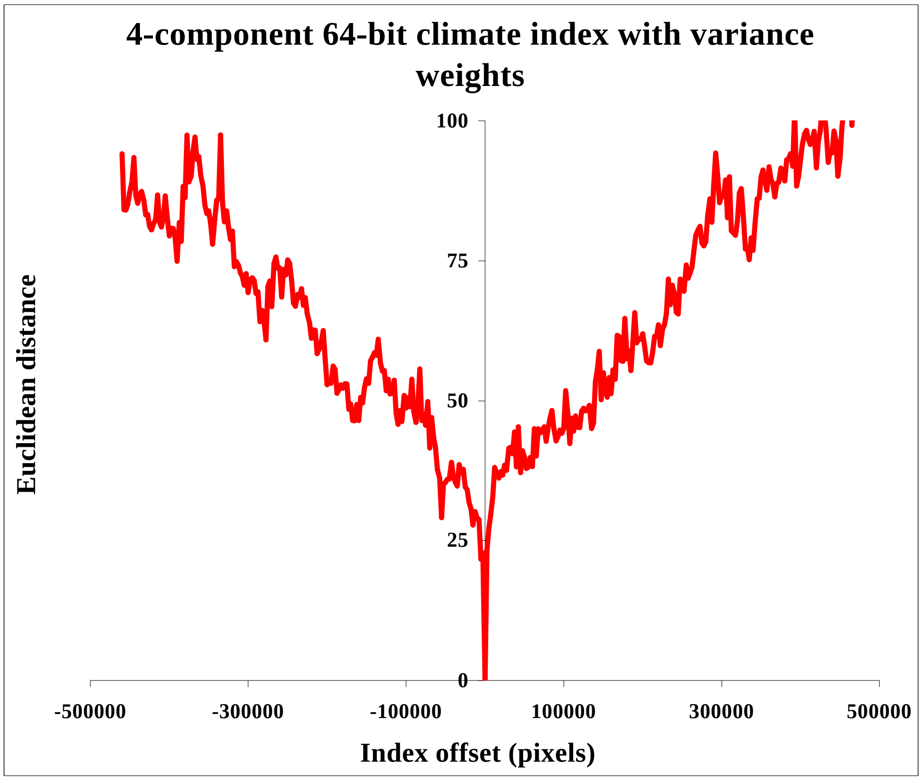

Figure 3. Climate similarity using simple Euclidean distance versus offset against a target record.

In Figure 4, the red line shows a piece of a typical, random, Peano-type curve defined by a Morton key composed from the X and Y positions of the points. In order to find all the points in the blue ellipse, it is necessary to traverse the region of the index marked in green. The stopping points on the index are marked with the blue stars. In the case of the geographic index, where X and Y are longitude and latitude, the problem is simple. The bounds of the orange rectangle are easily calculated and the search stops when the star-marked points are encountered.

In the case of the climate indices, this is not so simple as the user's distance measure will need calibrating against the Morton key. Work on this aspect is now in progress.

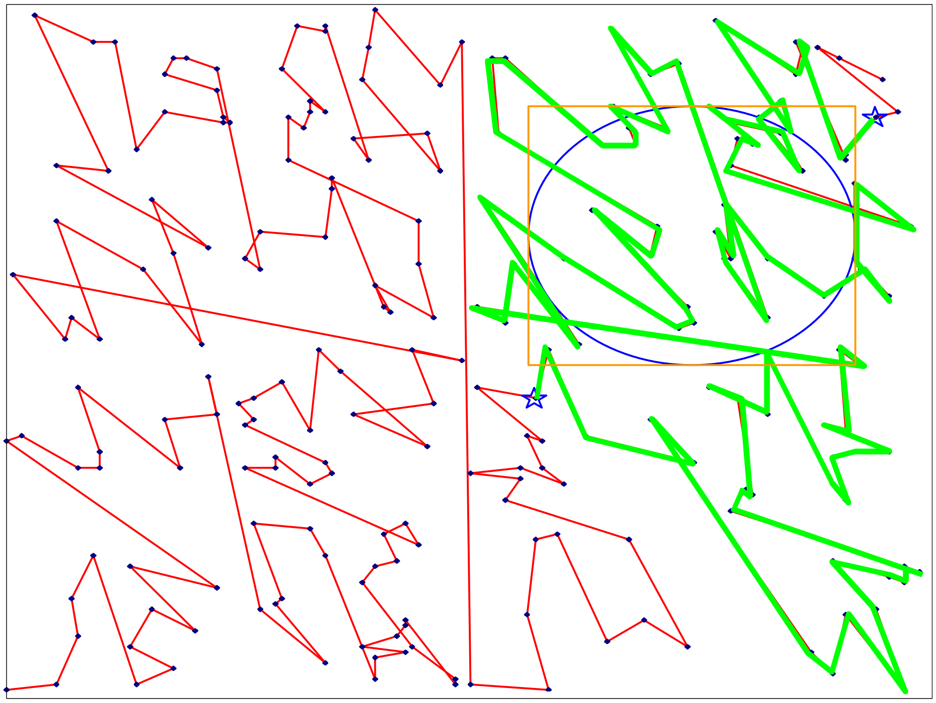

Figure 4. A random, Peano-type curve defined by a Morton key.

Outputs

The Fortran routines for index construction, Morton key manipulation, and index search and management will be used to create a data retrieval system that is transparent to the user. It will be loaded directly with CIAT climate applications, which will all use the common data structures and access methods. We are considering packaging the access methods as an ActiveX component for third party use.

Contributor: Peter G Jones (consultant)

1.4. CGIAR Consortium for Spatial Information (CSI)

Introduction

The CSI is a CGIAR system-wide initiative to advance geographic information science and technology for improved land management, sustainable agriculture, and poverty alleviation. Former CIAT Director General (DG), Grant Scobie, and other CGIAR DGs officially launched the CSI during the 1998 mid-term meeting in Brazil. CIAT has led the CSI since its founding. In accordance with CSI bylaws, coordination of the effort will be passed to IWMI in January 2003.

Materials and Methods

CIAT and the USGS organized and carried out the GASSIA workshop in Sioux Falls, South Dakota from 19th to 31st of May 2002. Twelve CGIAR centers participated along with our partners from international, regional, and national organizations. The workshop included USGS- and ESRI-led training in the development of structured geographic metadata, spatial data clearinghouses, and dynamic Web mapping with ArcIMS software. The Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) conducted a 1-day seminar on legal and intellectual property rights issues in the use of GIS for agriculture. Workshop participants took part in a 2-day consultation and planning exercise to set up future initiatives advancing geographic information science and technology for sustainable agriculture.

CIAT advanced efforts to develop and participate in spatial data infrastructure initiatives at all levels. The first CGIAR spatial data clearinghouse node was set up on CIAT servers and registered in global networks (links). The CIAT clearinghouse node holds metadata records for 74 digital maps available for download, or by ordering through the CIAT Communications Unit. Our participation includes several dynamic mapping Web pages built with Open GIS protocols for data sharing and distributed GIS. These protocols permit dynamic mapping on the Internet from multiple geographic data servers. The training and software provided at GASSIA will allow other CGIAR centers to build their own clearinghouses, which will advance our common goal of coordinated spatial data management in the CGIAR.

On behalf of all CGIAR centers, CIAT negotiated an expanded new software and training agreement with ESRI. The agreement will give CGIAR centers greater access to GIS software and training at lower costs. The agreement includes the donation of ArcIMS software for building dynamic Internet map servers.

Results

?? All 16 CGIAR centers can take advantage of the new software agreement with ESRI.
?? Under ESRI agreement, all CGIAR personnel can use the ESRI Virtual Campus.
?? 25 CGIAR GIS professionals were trained at the GASSIA workshop.
?? Internet map servers are already established at ILRI, the International Rice Research Institute (IRRI), IWMI, CIAT, and Center for International Forestry Research (CIFOR)
?? CSI membership was increased from 9 to 14 CGIAR centers.
?? CSI initiatives are expected to advance coordinated spatial data management in the CGIAR.
?? The GASSIA planning seminar is expected to set course for new initiatives in geographic information science and technology in the CGIAR.

Contributors: Glenn Hyman, Simon Cook, Steffen Schillinger, Elizabeth Barona, Begoña Arana, Claudia Perea

1.5. Development of a tool for planning infrastructure in Andean countries, in Internet environment, and for different users

Objectives

- ?? Develop and implement a GIS in Internet environment for preliminary planning and evaluation of infrastructure projects based on the CONDOR tool
- ?? Create access via Internet with a user-friendly tool to support the decision-making process for internal and external users and clients of the Corporación Andina de Fomento (CAF) and Conservation International (CI)

Materials and Methods

The methodology defined for the present project is based on developing several stages from the viewpoint of technical evaluation of programs, on developing and programming of the interface, and on institutional implementation and analysis for creating capacity to use the tool.

The first stage was to evaluate the map servers. A technical evaluation was carried out on the possibilities and limitations of the different Map Server systems available on the Internet. The criteria of the evaluation were defined based on navigation and viewing, logical and graphic consultations, basic geometric operations, variation of symbols and colors, advanced geometric operations, generation of reports on consultations, viewing of documents, automated map generation and printing, and access to external databases and the Metadata system.

Based on the map server selected, a new version of the tool, CONDOR 1.2, was designed, and the user interface. Next, the CONDOR 1.2 database and other databases were organized into basic, environmental, and socioeconomic data. The tool's functional character of spatial analysis and navigation was improved to design, develop, and implement the new system using Web technology. Finally, the new system was integrated in the CAF and CI Web pages, and installed on-line. On-line help was created, training materials for the user institutions of the tool, and evaluation questionnaires for the stage of validation and testing of the interface and the tool.

Results

The project provides relevant information, tools, and analysis about infrastructure, environment, and society to different users for the Andean region and countries. The interface developed allows users to download and print useful information and analysis developed with the CONDOR 2 tool via a user-friendly Web interface in Internet. At the same time, the CONDOR 2 tool contains a series of functions that allows users to analyze and produce useful information to improve planning and decision-making processes. For example, the early warning functions allow users to analyze and produce information about different components of the development and planning processes.

Finally, with the development of the CONDOR 2 tools, an improvement of the information available at CIAT and partners' institutions (CAF and CI) for the Andean countries was obtained, as well as a better understanding of the different stages to develop and use this type of tool at institutional level. All the information, interface, and help are available on-line at the Internet site created for the project at: http://gisweb.ciat.cgiar.org/condor/condor.htm

Contributors: Steffen Schillinger, Manuel Winograd, Begoña Arana
Collaborators: CAF; CI

1.6. Documentation and use of the "MapoTeca" – a treasure of information to provide support to all of CIAT

Objectives

?? Document the significant collection of maps for the project
?? Create a user interface to consult the "MapoTeca"
?? Promote and grant access to the MapoTeca for CIAT scientists

Methods

Over the past few years, the project has been investing in the documentation of the map collection, and this year it was completed. The database is in ISIS, and has been linked to a Web interface to permit users within and outside CIAT to search for specific maps based on various fields from geographic coordinates and administrative units to thematic properties.

Results

In the last 15 years, the Land Use Project (formerly the Agro-ecological Studies Unit) has collected some 7000 maps in 74 different countries, so that we now have one of the best map collections for the tropics. The "MapoTeca" (or map library) counts on a large collection of maps at different scales and of different countries mainly of the tropical zone. These maps are now found registered in an ISIS database.

In order to assure that the data were consistent, a thesaurus was generated in both English and Spanish. The new thesaurus consists of a combination of existing thesauri commonly used in libraries (AGROVOC and CAB) with some modifications and additions. This thesaurus is to be used in all documentation of spatial data for the project.

We are now in the process of promoting the use of the MapoTeca within CIAT, and setting up a system of loaning these maps for scientific support to other projects.

Contributors: Silvia-Elena Castano, Rosalba Lopez, Lygia Garcia, Andy Jarvis
Collaborators: Edith Hesse, Carlos Saa, Mariano Mejia (Information and Documentation Unit)

1.7. Characterization and development of a geographic information system for the CIAT experiment station

Objectives

The objective of this project was to organize the existing spatial data for the CIAT fields and place them in an accessible database. Specific objectives were to:

(1) Produce maps of soil conditions using the existing soil analyses that have been made around the CIAT fields;
(2) Spatially map the CIAT fields, and create a digital elevation map of the CIAT station in Cali;
(3) Georeference all of the CIAT drainage canals, and carefully examine drainage gradients; and
(4) Collate this information and produce a GIS to clearly present these data to non-GIS professionals whose work involves the CIAT fields.

Materials and Methods

Extensive data collection in the field was coupled with documentation of paper records to provide a digital and spatial information system for the CIAT fields, past and present.

Howeler (1986)[3] made a classification of soil types and soil conditions within the CIAT campus. This information was digitized, and interpolation techniques were used to create contiguous surfaces of soil conditions throughout CIAT. Additionally, a global positioning system (GPS) was used to accurately survey the CIAT fields, and the data used to generate a digital elevation model (DEM). GPS and laser distancometry provided information on the position of the drainage canals, and the drainage slope was calculated. All this information was then collated into a GIS to provide an easy-access interface to information on physical conditions, past and present, in the CIAT fields.

Results

This project has created a digital record of field conditions at the CIAT station in Cali. This information is essential in supporting field-based research, and in managing the CIAT fields into the future. The project has highlighted some key problems in the drainage canals, and these have been communicated to the relative people to ensure long-term maintenance of CIAT facilities.

Outputs

- ?? Spatial information of soil conditions around the CIAT fields
- ?? GIS interface for access to spatial information by non-GIS professionals.
- ?? Geopositioning and inventory of the network of drainage canals around CIAT
- ?? Evaluation of the quality and functioning of the drainage canals

Contributors: Silvia-Elena Castano, Victor Soto, Alejandro Daza, Carlos Nagles, German Lema, Glenn Hyman, Andy Jarvis
Collaborators: Ramiro Narvaez, Adriana Agudelo, Delmar Peña, Rito Leon Valencia (Field Operations Unit)

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[3] Howeler, R.H. 1986. Los suelos del Centro Internacional de Agricultura Tropical en Palmira, Colombia. CIAT, Cali, CO. (Working doc. No. 16)

1.8. Land use change in San Dionisio, Nicaragua

Objective

?? Develop a methodology that permits identification of hillside agricultural areas that are likely to be stable, small, and extremely vulnerable to the impacts of land use change

Results

Only few reliable spatial data are available that we can use for further analyses. Climate data in particular are in short supply, and not very reliable. We recommend on-field collection of climate data. The DEM is our best source of information. Unfortunately, we cannot trace back its generation, and are thus unsure about the quality. We have generated a new model. Mapped soils data are useful, but small scale might limit their application. Data collected in nutrient limited trials might be combined with the soils map to increase information density.

The DEM has been further analyzed, and derivates generated. These characteristics have been utilized in a fuzzy-k clustering approach to derive units that minimize the variation with respect to topography. The classification analyses provides the means to allocate now further monitoring / measuring devices for characteristics that are dependent on topography, such as rainfall and parameters related to sedimentation and erosion.

Classification analyses were also used to assess the similarity between the San Dionisio watershed and its sub-watersheds with respect to topography, and thus topography-related characteristics. It was shown that the sub-watersheds of Piedra Col, Piedra Lar, and Corozo are very similar to San Dionisio in all conducted fuzzy-k classifications. Of ongoing research, only the biodiversity experiments of Elena Vasquez / Juan Jimenez are capturing the main variation in the watershed related to topography. Sites chosen for the biophysical characterization, sites of trials on limited nutrients, and locations of climatic measurements need to be reconsidered, and most likely re-relocated and / or complemented with other sites.

Figures 5 and 6 summarize some preliminary results of the classification of satellite imagery for the San Dionisio benchmark site. In Figure 5, land use in 1988 was compared with land use in 2000. Overall, there was a 3% reduction of forests; similarly, bushy and other fallow vegetation decreased by about 10% (i.e., more intense land use), while bare soils (indicator of degradation) increased by almost 5%. The trend to intensification was underlined by the extension of annual cropping systems (3.9%) and pastures (3.3%). It is also obvious that the spatial fragmentation is different in both years, warranting further investigation. Figure 6 reveals interesting trends for a range of land uses—increased degradation in recent years (bare soil), increased intensification (maize-bean systems increase, fallow systems decrease), and response of coffee to the falling world market prices.

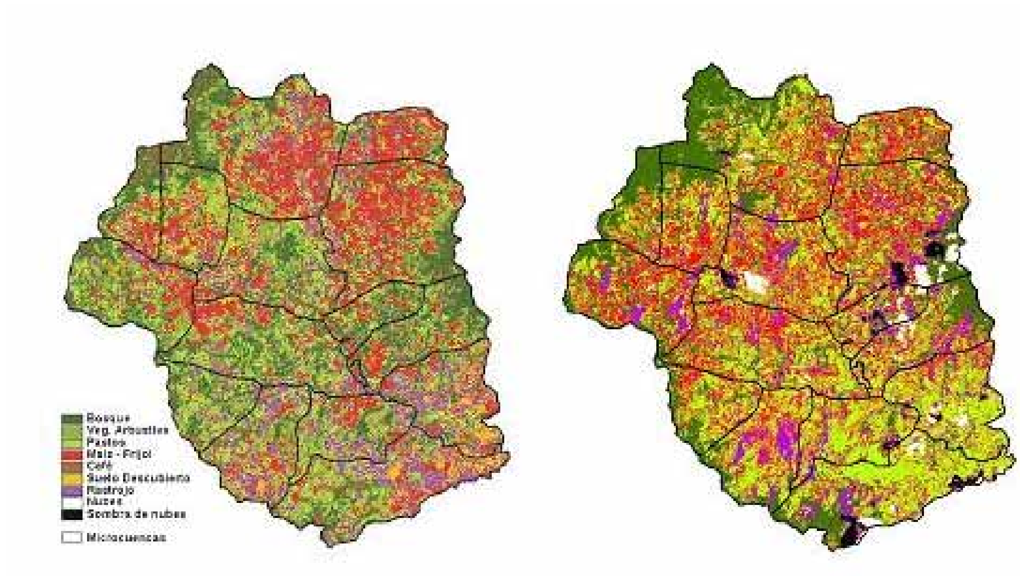

Figure 5. The image shows the satellite imagery based, land use classification for 1988 (left) and 2000 (right) in the San Diniosio benchmark site.

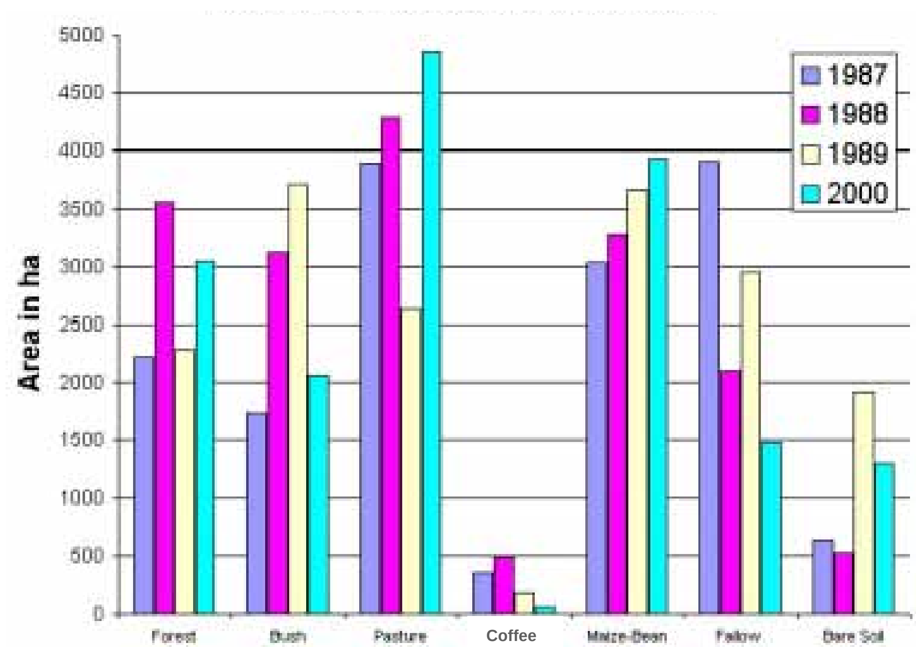

Figure 6. The image shows the land use dynamics for 4 years with interesting trends for coffee, bare soil (land degradation indicator), pastures, maize-bean systems, and fallows.

Output

Facilitation of improved and economically viable community-based land use management strategies that enable increased production, while safeguarding watershed environmental services.

Contributors: Luz Amira Clavijo, Sandra Bolaños, Thomas Oberthür
Collaborators: Axel Schmidt (CIAT-Nicaragua PE-2); Acquisition of the imagery was made possible by funds equally contributed by the Soils, Forages, Hillsides, and Land Use Projects

1.9. Research priority setting: Strategies and tactics to maximize impact of the CIAT Land Use Project (PE-4)

Objective

?? Refine the goals of PE-4 research by modifying targets and pre-selection criteria in order to better allocate scarce human and financial resources

Methods

We compiled summaries of the distinct PE-4 subprojects in order to facilitate knowledge sharing amongst scientists. With a common knowledge, the scientists themselves can debate the criteria with which to prioritize research themes.

Results

The potential impacts of PE-4 activities mirror the broad international development context in which CIAT conducts research. These desired impacts serve as a general guideline for identifying the selection criteria of PE-4 subprojects. CIAT and the PE-4 Project aim to affect many positive changes with broad goals including: Poverty alleviation, environmental sustainability, and economic growth[4]. While these three goals appear to be logical and compatible, they can also conflict. For example, economic growth may come at the cost of environmental sustainability, or forsake the needs of the poor. Progress toward multi-objective goals often requires research to be specially targeted (as shown by the darkly shaded area in Figure 7) by adding extra planning, analysis, and collaborative work beyond the research product. The spatial analysis expertise of PE-4 can help CIAT better focus research and development efforts to the most critical areas and peoples.

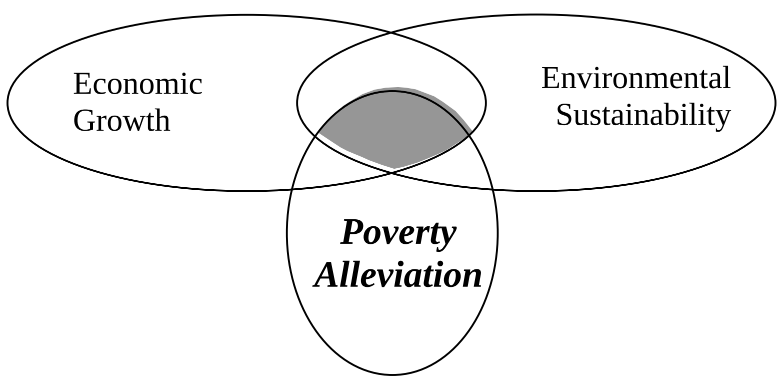

Figure 7. CIAT goals and their inter-relation.

4 These three goals can be stated in many ways. Rural competitiveness could also imply economic growth, poverty alleviation relates to household livelihoods, and agro-ecosystem health has strong environmental sustainability components. These three goals are also termed the "critical triangle" of sustainability, growth and poverty alleviation (Reardon, T.; Vosti, S.A. 1995. Links between rural poverty and the environment in developing countries: Asset categories and investment poverty. World Develop 23:1495-1506).

The PE-4 research themes address the three CIAT goals with different levels of emphasis (Table 1). The table demonstrates that issues of poverty are paramount. Environmental sustainability and economic growth are of somewhat lesser importance.

Table 1. Land Use Project (PE-4) research themes and CIAT goals.[a]

Research theme	Poverty alleviation	Environmental sustainability	Growth (economic)
G x E[b] technology targeting	P		G
Including management: GxExM	P	e	G
Participatory research	P	e	g
Local knowledge	P	E	g
Land use dynamics	P	E	g
Climate change	P	E	g

a. Capital letters represent primary objectives of the research, lower case letters depict secondary objectives, and no marking signifies little or no attention to the specific goal.
b. G x E, genotype x environment.

Conclusion

GIS research can improve the validity of impact assessments by providing more accurate information. Fewer crude assumptions would be employed, such as homogeneity of biophysical and socioeconomic characteristics across relatively large geographic areas. The potential impact of PE-4 can be illustrated with specific examples:

(1) Agriculture is intrinsically spatial, hence spatially variable. All processes that CIAT aims to improve have spatial “variation”. Changes that ignore environmental variation introduce uncertainty that, in turn, can obstruct development efforts.
(2) Defining the contextual environment in which agriculture operates is a function of GIS. Knowledge of this function should be used more interactively during the design of new agricultural systems. What can we define better by association with spatial data?
(3) Why not use the power of GIS to “experiment”? Set up a hypothesis of land use change and see if it happened that way. This could occur at local or regional scales.

What information is being underutilized? Spatial information is likely to become underutilized as its availability and the demands on the agricultural systems increase. For example, what functions can be diagnosed using spatial information, scanning through space and time?

Output 2. Information and insight of biological limitations and drivers of land use change

2.1. FloraMap second edition

When we released FloraMap in January 2000, we produced 500 copies of the manual and CD-ROM. Early this year, it was obvious that a second edition was necessary, as the original issue was sold out. About 120 copies were distributed as complimentary at the release date, but all subsequent copies have been sold, although many at discount. Many of those sold at discount are being used for educational purposes, but we estimate that we now have well over 200 copies being actively used for research purposes.

We made a full revision of the manual, and incorporated a new section in the theory chapter describing the new data rotation incorporated in FloraMap 1.01. We included the new climate grids that have previously only been available from the FloraMap Web site, and burned a further 200 CD-ROM copies. Along with a reprint of the updated manual, these copies will satisfy demand until the major release of FloraMap 2.0 that we hope to achieve in 2003.

New climate grids were made for Bolivia and Paraguay at users' requests. Extra data were used for Bolivia to better define the Andean valleys. A semi-local regression was used to fit rainfall to elevation. The grids were fitted to the 30-arc second elevation model GTOP030, giving about 1-km precision. However, it was found that even when cut back to the country boundaries, the grids were too large for the present FloraMap algorithm. They were therefore cut to 1 arc minute resolution for conversion to FloraMap format.

This illustrates the need for the new data structures for CIAT climate applications. Initial work on these is reported elsewhere in this annual report.

Contributors: Peter G Jones (consultant); William Díaz

2.2. Targeted *ex situ* collection of wild genetic resources: Contributing to improved conservation in selected gene pools and the validation of predictive models

Objectives

- Produce wild species distribution predictions based on biophysical data sets at the national scale
- Prioritize target areas for *ex situ* collection of genetic resources in wild peanut and wild chili in Paraguay, and wild *tomatillo* in Mexico
- Devise a sampling strategy to validate models, and enact in the field collection

Materials and Methods

We collaborated with the USDA and IPGRI on four collecting missions in 2002. These were:

(1) Collection of the rare wild chili *Capsicum flexuosum* in Paraguay - March. This species has high potential for chili breeding, but is only conserved *ex situ* with one germplasm accession in the USDA.
(2) Collection of wild peanut species in the Chaco of Paraguay – April. This region has only briefly been explored for wild peanuts in the 1970s, but the neighboring Bolivian Chaco has been found to harbor many important species, including 10 soon to be described as new to science, which were discovered in 1994.
(3) Collection of wild peanut species in Paraguay with forage potential, and adaptations to low temperatures and wet environments – May. The USDA is looking for wild species with specific characteristics for breeding.
(4) Collection of wild and cultivated *tomatillo, Physalis philadelphica,* in the southern Mexican states of Guerrero, Oaxaca, and Chiapas – October. The germplasm is not represented in US or Mexican gene banks, and the area is thought to be a center of genetic diversity.

For each collecting mission, we provided predictions of which areas are likely to contain the respective genetic resource. The method was different for each collection trip, taking into account the different objectives and biological adaptations of the species. In all cases, FloraMap was used to map the predicted distribution, and secondary data sets and satellite images were then used to further refine the predictions based on land cover, logistical accessibility, and climatic characteristics.

For the collecting missions for wild peanuts in the Chaco (Figure 8), and wild chili in Paraguay, a more thorough sampling strategy was made, and then used in the field collection. A number of sites with both high and low probabilities of finding the species were identified, and validated in the field. A number of observations and measurements were made for each site, to permit a rigorous validation of the models using both presence and absence data points.

Results

For each of the collecting missions, the use of the model was helpful in varying degrees. For all, it provided a more detailed and more formal means of planning a collecting mission. Prior to leaving for the field, there was a clearer idea of where to go, and – more important in saving time and money – where not to go.

For the *Capsicum flexuosum* collecting trip, the results were staggering. In all, some nine new populations were found, and seeds collected for long-term *ex situ* conservation in USDA. Previous attempts to locate the species for germplasm collection had been unsuccessful. In this case, blind faith was given to the predictive model, and the results were very encouraging. Furthermore, it has provided a thorough data set for a formal validation of the predictive model.

In the wild peanut example in the Chaco of Paraguay, the satellite images were found to be of most use in targeting collection, specifically by deriving normalized differential vegetation indices (NDVI). The presence of wild peanut species was found to be restricted by local soil conditions (soils with high clay content are unfavorable to wild species), and the closed canopy bushland vegetation.

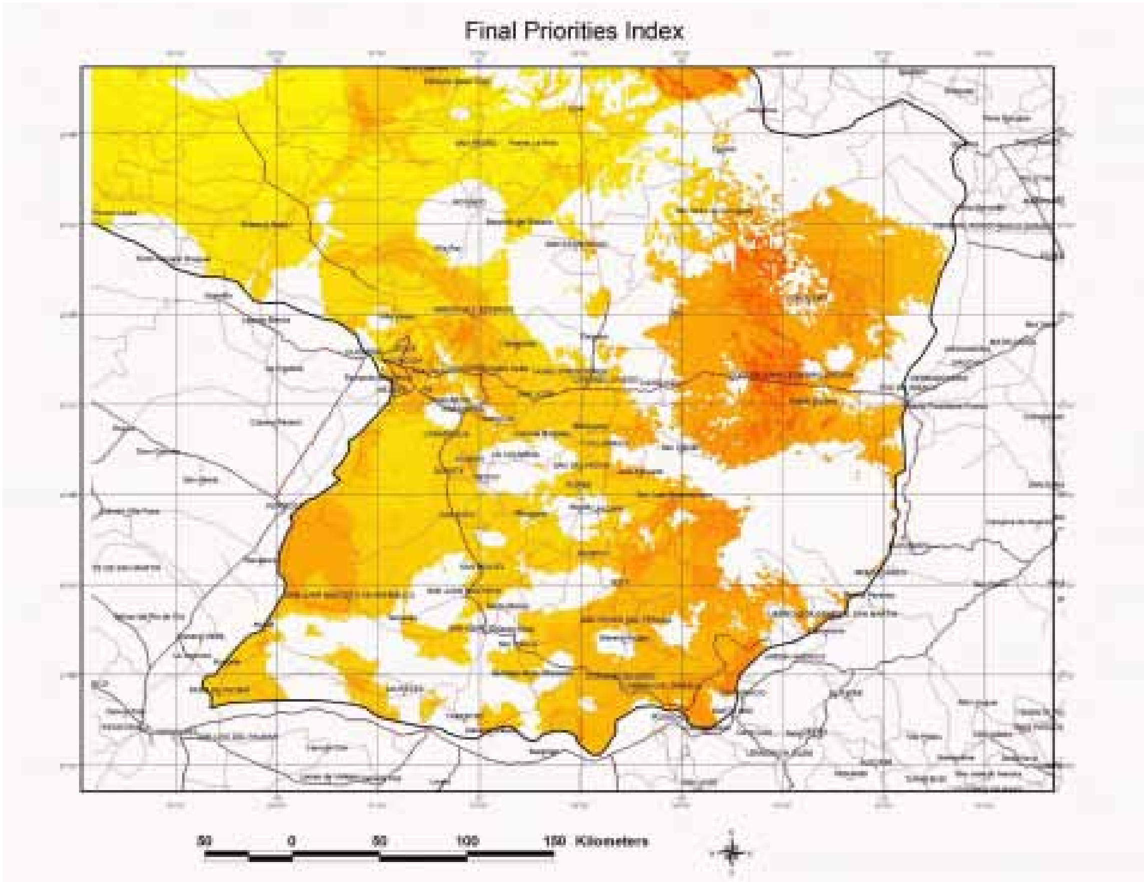

Figure 8. Priority collecting map for wild peanuts in southern Paraguay. This is calculated through the modeling of species distributions, with priorities given to areas with cold temperatures and heavy rainfall. The map was taken into the field in May 2002, and aided the collection of new wild peanut germplasm.

Results from the targeted collection of germplasm of wild peanut with forage potential were also encouraging, but cannot be analyzed until characterization of the germplasm tells us how well adapted it is to low temperatures and moist conditions. The *tomatillo*-collecting mission is still to take place as this report goes to press.

These four examples will provide data for a formal validation of methods for *ex situ* conservation prioritization. Such a validation has been highly restricted until now because germplasm collections only register presence. The absence of a species in a site is just as significant to make a complete assessment of model accuracy.

Output

This work has aided the long-term conservation of genetic resources in selected gene pools. Furthermore, the rigorous testing of the methodology and the planned formal validation will improve the process of collection mission planning and conservation targeting. This provides a tool for more efficient (in terms of time and money) collecting of genetic resources, ensuring that agrobiodiversity is conserved and appreciated.

Contributors: Andy Jarvis; Peter G Jones (consultant); David Williams (IPGRI); Karen Williams (USDA)

Collaborators: Luigi Guarino (IPGRI); Mimi Williams (USDA); Maria Chacon (University of North Carolina); Charles Simpson (Texas A&M); Israel Vargas (Fundacion Amigos de la Naturaleza, Santa Cruz, Bolivia)

2.3. Measuring and modeling biodiversity in tropical forests of the Ecuadorian Amazon and the Colombian Andes

Objectives

This project is a long-term effort in collaboration with King's College London. This year, the objectives were to:

?? Take high resolution georeferenced aerial imagery of the field site in Tiputini Biodiversity Station in Napo, Ecuador;

?? Complete 10 biodiversity plots on the ground in each study site, where trees are marked, measured, and identified, and environmental characteristics of the plots measured; and

?? Initiate analyses of forest structure and diversity

Methods

Two field trips to Napo, Ecuador were made in the year, each with three CIAT employees and five students and lecturers from King's College London. Some short trips were also made to Reserva Tambito to terminate the fieldwork component of the project.

Eight hours of flights were made over Tiputini Biodiversity Station (TBS), and high-resolution imagery was taken at varying altitudes. The imagery covers the whole of TBS, and parts of Yasuni National Park. Ground control points were then taken using a GPS to georeference the imagery. Ten 25-m x 25-m plots and one 1-ha plot were sampled. All trees with diameter at breast height > 5 cm were marked, measured, and collected. Micro-topography within the plots was also taken, and some soil samples. Fish-eye lens photographs were taken up to the forest canopy.

A large volume of satellite images has also been used to examine land-use trends in the region. These images have been classified to forest and non-forest, and have given a spatio-temporal deforestation record from 1977 – 2001. These data will be used to monitor and predict the loss of deforestation.

Results

The database of trees has 2499 individuals included in TBS, with 602 species in 51 families distinguished. These levels of diversity compare with the nearby Yasuni 50-ha plot, which has registered the world's highest plant diversity. In TBS, the plots contain some 245 species, in 45 families. Additionally, random collections in the reserve were used to produce a species list that contains 585 species in 85 families. This list has been submitted to a peer-reviewed journal to communicate the outstanding diversity of the region, and aid insightful decisions at the national scale to adequately conserve the biological resources.

The plot data for both sites represent one of the most comprehensive databases of biological and environmental characteristics for tropical forests. These data will be used in the coming year to understand the influence of environment on forest diversity and structure, in the hope of finding patterns that can be predicted using environmental surrogates. Land-use change data will be used to develop predictive models of deforestation, and examine the loss of biological resources in the region.

Contributors: Andy Jarvis; Mark Mulligan, Sophia Burke, Pablo Vimos (King's College London); Carlos Eduardo Gonzalez, Mike Salazar, Javier Puig (Bonn University)

Collaborators: Javier Robayo (Universidad de San Francisco de Quito); Hugo Navarrette (Universidad Catolica, Quito); Mauricio Larrea (PetroProduccion, Ecuador); Nigel Pitman (Duke University, North Carolina).

2.4. Wild beans and climate change

Background

Because of the founder effect on domestication, many genes have been left behind in wild populations of the progenitors of modern field crops. The arcelin gene, which confers resistance to grain-damaging Bruchids in *Phaeolus vulgaris*, is a prime example. Transfer of these genes from wild populations to modern cultivars has been achieved in a landmark-collaboration between the University of Wisconsin and CIAT, and is potentially worth over US$1.2 billion in prevented crop losses.

It is obviously worth preserving such potentially valuable genes, and a good way of doing this is by conserving natural populations *in situ*. However, the Central America wild bean populations occupy relatively small niches in the highlands. We therefore decided to look at the effect of climate change on the future stability of these populations.

Materials and Methods

A 30-arc second climate grid was created using the CIAT climate database and the digital elevation model GTOPO30. The 50-year climate change predictions were taken from the published data of the HADCM2 general circulation model, interpolated to 30-arc seconds, and grafted onto the climate grid to give a predicted climate surface for the years centered on 2055.

We took 40 collected samples of wild *P. vulgaris* from the CIAT germplasm bank, and four sample collection points from a collecting trip made by S Beebe in 1996 as the calibration set, and fitted a climate probability model to the present and future grids using FloraMap. These results were overlaid with a re-classed version of the USGS land cover at 1-km precision, and the potential conservation areas extracted by land cover class.

Results

Figure 9 shows the probable distribution of wild *P. vulgaris* at present, and in the year 2055. We can see that there remain viable areas in southern Mexico, although some are geographically removed from the present areas and intervention might be needed to assist populations to shift as the climate changes over the next 50 years. In Guatemala, there does not appear to be too great a problem, because the future areas are geographically contiguous with the present ones. However, the areas in El Salvador, Honduras, Guatemala, and Costa Rica are much diminished.

The USGS land cover was re-classed to “appropriate” lands (including crop and pasturelands, and wild scrubland) and “inappropriate” lands (including closed forest, urban areas, and water bodies). The probable conservation areas were extracted by these classes. Table 2 shows results.

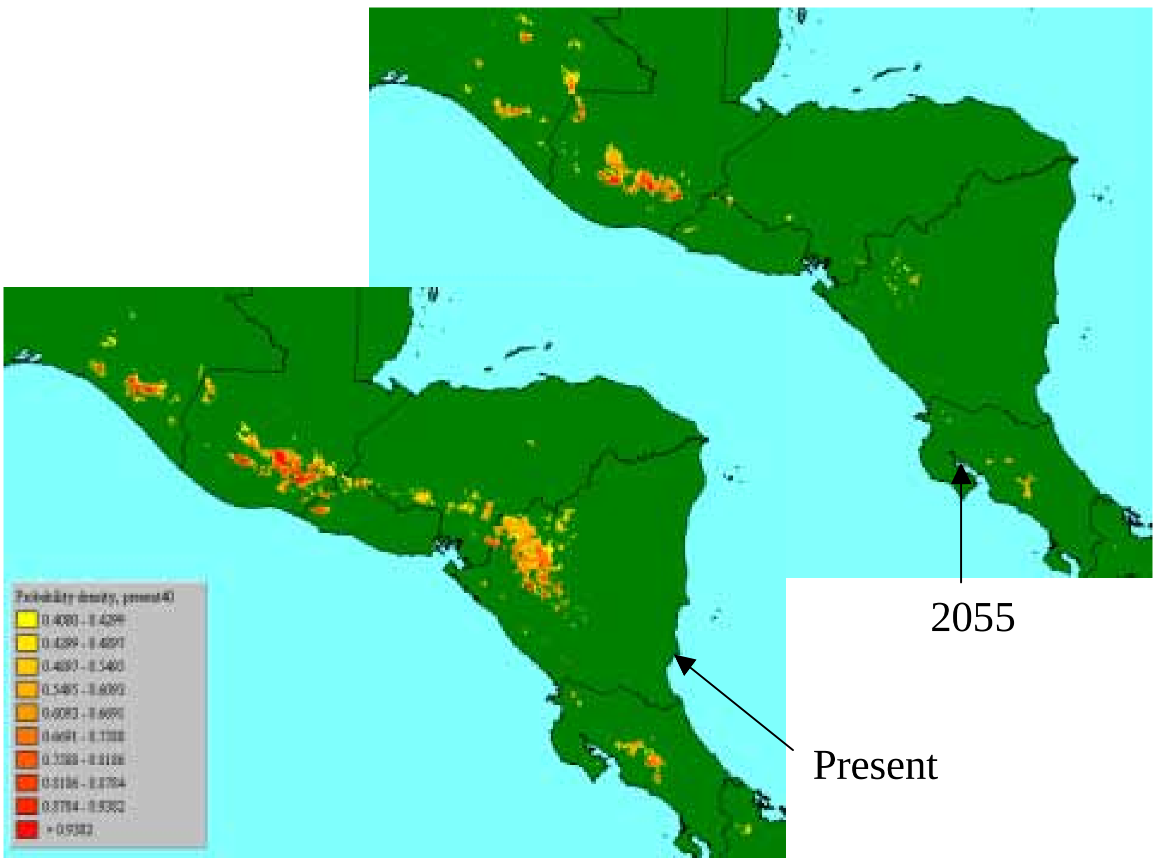

Figure 9. Potential distribution of wild *Phaseolus vulgaris* in Central America.

When the area of appropriate land in each of the potential conservation areas is taken into account, we can see that in El Salvador, Honduras, Nicaragua, and Panama the sites suitable for *in situ* conservation almost disappear. If the genetic constitutions of these populations are highly similar to those of the Guatemalan ones, then world agriculture will lose little and the problem is merely a national one for those countries.

Table 2. Area (km^2) of potential *in situ* conservation for *Phaseolus vulgaris* in Central America.

Country	Present		Year 2055		Percentage reduction of appropriate
	Appropriate	Inappropriate	Appropriate	Inappropriate	
Mexico[a]	61 542	84 708	33 696	92 430	45
Guatemala	200 538	149 760	140 634	130 572	30
El Salvador	17 550	42 354	2 340	14 040	87
Honduras	92 664	49 608	1 170	4 212	99
Nicaragua	270 738	106 236	20 124	10 296	93
Costa Rica	22 230	59 904	8 658	22 698	61
Panama	4 212	0	0	0	100

a. Only that part of Mexico to 18 ºN 94 ºW.

If there are marked differences, than it is a problem for everyone. The only solutions may be *ex situ* conservation in germplasm banks, or transfer to *in situ* sites in other countries. Either of these solutions may present problems under the present legal situation. Following the resolutions under Agenda 21 of Rio 1992, the native germplasm of each country is the property of that country, and without the correct legal measures in place cannot be taken out of the country. To our knowledge, these have not been enacted and the samples collected by S Beebe in Honduras in 1996 are still in Honduras. Steps should therefore be taken to check the genetic constitution of the populations, and to encourage the legal steps to be taken that will enable the relevant solutions.

Outputs

This work was presented at the III International Conference on Geospatial Information in Agriculture and Forestry in November 2001 at Denver, Colorado (Jones and Beebe, 2001)[5]. It won the award as best paper of the conference. The results have drawn attention to the need for conservation of the germplasm of Honduras, Nicaragua, El Salvador, and Costa Rica. It is hoped that they will stimulate conservation efforts.

Contributors: Peter G Jones (consultant); Steve Beebe (IP-1)

2.5. Incorporating socioeconomic data and expert knowledge in representations of complex spatial decision making, using the case of forages

Rationale

The overall approach which intends to integrate agro-ecological, economic, and social information, is based on the following two main assumptions:

[5] Jones, P.G.; Beebe, S. 2001. Predicting the impact of climate change on the distribution of plant genetic resources in wild common bean (*Phaseolus vulgaris* L.) in Central America. Paper presented at the III International Conference on Geospatial Information in Agriculture and Forestry, Nov 2001, Denver, CO, USA.

(1) A wealth of information on the agro-ecological adaptation of forage germplasm is available in CIAT-held forage databases. However, the access and hence utilization of this information needs to be improved. In addition, data are often uncertain or missing, and methods are needed to combine existing data with expert knowledge to provide better analysis.
(2) In previous evaluations of forage germplasm adaptation to environmental conditions, agro-ecological information is separated from socioeconomic factors influencing forage germplasm adoption.

Based on these assumptions, the targeting of forage germplasm is intended to enhance the utility of existing information and, in future, to integrate environmental and socioeconomic adaptation of forage germplasm for multiple uses. It is anticipated that this approach will allow a more accurate and client-oriented prediction of possible entry points for forage germplasm.

The project is linked to SoFT (Selection of Tropical Forages) with the developed tool separate, but complimentary, to their work.

Materials and Methods

Review of literature and of existing similar models and software is ongoing. Possible approaches to representing spatial decision making with particular emphasis on incorporating socioeconomic data and expert knowledge are under investigation. Existing tools are being evaluated to determine their effectiveness in representing expert spatial decision-making processes, and in particular in targeting forage germplasm. Bayesian modeling has been identified as the most appropriate method, especially with sparse and uncertain data.

As a case study, a decision support tool to target forage germplasm is being designed and developed, using GIS technology. This targeting consists of identifying which forages would be suitable or successful in a particular location, given data and/or knowledge about the forages, and about the location in question. The forages data are in the form of spatial coordinates for a number of locations at which accessions have performed successfully. Success is defined from data available in the CIAT forages database, other data sources, and input from experts, including adaptation, production, and adoption. It is recognized that definition of success may vary from species to species, and may also depend on the unique characteristics of the farmer. In particular, a risk-averse farmer may require a high level of certainty that the selected forage will be successful according to his or her criteria, whereas in other situations a lower level of certainty, but a higher rating of success, may be desirable. Data have been collected for Central America, focusing on the San Dionisio region in Nicaragua and the Yorito region in Honduras.

Prior to and during the development of the tool, there has been consultation with potential users. These potential users are representatives from CIAT, and development agencies, NGOs, national research institutions, and ministries of agriculture and natural resources in Central America, with focus on Honduras, Nicaragua, and Costa Rica. The tool is being implemented using Delphi in conjunction with MapObjects LT. In this way, the user requires no proprietary GIS platform. In addition, the model is being adapted for use in tropical fruits targeting.

Results

The project is in a preparatory stage, but some initial tools have been developed. Bayesian modeling has been applied to core forage species using climate and soil data and expert knowledge (Figure 10).

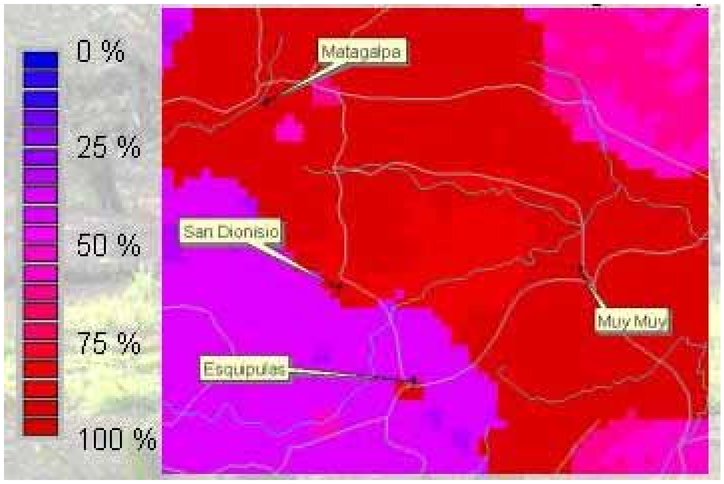

Figure 10. Bayesian modeling applied to *Stylosanthes guianensis* using elevation, annual rainfall, and length of dry season to predict the probability of adaptation being excellent or good.

A demonstration tool was implemented in Visual Basic showing the various steps of the model: Choosing a location, filtering out species, updating prior probabilities, calculating joint probabilities, ranking species for a given location, viewing and querying map output (Figure 11).

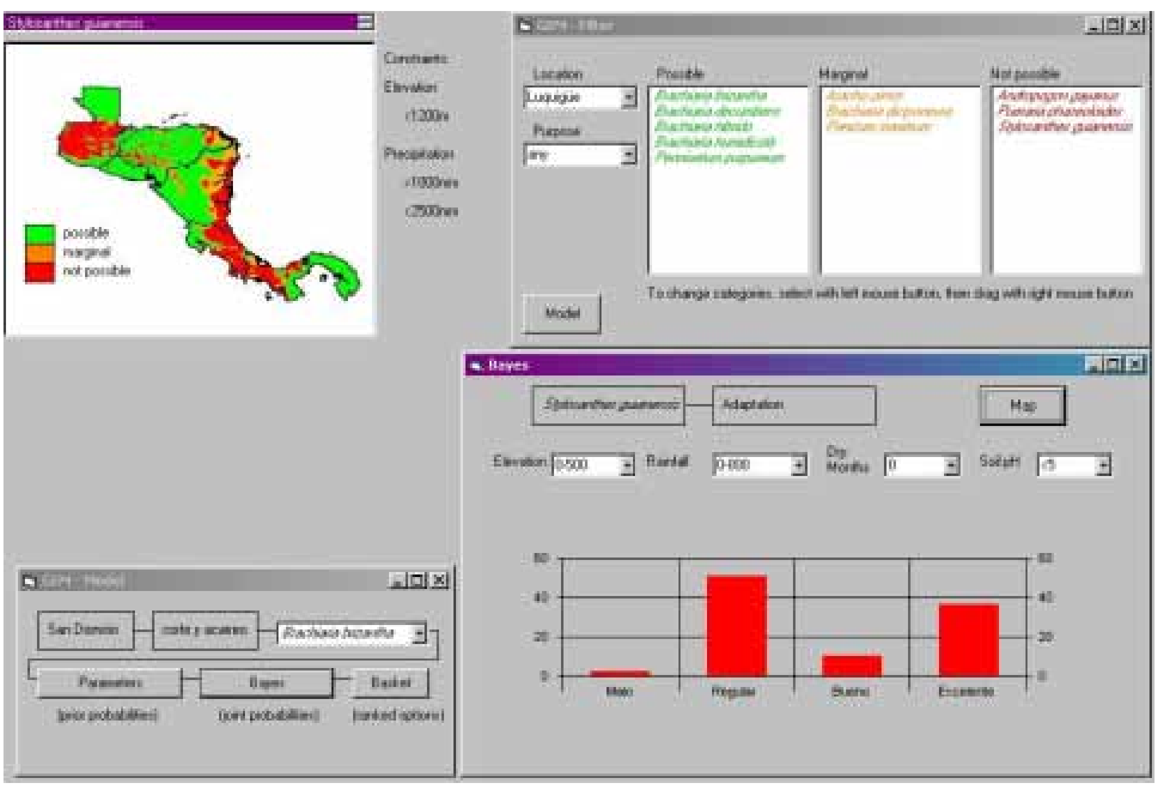

Figure 11. Demonstration tool showing steps in the model.

A prior probability tool was developed in Delphi to elicit expert knowledge to update data-derived prior probabilities. The expert can manipulate probabilities with simple point-and-click operations, and examine via bar charts and tables the impact on all other probabilities (Figure 12).

Figure 12. Tool to elicit expert knowledge to update or create prior probabilities for use in Bayesian modeling.

Outputs

One product of this research will be a fully functional, Web-based or CD-ROM tool, primarily designed for targeting forage germplasm in Central America. The primary target users are NGOs, development agencies, national research institutes, and decision makers in government. In conjunction with farmers, these users will be able to more effectively target suitable locations for new forages, with the aid of the tool. This will result in more informed choices being made, thus allowing more effective use of public funds dedicated to agricultural development and natural resource conservation.

Tools to better target forages will also help improve the well-being of smallholders by assisting them to more effectively utilize their resources in sustainable ways. The addition of carefully selected forages to a farming system has a plethora of benefits both for the farmers and for the environment as well as the wider community. These benefits derive both from the direct influence of forage planting, and the indirect increase in cattle production and cropping system improvements, and include for example improved sustainable intensification, reduced erosion, and alleviation of protein and micronutrient deficiencies in the community.

Contributors: Rachel O'Brien, Simon Cook, Thomas Oberthür; Michael Peters (IP-5); Robert Corner (Curtin University)

Collaborators: Andrew Jarvis; Peter Jones (consultant); James Cock (IP-6); Arturo Franco, Luis Horacio Franco, Belisario Hincapie; Rein van der Hoek, Heraldo Cruz, Luis Brizuela, Orlando Mejía (CIAT Honduras, PE-3); Axel Schmidt (CIAT Nicaragua, PE-2); Pedro Argel (CIAT Costa Rica, PE-5); Peter Horne (CIAT Laos, Forages for Smallholders Project [FLSP]); Conrado Burgos (Dirección de Investigación de Ciencias y Tecnología Agrícola [DICTA]); Martín Mena, Alejandro Blandón, Octavio Menocal (Instituto Nacional de Tecnología Agropecuária [INTA]); Marta Loyman, Arcángel Abauza (Ministerio Agropecuário y Forestal [MAGFOR]); Marcos Lobo, Carlos Hidalgo, Rodolfo Méndez (Ministerio de Agricultura y Ganadería [MAG]); Muhammad Ibrahim, Sebastian Wesselman, Jeffrey Jones (Centro Agronómico Tropical de Investigación y Enseñanza [CATIE]); Bruce Pengelly (SoFT, Commonwealth Scientific and Industrial Research Organisation [CSIRO])

2.6. Comparing deterministic and probabilistic algorithms for prediction of landslides caused by extreme climatic events

Objective

?? Evaluate the potential of common, and readily available, deterministic and probabilistic GIS-based models to predict landslide events that were caused by extreme rainfall events of Hurricane Mitch in Central America, October 1998

Methods and Results

In a field survey, 144 landslides were identified, georeferenced, and complemented with basic field data about terrain, land use, and soils. They were split into a trainings set to calibrate, and a validation set to validate, landslide prediction models.

Two models, one with deterministic and one with probabilistic approach, were identified for landslide prediction. SINMAP (Stability Index Mapping) is process driven, and ArcWofE (Weights of Evidence extension for the GIS ArcView) is a purely probabilistic approach. The study revealed that both approaches are unable to predict landslides caused by extreme climatic events with accuracy sufficient for potential model users (such as agricultural planners or NGOs working in regional rural development).

The reasons for the lack of accuracy are different for each algorithm: SINMAP's deterministic approach does not replicate the processes triggered by extreme events. The probabilistic approach in ArcWofE yields slightly better results. Especially highly unstable areas are differentiated from the other zones. However, there are only few highly unstable zones in the region. The main reason for ArcWofE's failure is the lack of knowledge about factors that drive the occurrence of landslides under extreme climatic events. With better understanding, relevant information layers to construct the "evidence path" in ArcWofE can be selected.

Output

Enabling local and regional authorities, organizations, and institutions active in rural planning and development to make informed choices about spatial modeling approaches that attempt to quantify risk of disastrous climatic events.

Contributors: Steffen Walther (University of Hohenheim); Sandra Bolaños, Thomas Oberthür, Jorge Rubiano
Collaborators: Axel Schmidt (PE-2); Campo Verde San Dionisio; CIAT-Nicaragua Office

2.7. Spatial modeling of soil fertility using geographical information systems

Objective

?? Develop an easy-to-use, pragmatic tool for spatial evaluation of soil fertility for local to regional scales

Materials and Methods

Although GIS and accompanying spatial analytical techniques have evolved substantially over the last two decades, we are still limited in our ability to model agro-ecosystem functions from within GIS. Strategies for interfacing GIS with agronomic models include (1) linking, which is defined as merely passing input and output between a GIS and a model, (2) combining, which is defined as automatic data exchange and GIS tool functions, and (3) integrating, which is defined as embedding a model in a GIS or vice versa.

This research, however, examines an embedding approach within a GIS environment that is achieved by developing the existing QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils[6]) model with the macro language of GIS. Such an approach makes it easy to capitalize on the GIS visualization and spatial analysis functions, thereby significantly supporting the dynamic simulation process of soil fertility modeling. The embedding approach is illustrated by developing ArcQUEFTS with the macro language Avenue of ArcView. The approach provides a convenient, single environment for users to visually interact and adjust soil fertility parameters, and to observe the corresponding results simultaneously, which significantly facilitates users in exploratory analysis and decision making.

[6] Janssen, B.H.; Guiking, F.C.T.; Van der Eijk, D.; Smaling, E.M.A.; Wolf, J.; Van Reuler, H. 1990. A system for Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS). Geoderma 46: 299-318.
Smaling, E.M.A.; Janssen, B.H. 1993. Calibration of QUEFTS, a model predicting nutrient uptake and yields from chemical soil fertility indices. Geoderma 59: 21-44.

The interface has been developed in a Beta-Version. A test modeling has been conducted using data at farm-scale that were available for the San Isidro Experimental Farm (see Project PE-4 Annual Report 2001, p. 39-40).

Results

QUEFTS describes, in four steps, relations between (1) chemical soil test values, (2) potential NPK supply from soils and fertilizer, (3) actual NPK uptake, and (4) maize grain yield, acknowledging interactions between the three macronutrients. All steps were calibrated separately, and yield a modified version of QUEFTS (Smaling and Janssen, 1993[6]). Figure 13(a) to (c) illustrates some of the results of the second step within QUEFTS, potential nutrient supply in kg ha^{-1} of one macro nutrient depending on the concentration of the others using data for the in San Isidro Farm. Figure 13(d) presents the potential, nutrient-limited, maize yield in kg ha^{-1}. While we did not calibrate QUEFTS using data from Southern or Central America, the obtained results present a reasonable picture that reflects general knowledge of nutrient-limited maize yields. We strongly suggest a collaborative effort between the Soils and Land Use Projects to bring together available data for model calibration. Figure 14 shows a snapshot of the interface.

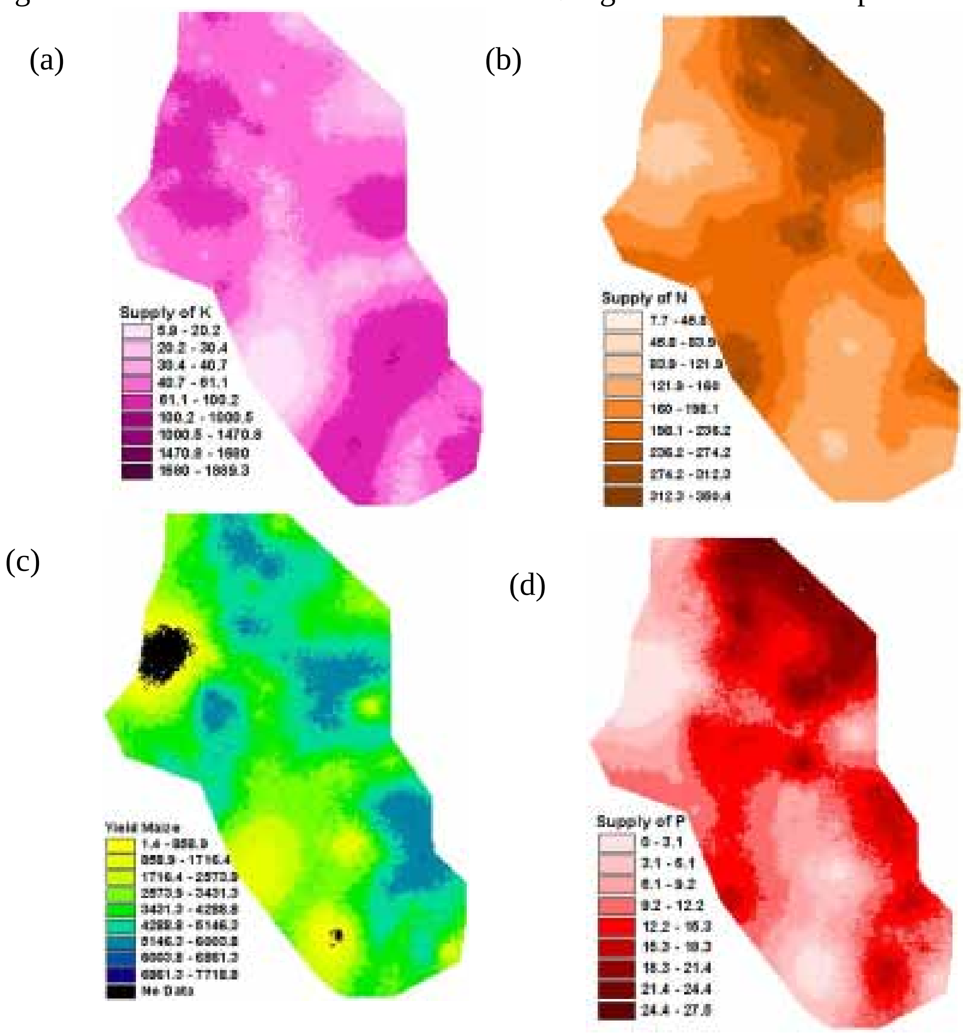

Figure 13. The images (a) to (c) show the results of the first step of the Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS) modeling approach, potential nutrient supply of N, P, and K in kg ha^{-1}. Image (d) presents the outcome of the final step, maize yield in kg ha^{-1}. The zones with “no yield” in image (d) are not realistic, and highlight the need for calibration of the model with regional data.

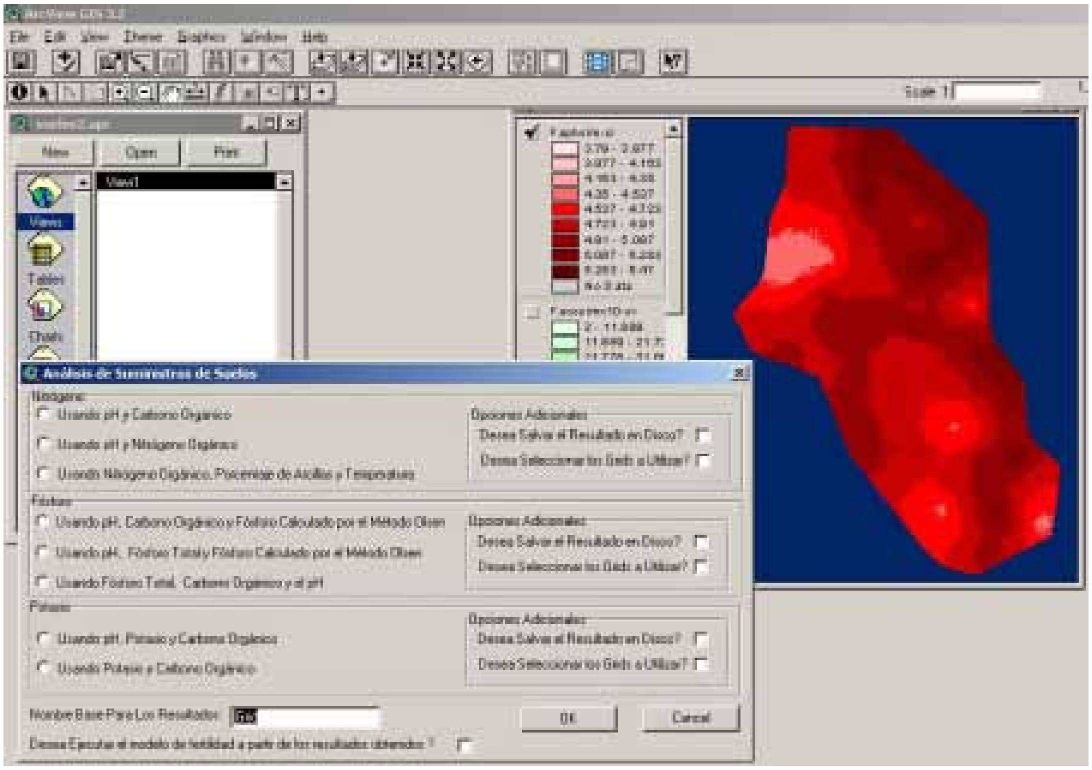

Figure 14. The image shows a snapshot of the interface where window-based menus guide the user through the selection of the original input maps.

Output

Enabling improved soil fertility management from local to regional scale.

Contributors: Luz Amira Clavijo, Thomas Oberthür

Output 3. Analysis and prediction of socioeconomic factors influencing land use development

3.1. Food security and poverty mapping project

Objective

The system-wide food security and poverty mapping project completed the first year of the 3-year initiative in September 2002. The government of Norway funds this project through their support to the Food and Agriculture Organization (FAO). CIAT, FAO and Global Resource Inventory Database (GRID)-Arendal make up the three principal project partners. The project aims to advance food security and poverty mapping methodology, and geographic information for development at global, regional, and national scales.

Materials and Methods

CIAT's role in the project is to manage, monitor, and evaluate the country-level case studies conducted by our CGIAR partners. This year the project secured new funding, increasing the number of case studies from four to eight (Figure 15).

Figure 15. The eight countries selected for food security and poverty mapping case studies.

A workshop to improve CGIAR center methodological capacity in poverty mapping was held in Rome in April. Workshop participants focused on spatial analysis methods for mapping socioeconomic variables. The workshop stressed the measurement and evaluation of spatial autocorrelation when analyzing socioeconomic data. Following the workshop, each CGIAR center revised its original case study proposal to include better spatial analysis methods and improved communication with national partners and end-users of the research. The new proposals were incorporated into the terms of reference for each participating CGIAR center.

Project partners met again in May 2002 at the Geospatial Applications to Support Sustainable International Agriculture workshop in Sioux Falls, South Dakota. The CGIAR centers developing case studies committed to incorporating standardized metadata and spatial data clearinghouse elements into their case studies.

Results

The case study work aims to improve methodological capacities to map food security and poverty at the country level. Improved methods will benefit CGIAR centers and partners in the development of future work. The project will make results available to the research and development community.

Project progress reports are available from the CIAT Projects Office. For more information see the project Web site at www.povertymap.net.

Contributors: Glenn Hyman, Simon Cook

3.2. Launch of project "Improved Mapping and Spatial Analysis of Food Security and Poverty in Ecuador"

Objectives

?? Identify how access to food varies spatially in Ecuador
?? Identify the linkages between food security and the spatial dimensions of the wider socioeconomic and biophysical environment
?? Communicate these insights to decision makers in Ecuador
?? Develop cross-scale spatially explicit food security model
?? Strengthen Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS) activities in Ecuador

Methods

Three visits were made to Quito in 2002 (April, June, and October). The first visit was to make contact with all institutions involved in food security mapping and evaluation and assess their capacities, needs, methods and potential for collaboration. The June visit was to host a workshop to launch the project inviting participants from institutions involved in strengthening food security in Ecuador. In October, we coordinated work plans with FAO - Ecuador and World Food Programme – Ecuador, searches for information in order to complete data inventory, and reached agreements of understanding with key data providers.

A network of stakeholders is crucial for this project to have impact in Ecuador. Much of the data required will come from in-country stakeholders, and the products and methods produced will be used principally in Ecuador.

A consultation exercise was initiated in Quito that introduced the project to potential stakeholders, which included FAO – Ecuador, the World Food Programme (WFP) – Ecuador, Fundación Ecuatoriana de Estudios Ecológicos (EcoCiencia), Oficina de Planificación de la Presidencia de la República del Ecuador (ODEPLAN), Programa Especial de Seguridad

Alimentaria (PESA), Red Estratégica para el Desarrollo de la Cadena Agroalimentaria de la Papa (REDCAPAPA), and Alianza Jatun Sacha – Corporación Centro de Datos para la Conservación del Ecuador (CDC).

As a result of the first trip to Quito, the following conclusions were reached.

> *In the past 5 years Ecuador has been "dollarized", privatized and decentralized, or is moving in those directions. In order to modernize the state, national institutions are being stealthily dismantled. As a result, initiatives at the national level are being neglected or have never been implemented. The need for national level assessments (using subnational level data) remains high, but the institutions capable of doing this, or of securing funds for this, are few. In summary, any results produced by this or subsequent projects will be to the benefit of many different institutions in both targeting their resources and their research.*

The launch workshop was held in Quito on the 19th and 20th of June and attended by 12 participants from 10 institutions. The workshop was organized in four sessions covering the following themes:

(1) Hypotheses of the causes of poverty and food insecurity in Ecuador,
(2) "Possible Futures" of poverty and food insecurity in Ecuador,
(3) Project Case Study sites in Ecuador, and
(4) Communication Strategies – inter-institutional Web site.

As a starting point, the participants came to an agreement for a working definition of food security, i.e., the definition from the World Food Summit of 1996:

> *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life."*

For Theme 1, the participants shared an experience that dealt with food insecurity or poverty in Ecuador, be it from their personal or professional life. These experiences were anecdotal and descriptive. The group subsequently analyzed these, and a matrix was constructed highlighting the principal driving forces and the levels at which they are experienced. The participants discussed the concepts of opportunities and threats as a means of constructing scenarios of possible futures (Workshop Theme 2). It is interesting to note that most of the opportunities were thought to operate at the local scale, whilst the threats tend to be global in nature.
From the list of factors the following scenarios were constructed:

?? More frequent and forceful return of the El Niño phenomenon;
?? Arrival of the Area de Libre Comercio de las Américas (ALCA) Andean trade agreement with markets opened even further;
?? Decentralization (taking advantage of social capital, and the knowledge and resilience of the population); and

?? Improved productivity in the agricultural sector (including better post-harvest management).

Future work in the project will involve the construction of these scenarios in terms of the factors that influence food insecurity.

Having discussed the hypotheses of the causes of poverty and food insecurity, it was apparent that different problems exist in different locations within Ecuador (Table 3). One of the project activities is to locate case studies in the three regions of continental Ecuador, viz. the coast, the sierra, and the Amazon basin (Figure 16). Using criteria, which include geographical balance (one study in each region), intermediate sites (not too poor nor too wealthy), existence of threats, availability of data, institutional presence, and support of the community, the participants selected nine candidates for case study locations.

Table 3. Factors of food insecurity in Ecuador according to scale.

International	National	Regional / provincial	District / parish	Household
-	-	Drought	Access to water	Soil quality
-	Gender	Gender	Cultural factors, gender, access to land	Gender
Markets	Markets	Markets	Productivity, diversity of production	Income
Trade, ALCA[a]	Bad management of harvest, commercialization	Deterioration of natural resources => migration?	-	-
Influence of countries and institutions	Education and information, policies	Education and information, climate (El Niño phenomenon)	Education and information, organization	Education and information, lack of knowledge of cooking all types of foodstuffs
Global economy, consumption patterns, international treaties	Gender, income, social capital, access to health services, consumption patterns	Gender, income, social capital, access to health services, consumption patterns	Gender, income, social capital, access to health services, consumption patterns	Gender, income, social capital, access to health services, consumption patterns
-	Coverage of health services	Diseases are dependent on altitude	Initiatives of home gardens (and others), access to markets	Composition of the diet, respiratory and diarrheal diseases
-	Importation of foodstuffs, commercialization.	-	-	Income, training and education about the proper use of foodstuffs
-	-	Inequality in land tenancy and in available resources	-	Fertility of women

a. ALCA, Area de Libre Comercio de las Américas.

Figure 16. Candidates for case study locations (map source: ODEPLAN [Oficina de Planificación de la Presidencia de la República del Ecuador]. 1999. INFOPLAN. Atlas para el desarrollo local. ODEPLAN, Quito).

A very important aspect of the project is the communication of the methodology and the results. For this reason, the participants discussed the possibility of creating a Web site designed around the theme of food security in Ecuador. A proposal that the Web site form part of REDPESA (Network of Ecuadorian Food Security Projects) was presented to the committee of REDPESA in their meeting on the 3rd of July 2002, and was accepted. A five-member committee will be formed to evaluate the reports and maps that will appear on the Web site:

(1) Andrew Farrow - CIAT
(2) Carlos Larrea - Independent
(3) Silvia Vidal - Centro de Planificación y Estudios Sociales (CEPLAES)
(4) Rafael Burbano – Politecnica National
(5) Malki Saenz - EcoCiencia

The Web site has the URL http://www.ecuamapalimentaria.info, and has been active since September 2002. The workshop proceedings can be found on the Web site.

In the final visit to Quito, the project moved forward considerably in the definition of methodologies with both Carlos Larrea and partner institutions (FAO, World Food Programme). EcoCiencia provided new data and an agreement was reached with the Dirección Nacional de Recursos Naturales Renovables (DINAREN) for them to provide the project with more biophysical data. A similar agreement was arranged in order to access some data from the 2000 agricultural census, but this is less than hoped for. The definition of vulnerable populations has also been advanced with the inclusion of base data from the *Defensa Civil* and vulnerability maps from OXFAM-Cooperazione Internazionale (COOPI)-Sistema Integrado de Indicadores Sociales del Ecuador (SIISE), and DINAREN.

Contributors: Andrew Farrow, Glenn Hyman, Rosalba Lopez; Carlos Larrea (CIAT consultant); Silvia Andrea Perez (CIAT Communications Unit); Lautaro Andrade (REDCAPAPA); Malki Saenz (EcoCiencia)

Collaborators: Janet Pavon (FAO – Ecuador); Marcelo Moreano (consultant for FAO-Ecuador); Carmen Galarza (WFP – Ecuador); Maria Victoria Arboleda (consultant for WFP – Ecuador)

3.3. Developing basic needs index maps for Central America

Objective

?? Improve the visualization of basic needs index tables for six Central American countries

Methods

Basic needs index tables were provided by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). These have traditionally been visualized as choropleth maps for national or subnational administrative units (Figure 17). The objective of this exercise was to utilize existing accessibility surfaces to produce a more realistic, but modeled, visualization of the state of basic needs provision in Central America.

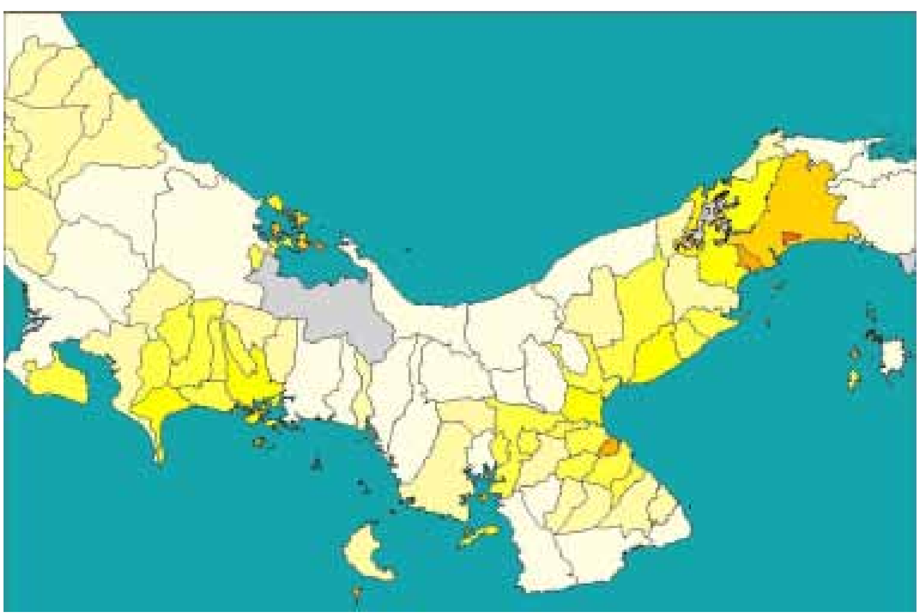

Figure 17. Choropleth map of Central America population density of two basic needs unsatisfied – red colors indicate a high proportion of households with basic needs unsatisfied.

In previous work to produce a population surface (http://grid2.cr.usgs.gov/global/pop/lac/part-two.htm), accessibility to markets was used to model population density within 3rd level administrative units for Latin America.

The first surface created was accessibility to markets, using CIAT's accessibility analyst. This surface was then summed for each administrative unit, and a total accessibility figure produced. Each cell in the administrative unit was divided by this figure such that all the resulting cell values were between 0 and 1, and the cumulative value of these cells was 1. These values were then inverted so that the cells with the smallest accessibility values were those that had the highest values. This surface was used to map the number of households in the administrative unit that were lacking particular basic needs such as access to education, adequate housing, and sewerage services (Figure 18).

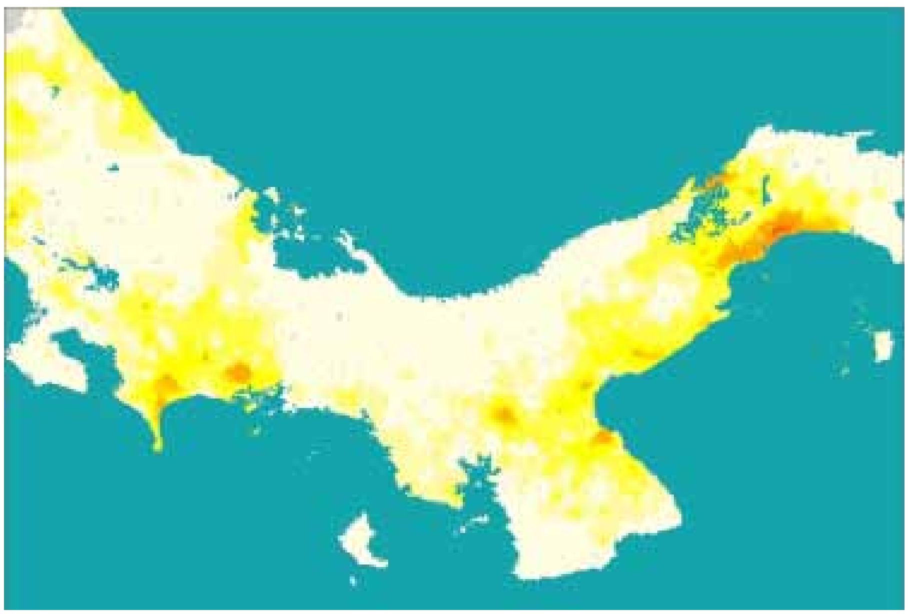

Figure 18. Gridded distribution of Central America population density of two basic needs unsatisfied – red colors indicate a high proportion of households with basic needs unsatisfied.

Results

Maps of densities of households lacking 1-4 basic needs were produced for the countries of Guatemala, Honduras, Nicaragua, Costa Rica, El Salvador, and Panama.

Contributors: Andrew Farrow, Manuel Winograd, Glenn Hyman; Andrew Nelson (World Bank)

Collaborators: Gilberto Gallopin, Hernán Dopazo (ECLAC); Alejandra Silva (Centro Latino Americano de Demografía [CELADE] – ECLAC)

3.4. Detailed analysis of the drivers of land use change and land depravation in the Peruvian Amazon

Objective

?? Identify decision points driving local activities that affect positive and negative soil processes

Methods

A survey was conducted with the farming systems research (FSR) methodology. The methods used were deep semi-structured interviews and participatory observations. Crop budgets were also estimated.

Results

The survey was conducted in two areas: in one village in a more degraded area, and in another village in an area where primary forest still is accessible. Most farmers in both areas do not perceive erosion as a problem. However, land degradation and "tired" fields are commonly seen as urgent matters. Most farmers believe that little can be done about degraded land, and it is seen as an inevitable process through which the fields have to pass. The farmers are highly aware of the green manure effect of plant material left on the fields, and there has been a change of practice from burning the plant material as was done previously. Some farmers with medium-sized estates are experimenting with permanent agroforestry systems with coffee, cacao, and fruit trees.

In the village in the degraded areas, farmers have less land (1-5 ha), but with a wide range of crops grown for the market. In the village in the forested area, the farmers have more land per family (8-15 ha), but the market production is mainly focused on maize. Estimating crop budgets on the commonly promoted cash crops in the region (such as maize, cotton, and coffee) revealed very low net income, or that the farmers even experienced net losses. Other crops that produce little, but constantly, throughout the year, such as plantain and coriander, have a relatively better payoff.

The results suggest that local farming systems, based on intercropping and agroforestry, may be the most suitable agricultural system in terms of both agro-ecology and farm income. A difference in farming strategies between the two areas could partly be explained by market access. Another explanation might be that degraded land has forced farmers to look for other market options besides traditional cash crops. Nevertheless, most farmers take few explicit measures to prevent land degradation. One reason for this would be that it is not considered as an anthropogenic problem, but as a natural phenomenon.

The implication of the diagnostic outcomes is that the research will continue to explore erosion and land degradation from mainly a social perspective, focusing on perceptions and strategies in local soil management, and on how innovative farmers deal with the positive and the negative soil processes in terms of local techniques, soil management knowledge, and learning processes.

We will also continue to explore the economic dimension of the local farming, and compare soil fertility of the different farming systems.

Contributor: Kristina Marquardt
Collaborators: Mario Arévalo Rivera, Daiwis Tuanama Pashanasi, Proyecto de Apoyo Rural de la Amazonía (PRADERA), Tarapoto, Peru; Lennart Salomonsson, Ulrika Geber, Magnus Ljung, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden; Douglas White

3.5. Distribution of *Bemisia tabaci* in Latin America

Objectives

Whitefly-transmitted geminiviruses are the most important constraint to common bean and horticultural crop production in the lowland tropics. Currently, over 30 distinct species of geminiviruses transmitted by the whitefly *Bemisia tabaci* attack common bean, tomato, pepper, cucurbits, and other horticultural crops in the lower altitude American tropics and subtropics.

The distribution of the whitefly seems to have been extending over the recent past. Whether this is because of increased crop production areas, better reporting, or actual introduction of the species is not clear. This study was an attempt to explain the present distribution in simple climatic terms to better understand the limits of the distribution, and to indicate possible areas of future spread.

Materials and Methods

We used 304 georeferenced points throughout Latin America drawn from a survey of *B. tabaci* and geminiviruses. These points were scored during the survey on a scale of 1 to 5 (where 1 shows low infestation, and 5 very high infestation) for severity of whitefly infestation. We used FloraMap to construct a general climatic probability model of the distribution on the 10-arc-minute climate grids. This gave unconvincing results with the distribution probability smeared over large areas, and areas of known incidence showing low or zero probabilities. This is a common occurrence when an accession set contains a number of distinct populations or climate types.

We therefore used Ward's method of cluster analysis within FloraMap to investigate this possibility. After a number of trials it was decided that six clusters explained the distribution best. The clusters showed a range of different climates, and the joint probability distribution gave a good description of the accession point distribution.

The mean climates of the six clusters were inspected, and a set of rules for a simplified climate description was devised. This was mapped against the distribution, and scored for success and failure. As a final check, the simple climate rules were mapped against a 1-km grid for Central America, and checked against the agricultural land cover classes.

Results

Figure 19 shows the composite distribution probability constructed by summing the six probabilities from the climate clusters as derived by FloraMap. Very few points fall outside this limit, which in this case is displaying all areas with a probability greater than 30%. On inspection of the climate types, we found a large variation. There were hot tropical high-rainfall climates, subtropical climates with cool winters and hot dry summers, hot dry tropical climates, and other combinations. However, one characteristic stood out in them all. They all had 4, or a few more, months of dry season with rainfall less than 80 mm.

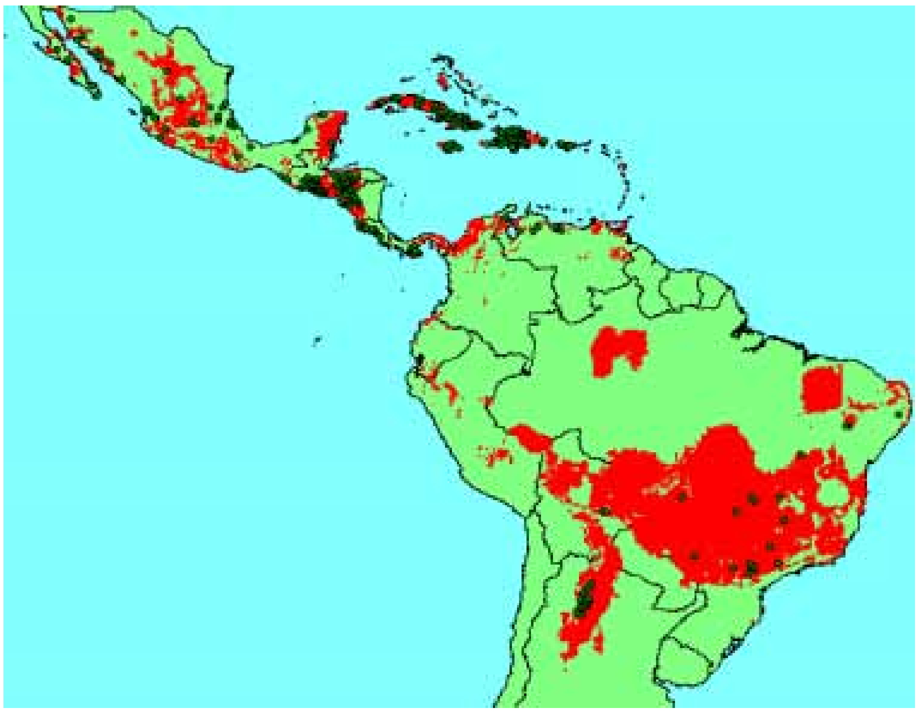

Figure 19. Distribution of *Bemisia tabaci* in Latin America with the climate probability derived as the joint probability of six cluster classes.

Whiteflies are hardly found above 1000 m throughout Latin America, but they are found more or less up to this limit regardless of latitude. This was a conundrum. The temperature regimes of the cluster classes varied widely, and the temperatures and annual temperature ranges vary greatly with latitude. How was it that the whiteflies would maintain the 1000-m limit in the face of this variation? The answer may be that, as we move away from the tropics, the annual temperature falls, but the annual temperature range increases. It is therefore possible that there are aspects of temperature that are constant with altitude over large latitude ranges. Figure 20 shows a case in point. As we move away from the equator, the temperature of the warmest month of the year is remarkably constant at an altitude of 1000 meters.

That this climate characteristic is actually determining the distribution of *B. tabaci* cannot be asserted from this study, but the coincidence is striking and could warrant some physiological investigation. In fact, the temperature of the warmest month in the six climate clusters never fell below 21 °C.

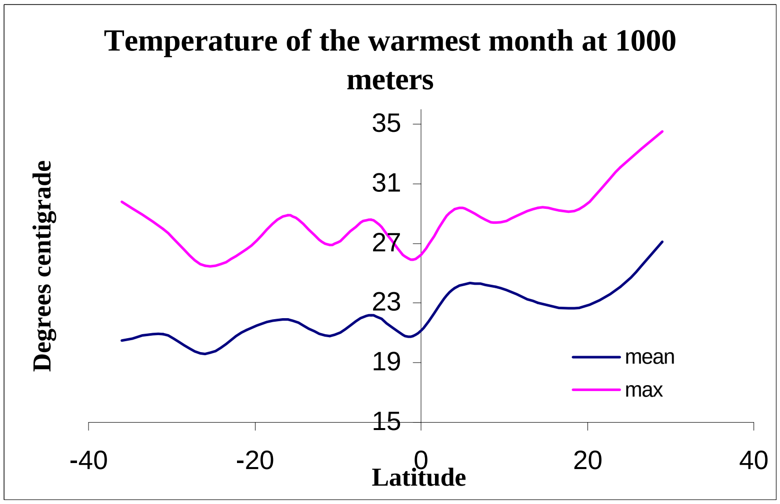

Figure 20. Temperature of the warmest month plotted against latitude for Latin America.

When we looked at the areas designated by the simple description of 4 dry months with less than 80 mm rainfall, and the temperature of the warmest month greater than 21 °C, we found a remarkable match with the survey points. The areas designated as *B. tabaci* should be present, but over 1000 m, predominantly in Mexico, are not primarily agricultural and so would not have been sampled.

Some of the points that missed the predicted distribution could be the result of fitting the model to a climate grid with pixels 18 km on the side. In mountainous areas, this level of precision is insufficient. We had available a 1-km precision grid for Central America, and so mapped the 103 survey points onto this grid using our derived climate bounds. Figures 21 and 22 show the result. The yellow circles highlight the six wrongly classified points.

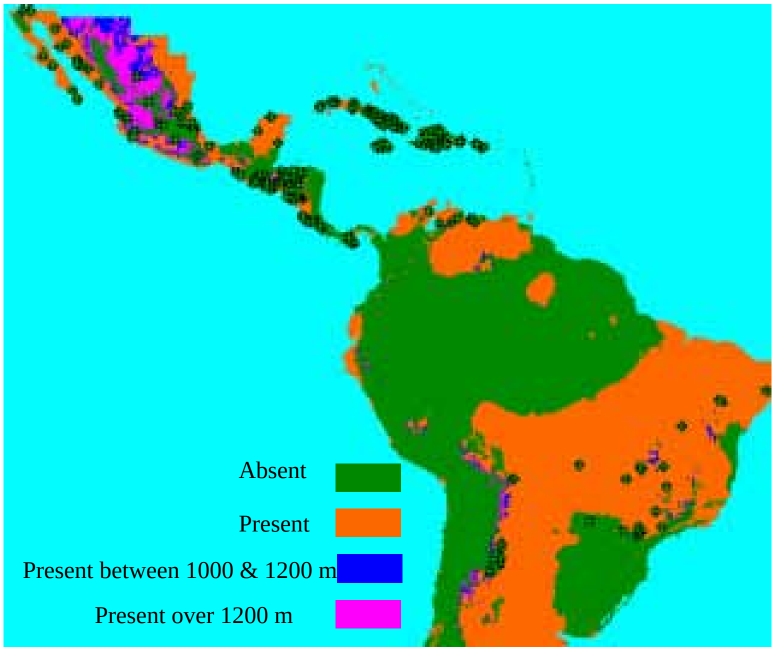

Figure 21. 304 accession points of *Bemisia tabaci* plotted in Latin America

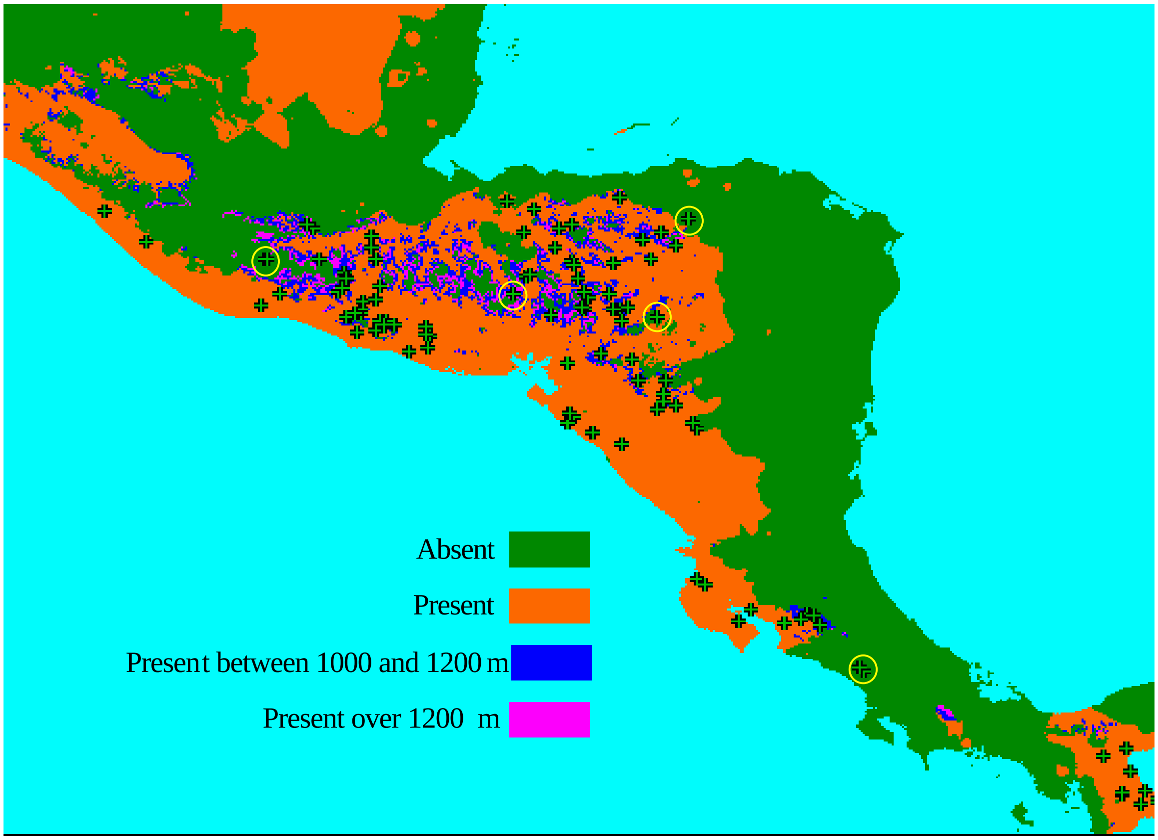

Figure 22. 103 survey points of *Bemisia tabaci* with derived climate limits, Central America.

Table 4 shows how the survey points were classed with respect to severity of infestation and elevation. None of the heavily infested areas was miss-classed by the classification, and the percentage of points miss-classed and the severity of infestation were very strongly related. Some eight points fell above the 1000-m limit, but almost none above 1200 m.

Table 4. Central America: 103 survey points of *Bemisia tabaci* and how they were classed.

Severity[a]	Wrongly classed	Correctly classed			
	(no.)	%	Below 1000	Above 1000	Above 1200
2	1	20.0	5	0	0
3	5	8.5	53	6	0
4	1	4.0	23	1	1
5	0	0.0	6	1	0

a. On a scale of 1-5, where 1 shows low infestation, and 5 very high infestation.

It would appear that we now have a very simple, but effective, rule for determining if an area could be susceptible to whitefly. Some of these areas, such as that around Manaus, will presumably remain free of whitefly, because the density of cultivation of susceptible crops is very low. More worrying is the case of the area predicted in the Central Valley in Chile. This area has considerable horticultural production and a Mediterranean climate. Whitefly is a major pest around the Mediterranean, but do not appear to have arrived yet in Chile.

Outputs

This work was presented in May at the VIIIth International Plant Virus Epidemiology Symposium in Ascherleben, Germany.

Contributors: Peter G Jones (consultant); Francisco J Morales (PE-1)

Output 4. Analysis and prediction of vulnerability of land use systems to significant external events

4.1. Farming Futures: Modeling the effects of climate change on agriculture

Objectives

Global warming is coming; there is now no question about it. The consequences are still to be determined in detail, but agriculture will undoubtedly be changed over the next 20 years.

Agricultural research has a long lead-time. A recent breakthrough in drought tolerance for beans at CIAT, although not costing more than a few million dollars, took nearly 25 years to deliver the goods. This means that scarce research resources have to be targeted with great care. This has never been easy, but with the moving goalposts of Global Climate Change upon us, the job has become much more difficult. We need to know what will be needed, and where it will be needed, **now**, to plan the next 25 years of research (Figure 23).

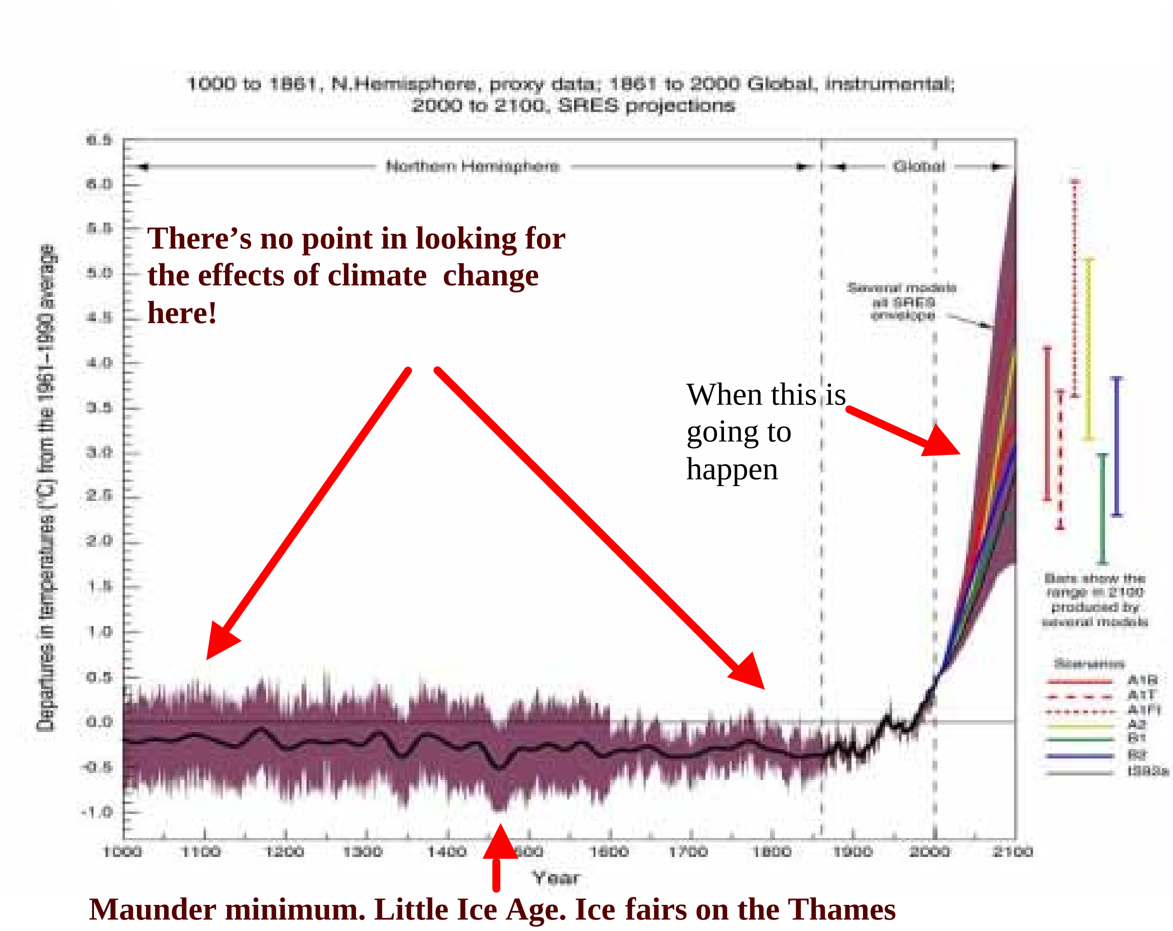

Figure 23. Variations in the Earth's surface temperature, 1000 to 2100.

We are obviously in an area where experience is of little use beyond our knowledge of the theory of plant growth and development. We have never seen the sort of changes that are coming and so we are reduced to guessing or modeling. Guessing is never a good idea.

Methods

We must resort to modeling the system. This is fraught with problems, but it can be done. We have shown (Jones and Thornton, 2002[7]) that crop process models can be linked to the output from GCMs to estimate the effects of climate change on agriculture in the tropics. We have now extended those studies to include an assessment of potential maize yields in the year 2055 for Africa and Latin America. We used the outputs of the HADCM2 model and interpolated the changes in climate onto the CIAT climate grids. Simulated weather was then generated using MarkSim. For each of 20 simulated years, the model CERES maize was used to estimate yield.

Results

The results show three main scenarios with which we will be dealing:

(1) There will be areas (particularly in the highlands) where some crop yields may improve – *It is imperative that research in these areas should make the maximum use of any potential gains, because there will not be many places where this will apply.*

(2) Quite large areas may show minor changes in yield potential, but will require differently adapted varieties and probably some shifts in crop mixes and agricultural practices. *These cases will require carefully planned research in cultivar development and farming practices.*

(3) A significant number of areas will require major intervention because of potential complete crop failure. *Major changes in the agricultural economy of these areas will be needed. Agricultural technology may be unable to solve these problems, but farming systems research may be able to warn decision makers of the possible consequences.*

Maize (the test case we decided to look at) is a C_4 plant probably better able to stand up to rising temperatures than most other crops. We chose it because we know the model used has been in use for about 30 years, and has been proved in most environments. Here are some examples of what we found:

[7] Jones, P. G.; Thornton, P.K. 2002. Spatial modeling of risk in natural resource management. Conserv Ecol 5: 27. [on-line] URL: http://www.consecol.org/vol5/iss2/art27.

The first is some good news for Ethiopia (Figure 24). It is not often that happens! Ethiopia is not a major, maize-growing nation, but the indications show that cereal growth with C_4 plants such as teff could be improved in quite a few areas. However, you will note from Figure 24 that local decompensations will occur. This is a typical case of the class 1 climate change problem. There are benefits to be had, but the agriculture of the area will have to be rebalanced to gain the benefits. Of course, the actual crops of the area have to be modeled under GCM conditions to assess the true situation.

Present yield **Yield change to year 2055**

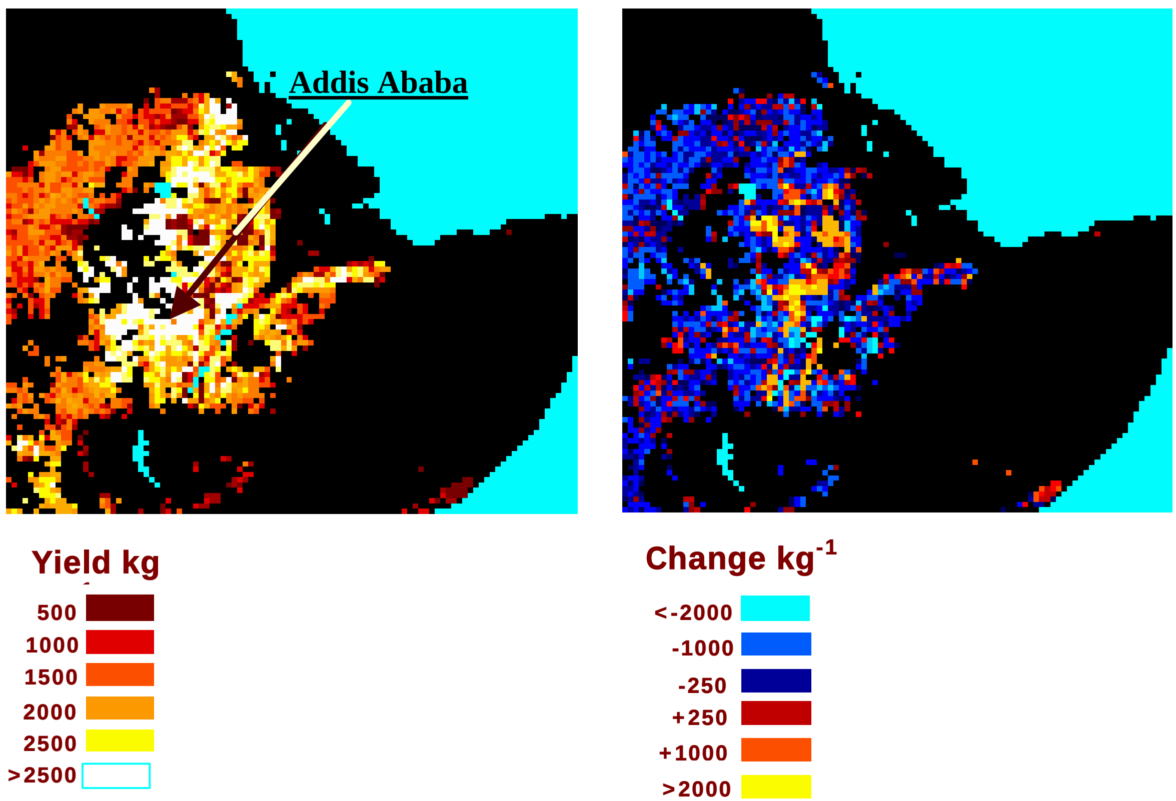

Figure 24. Predicted maize yield changes for Ethiopia to year 2055.

A typical class 2 case can be found in Brazil (Figure 25). Here we have a mosaic of minor yield decreases associated with local increases in yield potential. This is obviously of immense importance to the farmers of the region, but could be handled with judicious application of agricultural science without major catastrophe. Knowing just what new varieties will be needed will help to capitalize on the benefits and reduce the possible losses.

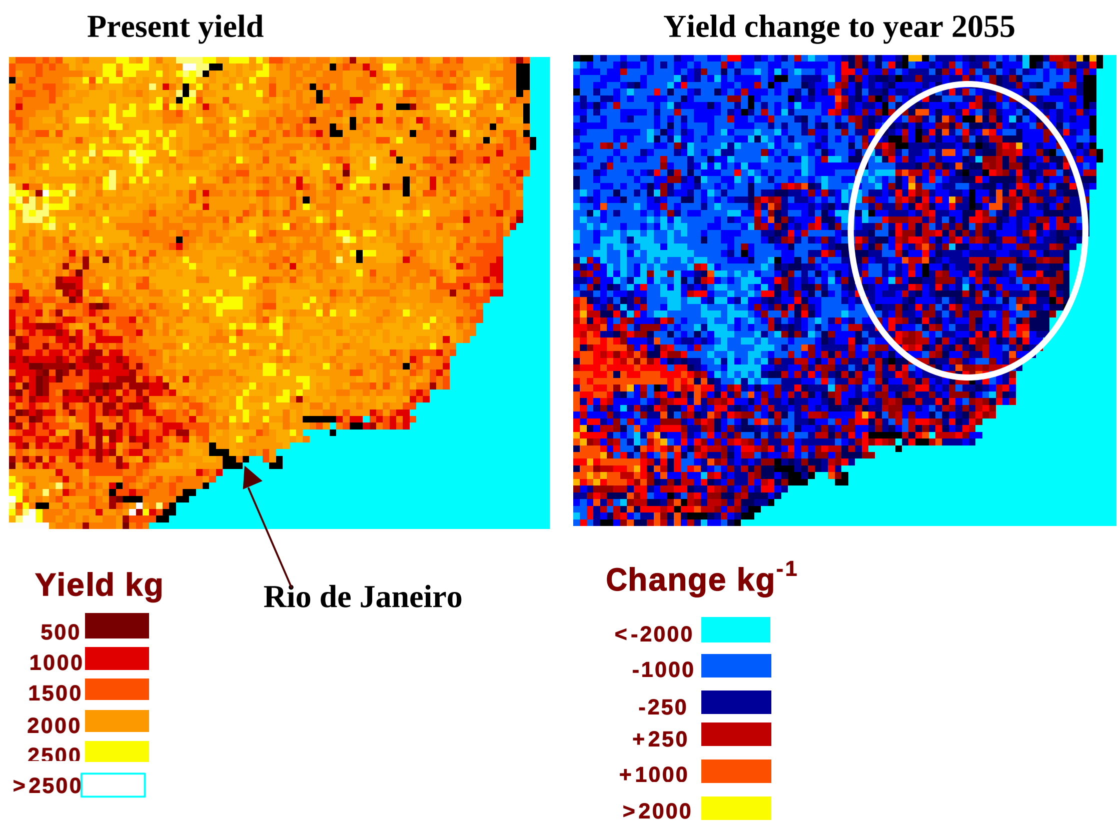

Figure 25. Predicted maize yield changes for Bahia, Brazil to year 2055.

This dry area in Venezuela (Figure 26) exemplifies the class 3 situation. When the markets have been right, this has been a major maize-producing area. It is dry, mainly scrubland, but can produce well under certain circumstances. The change in wind patterns will mean that it becomes much drier, and will probably have to go back to extensive grazing. The crop production of Venezuela does not look like a happy prospect in the next 50 years, and for rainfed crops like maize it would appear that a major shift might be indicated. Venezuela, of course, has much irrigable land, and so this may not be a major problem if the social implications are dealt with appropriately.

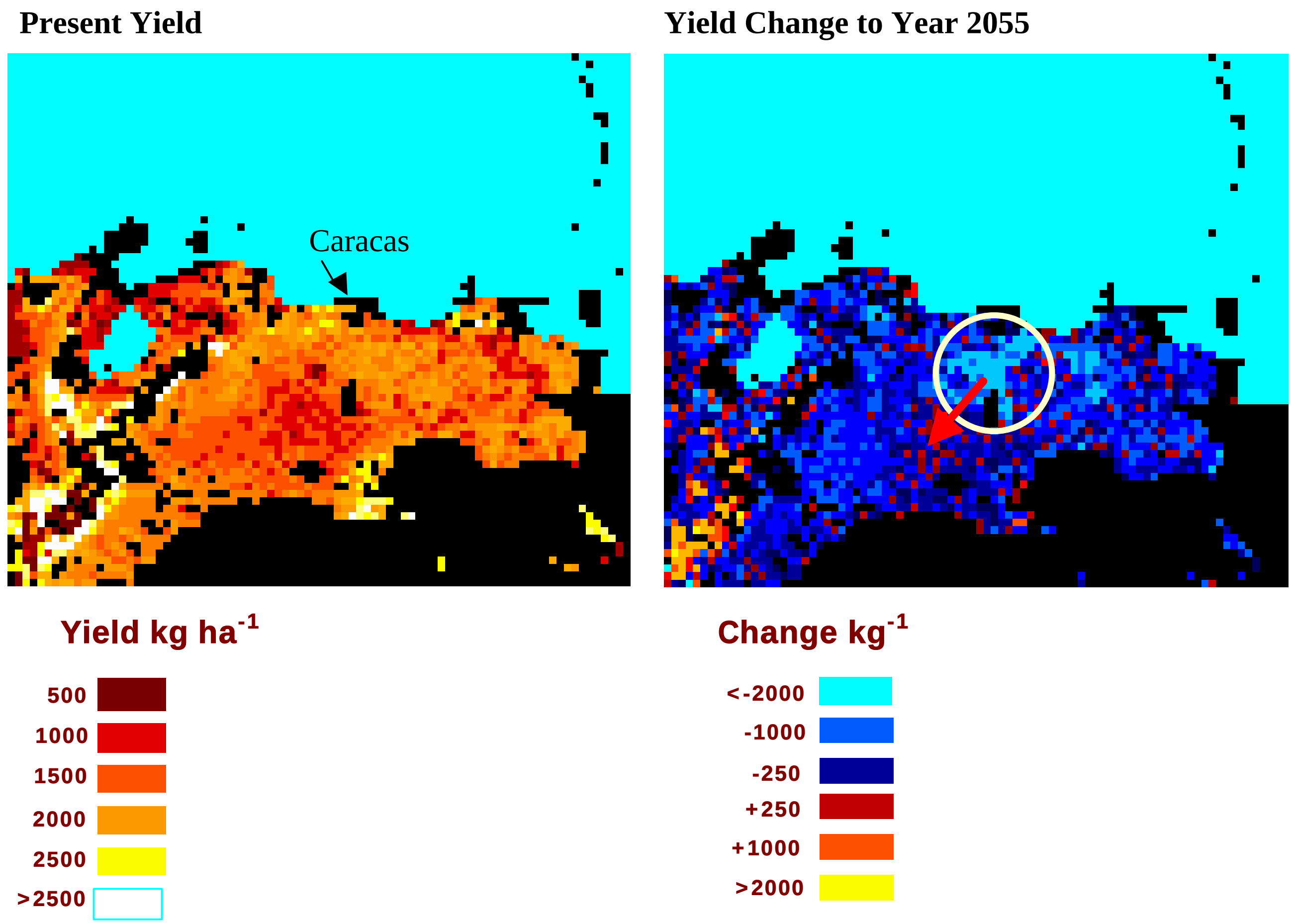

Figure 26. Predicted maize yield changes for Venezuela to year 2055.

Outputs

These examples show some of the complexity of the problem we are facing. Planning for agricultural research under these conditions needs pre-knowledge. We have shown that we can do this with one crop, but we need to do much more. The C_3 crops behave completely differently, and varietal adaptation is the key to successful agriculture. These results have been used to develop project proposals. The major one, entitled Farming Futures, is included in the Climate Change Global Challenge Program (CCGCP) and would involve a budget of $M2.6 over 4 years. A cut-down version of this, to try to classify the areas showing different response types, would take minimal funding and take a very quick look at the situation to assist in the planning for the CCGCP.

Contributors: Peter G Jones (consultant, CIAT); Philip K Thornton (consultant, ILRI); Glenn Hyman

4.2. Applying spatial interaction models to the dairy sector in Colombia

Objective

?? Test the hypothesis that the profitability and adoption of new technologies in the dairy sector of Colombia is positively related to the access to markets and center of innovation

Methods

The methodology used in this study combines "Reilly's Law" with an analysis of the cost of physical movement around Colombia. Reilly's Law states that flows of goods, services, and information between two places depend on the populations of those two places and the ease of travel from one to the other. This is analogous to the law of gravity in physics. The methodology has two stages: (1) create a friction surface of physical movement for the region to be studied, and (2) define the origins and targets and calculate the cost of traveling between these locations and the cumulative forces of attraction in a region.

Stage 1
When creating a friction surface we take into account the topography of the region (slope), the channels of movement (roads, railway, rivers, etc.), barriers to movement (international borders, rivers, civil unrest), and the geographical limits of the analysis. For this study, data have been collected for these variables and combined to form a friction surface. Only roads are considered as a **channel of movement** and there are three classes:

(1) Paved – equivalent to 60 km per hr
(2) Unpaved – equivalent to 18 km per hr
(3) Tracks – equivalent to 12 km per hr

Slope acts as a multiplication factor: 0 - 5 deg – *1; 5 - 15 deg – *2; 15 - 90 deg – *3.

Barriers were not chosen for this study, and non-roads are classified as equivalent to 6 km per hr. The resulting friction surface has values varying from 60 km per hr to 2 km per hr

Stage 2
The origins of movement are the farms that have been surveyed, whilst the targets are the municipal capitals of the regions of the study, for which we know the populations. For each municipal capital a surface is created (Figure 27) showing the time needed to arrive at the capital from all points in the region, based on the friction surface created in Stage 1. This surface is then used to give a time from each farm in the region to the capital. To calculate the attractiveness of the target, the population of the capital is divided by the <u>square</u> of this time value and the result stored for each farm. This process is repeated for each capital in the region.

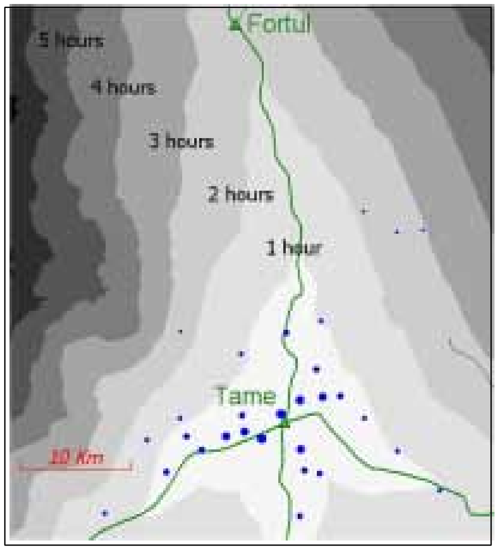

Figure 27. Time required to arrive at municipal capital (Arauca).

When the attractive force for all the capitals has been calculated, these values are summed to give a final value of how much each farm is "pulled", as well as which capital is the most attractive. Figure 28 shows how the population of Duitama in Boyaca attracts farms that are actually closer to other municipal capitals. To test the sensitivity of the time factor, we also calculated the "pull" when the population of the capital was divided by the time from the farm, and by the cube of the time. Figure 29 shows the total attractive forces for farms in Atlantico according to the three different versions of the model. In the first case, the population of Baranquilla attracts all of the farms. However, in the second and third cases – the quadratic and cubic versions of the model – the time factor becomes increasingly important and population becomes less significant.

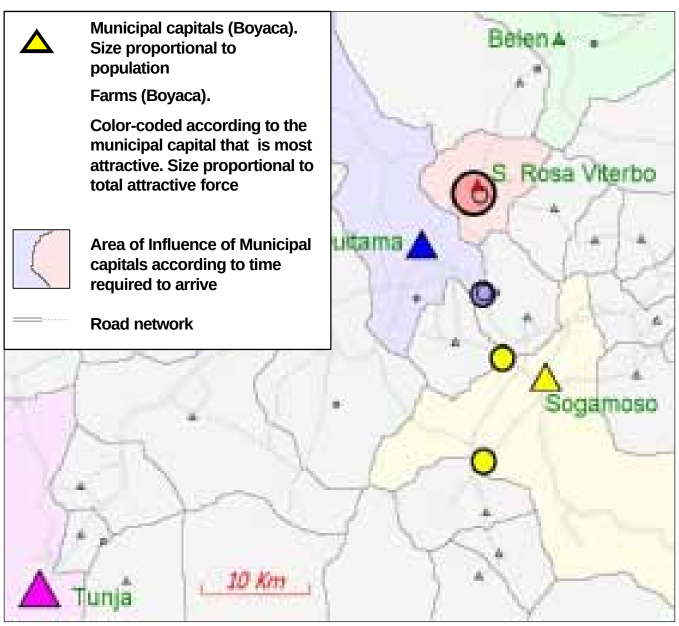

Figure 28. Influence of municipal capitals (Boyaca).

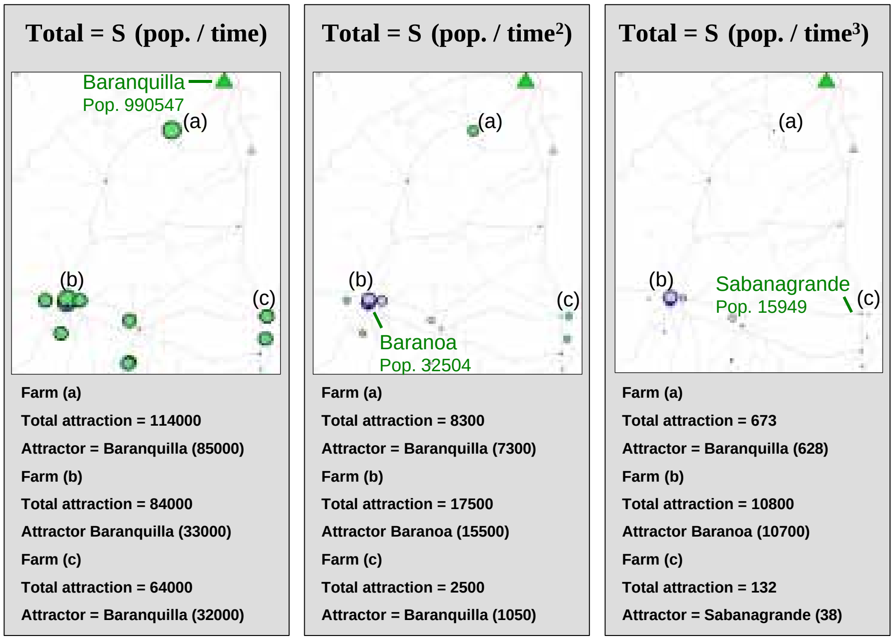

Figure 29. Sensitivity of model (Atlantico).

Results

The influence of markets using the quadratic form of the gravity model was shown to have little correlation to profitability of farms. However, there was a strong positive relation between the "pull" of markets and the productivity of farms (Holmann et al., 2002)[8]. The hypothesis that the profitability and adoption of new technologies in the dairy sector of Colombia is positively related to the access to markets and center of innovation has thus been proven for one aspect, but not for the other.

An interpretation of these results is that farmers with good access to markets have access to, and are investing in, technologies to improve production; however, this increased production has not resulted in improved profitability for the farm. Further research should be directed toward improved management of technologies, and a more detailed analysis of which technologies are most dependent on access to markets for their adoption.

Contributors: Andrew Farrow; Federico Holmann, Anderson Medina (TROPILECHE)
Collaborators: Juan Carulla (Universidad Nacional, Bogotá); Luis Alfonso Giraldo (Universidad Nacional, Medellín); Bernardo Rivera (Universidad de Caldas, Manizales); Silvio Guzman (Fundación Universitaria San Martín, Barranquilla); Manuel Martinez (Universidad de los Llanos, Villavicencio)

[8] Holmann, F.; Rivas, L.; Carulla, J.; Giraldo, L.A.; Guzman, S.; Martinez, M.; Rivera, B.; Medina, A.; Farrow, A. 2002. La produccion de leche en Colombia:Un analisis comparativo entre sistemas de producción y regiones. Improved legume-based feeding system for smallholder dual-purpose cattle production in tropical Latin America (TROPILECHE) Project. Draft Internal Document.

4.3. Training and capacity building on Rural Sustainability Indicators for Central America

Objective

Indicator tools can transform data into information, and information into actions, and thus help people and institutions make better decisions. As a result of the Rural Sustainability Indicators for Central America Project (a CIAT-World Bank- UNEP collaboration), a series of products were produced with the aim of helping and improving decision-making processes, and the monitoring of the development process. However, the tools by themselves will not make better decisions. Neither is it enough to provide only tools to the relevant institutions. Instead, real capabilities need to be created on how to produce and use the information and the tools for decision making. The way to create these capabilities is to train the personnel of the institutions on how to use and develop indicators and information tools.

Methods

Decision making, just like development, is a dynamic process and is carried out at different levels of society, taking into account different social, economic, environmental, institutional, and political aspects. At each stage of the decision-making cycle, different users/audiences take part, and use and require different types of information and tools. In practice, the training sessions and materials address two types of audience: (1) decision makers that *use* the information (i.e., Ministers, advisers); and (2) technical staff that *develop* the information (i.e., technicians, consultants). These two groups have different needs and responsibilities, implying two different types of training activities and material. Given the importance of improving the use of available information for decision making, it is sensible to concentrate on the "use of information".

Since the two audiences have different needs and approaches to using information, the training sessions will be different. However, for both groups it appears more cost-effective to develop distance-learning training given the needs and capabilities in the countries and the profile of the users. The training activities will be:

(1) For *decision makers*, the distance learning will be 1 day of 2-hour sessions based on the importance of indicators and information in decision making. The purpose is to sell this concept to decision makers so that the demand for indicators comes from them. One conceivable output of the session could be the formulation of a development problem that the decision makers would like technicians to "solve" for them. This could then be taken to the training of technical staff as a problem-solving part of the course ("hands-on training"). This idea would only work, however, assuming the two groups are trained in succession.

(2) For the *technical staff*, the distance learning will be over 4 days of 2-hour sessions, each day based on the importance of using indicators and information for decision making. In this way, they can be trained properly on all the features of the CD-ROM and the other products (produce information and improve tools). The purpose of these sessions will be to teach the participants how to produce the information that the decision makers need to make informed decisions.

The modules will be transmitted from Washington DC to all collaborator centers in Central America, using video-conferencing technology, with the participation of people from the Ministries of Agriculture, Environment and Planning, and Statistics offices, as well as people from international institutions and cooperation agencies from Costa Rica, Guatemala, Nicaragua, Honduras, El Salvador, and Panama.

Results

As a result of the training sessions, the measurable expected impact will be the improvement of the use of the indicator toolkit and information. An expected impact of the distance learning phase will be to increase the number of institutions using the indicator toolkit, and the capacities to produce and use data and indicators in order to provide information to decision makers. Measuring this impact is rather more difficult and would involve follow-up calls to all the participants of the distance learning, probably through the continued use of the questionnaires distributed in the dissemination phase of the project. At the same time, regarding the results of these distance-learning sessions, the goal of the World Bank is to analyze the usefulness of applying and disseminating the approach and modules to other regions (South America, Asia, and Africa).

At the same time, another impact should be an increase in the number of institutions using the lessons learned document in the indicator toolkit in order to plan their own indicator initiatives. Measuring this impact is also difficult, and would have to involve follow-up calls to all the participants of the distance learning, the continued use of the questionnaires, and keeping an eye on publications and bulletins from the region.

Contributors: Manuel Winograd, Andrew Farrow
Collaborators: The World Bank, the World Bank Institute

4.4. Quantifying impacts of cassava-based hillside land uses on system resilience to environmental disturbance

Objective

?? To understand the potential impacts of cassava-based land use systems on resilience of hillside agro-ecosystems to perturbations

Methods

Data from field trial research conducted at the Santander de Quilichao Research Station, Cauca Department of southwest Colombia were used in this research. The long-term cropping systems included:

?? Bare fallow continuously clean tilled, no fertilizer, and no crop;
?? Cassava with rototiller treatment, 4 t ha^{-1} chicken manure;
?? Cassava in monoculture with rototiller treatment, no fertilizer;
?? Cassava in minimum tillage, no rototiller, 300 kg ha^{-1} mineral fertilizer;

?? Cassava with rototiller treatment, 8 t ha^{-1} chicken manure;
?? Cassava as a single crop with vetiver grass as a double-row life barrier occupying 12.5% of the plot area with rototiller treatment, 4 t ha^{-1} chicken manure;
?? Cassava intercropped with *Chamaechrista rotundifolia* with rototiller treatment, 300 kg ha^{-1} mineral fertilizer;
?? Cassava in rotation with *Bracchiaria decumbens* and *Centrosema macrocarpum,* 300 kg ha^{-1} mineral fertilizer; and
?? Cassava with rototiller treatment, 300 kg ha^{-1} mineral fertilizer.

Soil structure was indirectly quantified by measuring the resistance of the soil to penetration using a pocket penetrometer (Daiki Soil and Moisture Sensors, Model DIK-5560) on a weekly basis during the period from January 2000 until December 2001.

The experiment plots were designed as completely randomized blocks with three repetitions. Six measurement points were established on each plot, two at each end and two in the middle part of the plot. Four readings were taken at each measurement point and their mean noted. Weekly standard deviations about the mean of the 18 individual data (i.e., six readings in three reps) were calculated for each cropping system, and considered as an indicator for spatial variation of soil penetration resistance in each cropping system.

Results

Soil penetration resistance within the investigated cropping systems was on the average higher in 2000 than in 2001, and corresponded to the distribution of cumulative annual rainfall between the two years. While the absolute values decreased markedly from 2000 to 2001, the decrease of the range between lowest and highest penetration resistance was much smaller, indicating a systematic decrease across all cropping systems.

Intuitively, it is expected that higher rainfalls will cause the soil's resistance against penetration to decline. However, data revealed no linear relation between rainfall and soil penetration resistance. But data suggested that higher rainfalls would increase spatial variation of a soil's resistance to penetration.

Cassava minimum tillage has the highest weekly standard deviation values for both years. While cassava intensive tillage has the lowest weekly standard deviation values in 2000, it is second lowest in 2001 to bare fallow. Remarkable is the magnitude by which standard deviation values in cassava minimum tillage are higher than those in the other cropping systems. Cassava minimum tillage has also, in both years, the widest range of weekly standard deviation. Lowest ranges are found in cassava intensive tillage (2000), and bare fallow (2001). One-way analyses of variance confirmed that weekly standard deviation in cassava minimum tillage was significantly different ($P < 0.001$) from those of all other cropping systems in both examined years. When cassava minimum tillage was not included, the analysis of variance (ANOVA) revealed no further statistically significant differences between weekly standard deviations for the remaining cropping systems in 2000. When cassava minimum tillage was omitted from the variance analysis of 2001 statistically significant differences between most of the other cropping systems were exposed.

The partitioned mean squares from an ANOVA, which used cropping systems and weekly dates of measurements as variables, were studied to investigate the influence of precipitation on the spatial variation of penetration resistance. Partial mean squares are an indicator for the variance that is accounted for by the variables included in the ANOVA. In 2000, the partial mean squares for cropping systems were 2.3 larger than the variance accounted for by the measurements dates. In 2001, however, the year with much lower annual precipitation, the cropping system accounted for 7.5 times more variance than the measurements dates. Furthermore, when cassava minimum tillage was excluded from the ANOVA, partial mean squares indicated that, in 2000, measurement dates accounted for 3.6 times more variation than cropping systems. In 2001, the year with low precipitation, however, cropping systems still accounted for about 1.5 times more variation than did the measurement dates. These results indicate that low precipitation acts as filter, amplifying differences in spatial variation between the various cassava-based cropping systems.

The general trends documented suggest that higher precipitation will increase both the soil's resistance to penetration and the spatial variation of the penetration resistance. This trend is not consistent with general understanding that relates higher precipitation with lower resistance of soils to penetration. To further investigate this trend, we grouped the rainfall data into precipitation classes combining weeks with low, medium, high, and very high weekly precipitation. In both years, resistance against penetration and spatial variation of resistance is generally decreasing from weeks with low to weeks with medium amounts of precipitation in most cropping systems. However, resistance against penetration and its spatial variation is again increasing in both years from weeks with medium to weeks with high rainfall. The exception is cassava minimum tillage, for which, in 2001, resistance and its spatial variation decrease consistently from weeks with low rainfall to weeks with high rainfall. Hence, increases in resistance and its spatial variation are predominantly caused by very high-rainfall events. Furthermore, correlation between the amount of weekly cumulative rainfall and resistance, and its spatial variation, is for both years consistently negative, indicated by low (2000) and moderate (2001) coefficients of correlation. It is likely that the impact of the aforementioned events with very high rainfalls prevented stronger negative correlations.

Output

Increased, but environmentally sustainable productivity of hillside cropping systems through improved land use management.

Contributors: Thomas Oberthür, Christian Thierfelder (PE-2), German Lema, Otoniel Madrid

Output 5. Methods of capturing farmers' knowledge in land use decision support

5.1. Exploring low altitude photography for improved management of local agricultural systems

Objective

?? Investigate, develop, and adapt methodologies based on low aerial photography (LAP) for the purpose of elucidating and communicating spatial information about natural and genetic resources at local scale

Results

The methodology was developed in two bean on-farm experiments, one at CIAT and one at Darien, Lago Calima, Colombia. The method permits capturing georeferenced infrared and digital images using a simple kite-based photographic system in conjunction with ground-based geographical positioning (Figure 30).

Figure 30. The image shows the camera setup, consisting of the remote control unit and a 35-mm film-based camera with cradle. The system can also be flown with a high-resolution digital camera, and is airborne using various kite and balloon platforms, depending on wind conditions.

Images of the two pilot experiments were taken weekly, and crop data (biomass, leaf area index, plant height, and diameter) for image calibration were collected at four growth stages. Images and calibration data are currently being prepared for detailed analyses (Figure 31).

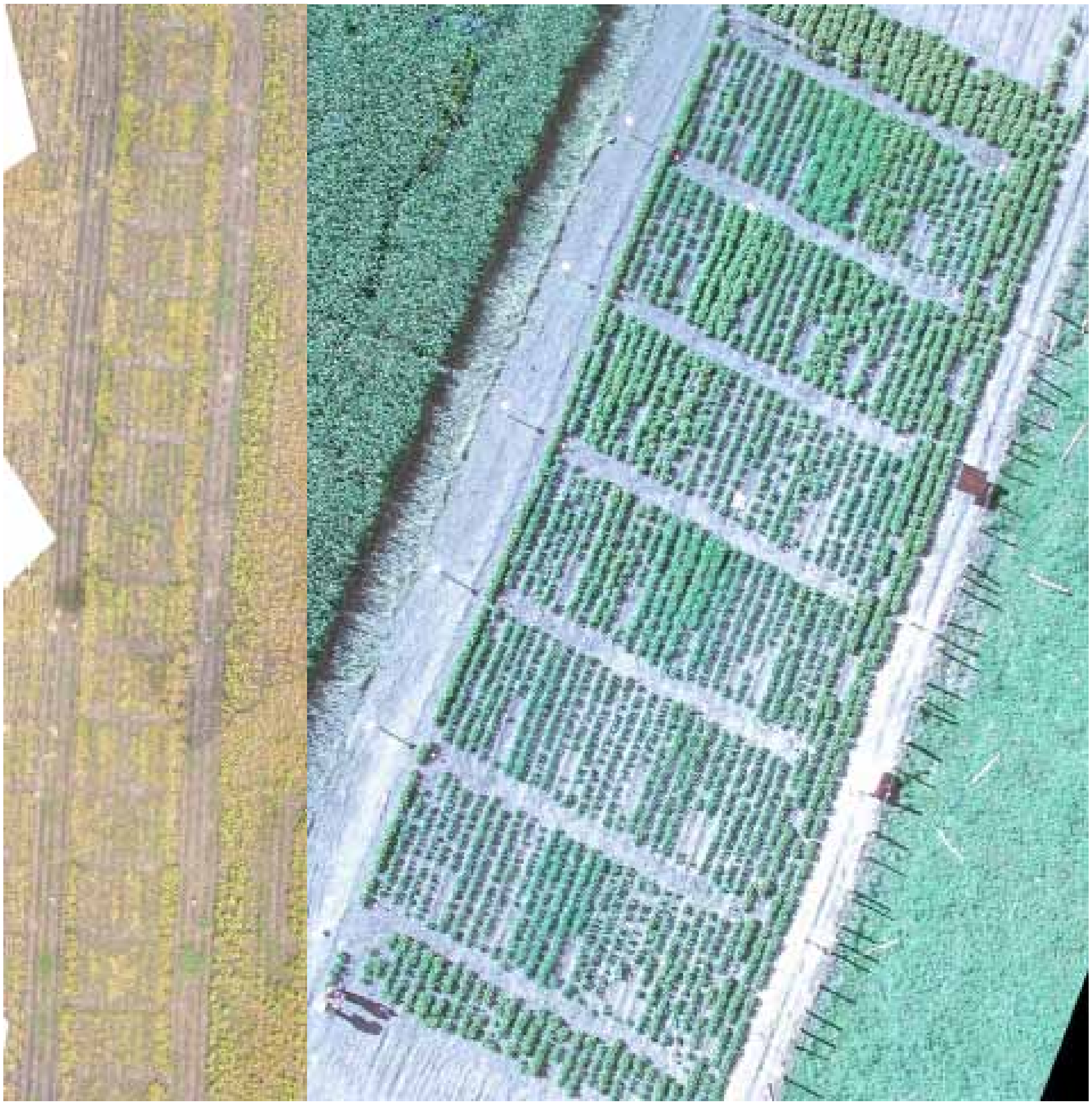

Figure 31. The image shows the two experiment sites (at left CIAT, with plants in a late-growth stage, and at right Darien). Data from the CIAT experiment are used to investigate the rapid identification of bean genotypes using plant phenology (shape) and color characteristics. Data from the Darien experiment are used to develop vegetation indices to rapidly distinguish genotypes in on-farm experiments based on spectral reflectance and / or color and plant phenology.

In a second line of research, we explored the opportunity to use the captured images to generate high spatial resolution DEMs at local scales, using existing photogrammetry algorithms. The difficult issue in this research was the design and implementation of a ground-based reference system. This has been developed and we are investigating currently the actual DEM generation (Figure 32).

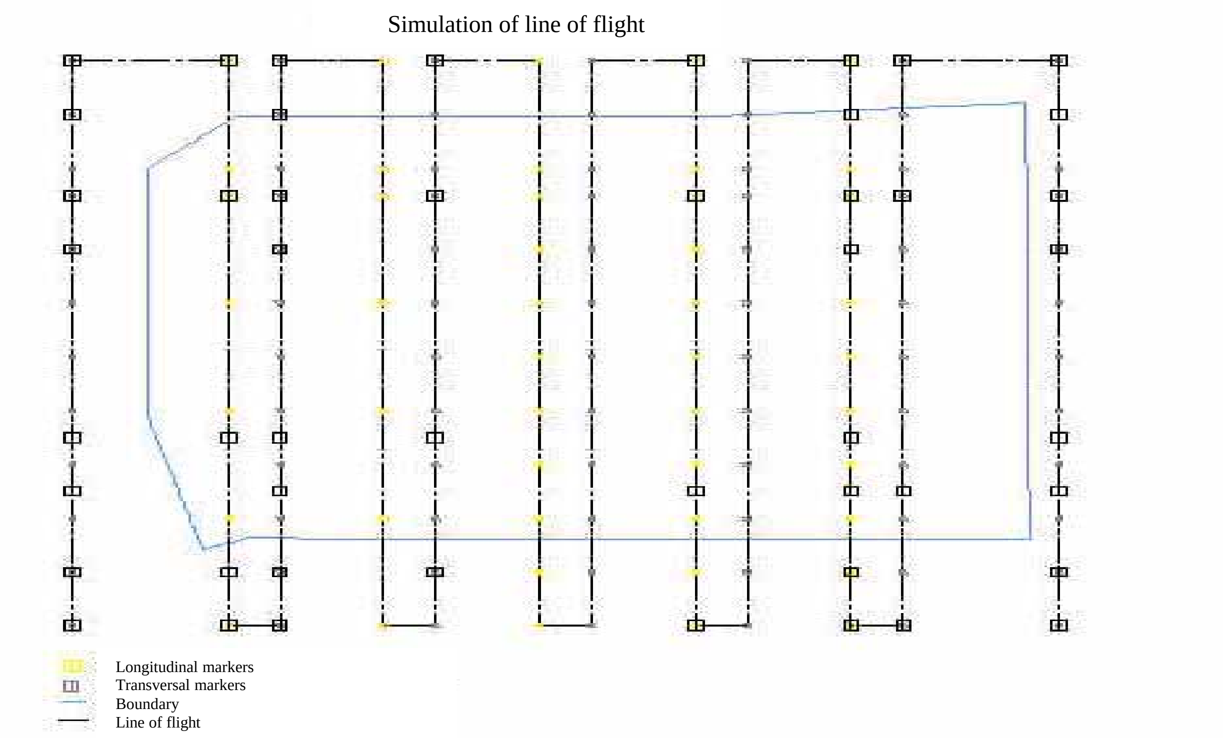

Figure 32. The graph outlines the design of the flight path for capturing low altitude aerial stereo images to generate high spatial resolution digital elevation models.

Output

When the current analyses are completed, the methodology will facilitate efficient and accurate community management of genetic and biophysical resources through:

(1) Rapid participatory identification and selection of genetic resources; and
(2) Monitoring of local, productive systems to provide accurate and timely options for intervention (e.g., in soil erosion, pest, and fallow assessment).

Contributors: Herman Usma, Rosa Nohelia Naranjo Mafla, Lix Danny Mosquera Hoyos, Juan Carlos Barona, Thomas Oberthür
Collaborators: Sandra Bolaños; Matthew Blair (IP-1); Idupulapati M Rao, Jaumer Ricaurte (PE-2)

5.2. Merging local and scientific spatial perceptions of agricultural systems

Objective

?? Develop and promote participatory, 3-dimensional models (P3DM) that are acceptable to farming communities, their institutions, organizations, and researchers for visualization / exchange of knowledge between farmers and scientists about resource variation.

Results

CIAT's Land Use Project developed the methodology jointly with farming communities in Cauca (Pescador) and Valle de Cauca (Yotoco and Restrepo). Using the method it is now possible to generate georeferenced models of farms and catchments that can be transferred into a GIS for advanced spatial analyses. Conversely, information housed in GIS can be plotted and superimposed on P3DM for community-based analyses (Figure 33). The method was presented at various workshops, and a manual is currently under revision for publication in early 2003.

Figure 33. The image shows the raw participatory, 3-dimensional model for Yotoco (Valle de Cauca). This particular model was used for gender-specific investigation of the spatial accuracy of locally derived surfaces depicting topographic and infra-structural features.

The group of the Vereda La Colonia (Yotoco,) has recently produced a new P3DM that has been used to negotiate, with the Corporación Regional Autónoma del Valle del Cauca (CVC), a project under the Fondo Vallecaucano para la Acción Ambiental.

Output

The methodology enables improved community-based resource management for safe intensification of agricultural hillside production systems.

Contributors: Herman Usma, German Escobar, Thomas Oberthür; farming communities in Cauca and Valle del Cauca
Collaborators: Sandra Bolaños, Luz Amira Clavijo, Otoniel Madrid

5.3. Land use impacts on soil macro-fauna biodiversity at catchment scale

Objective

?? Develop a methodology for rapid characterization at the landscape scale of soil biodiversity of macrofauna

Methodology and Results

A methodology was developed that is based on a stratified sampling approach where local knowledge is used to define strata at the landscape scale. Strata are then sampled using a sampling design that makes use of fewer samples than suggested in other common approaches. The methodology developed demonstrates that land use classification based on local farmers' knowledge can serve as the basis for the implementation of soil biodiversity assessments.

Results were presented to the community of the study area in Pescador (Cauca) at two workshops, and a pre-grade thesis is currently submitted to the Universidad Nacional, Palmira. Furthermore, the collected data were analyzed, organized, and presented in conferences under the following aspects:

?? Distribución y Abundancia de la Macrofauna Edáfica Asociada con Unidades Locales de Clasificación de Suelos en la Microcuenca Potrerillo, Cauca, Colombia (XI Congreso Colombiano de la Ciencia del Suelo, Septiembre 18-20, 2002).Muestreos comparativos de escarabajos coprófagos (Coleóptera: Scarabaeinae) para examinar pérdida de biodiversidad del Bajo Calima, Valle del Cauca (XXIX Congreso Sociedad Colombiana de Entomología).

?? Exploración de la presencia y abundancia de la coleópterofauna edáfica en diferentes usos de la tierra en una microcuenca del Departamento del Cauca. Ponencia (XXXVIII Congreso Colombiano de Ciencias Biológicas, Octubre 1-4, 2002).

Figures 34 and 35 present an example that shows differences in abundance and density of earthworms and myriapods for four local land quality categories, including fertile land (buena), nutrient-mined land (cansada), physically degraded land (brava), and otherwise unproductive land (mala).

Based on this research, we will now develop practical indicators for rapid soil quality monitoring and diagnostic at landscape scale.

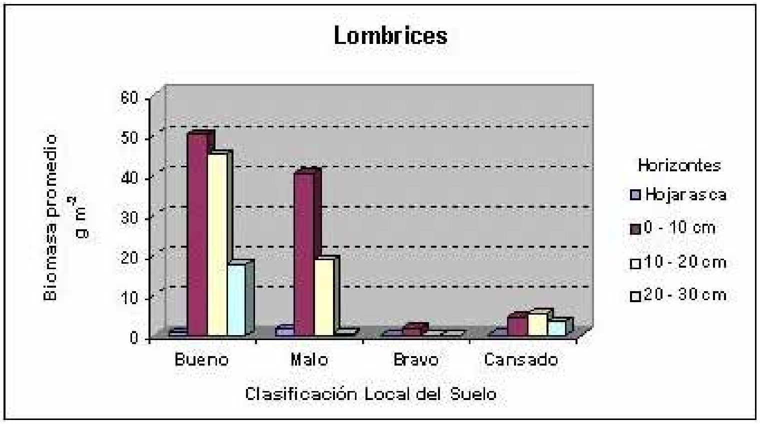

Figure 34. The biomass of earthworms (lombrices) in the leaf layer (hojarasca), and three soil horizons (0-10 cm, 10-20 cm, and 20-30 cm), sampled in four local land quality categories including good soil (bueno), nutrient-mined soil (cansado), physically degraded soil (bravo), and otherwise unproductive soil (malo).

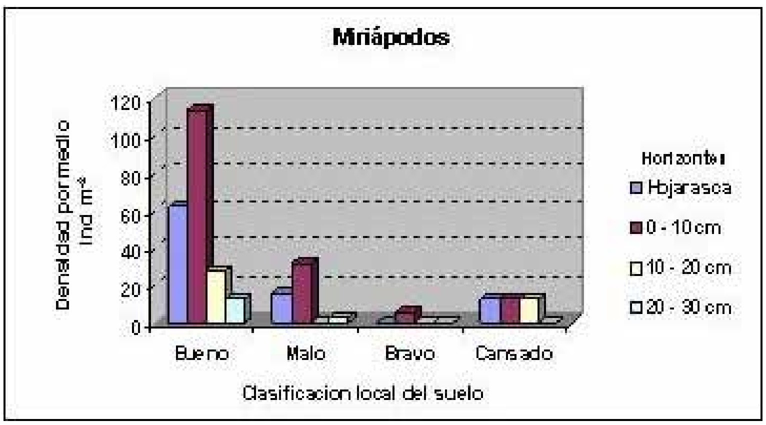

Figure 35. The abundance of myriapods in the leaf layer (hojarasca) and three soil horizons (0-10 cm, 10-20 cm, and 20-30 cm), sampled in four local land quality categories including good soil (bueno), nutrient-mined soil (cansado), physically degraded soil (bravo), and otherwise unproductive soil (malo).

Output

Increased, but sustainable, productivity through improved community-based soil fertility management.

Contributors: Fernando Sevilla, Otoniel Madrid; Edmundo Barrios (PE-2); Thomas Oberthür

Collaborators: Luis C Pardo Locarno (Instituto de Investigaciones Ambientales del Pacífico-IIAP); Juan J Jiménez (formerly PE-2); Claudia P Narváez (Fundación Universitaria de Popayán); Farming community of Pescador, Cauca

5.4. Framework for assessing the potential contributions of scientific and local knowledge to soil fertility management

Objective

?? Examine the opportunities for farmers and scientists to assess and manage agronomic uncertainty in risky hillside situations

Results

Farmers' local knowledge is both competent and flexible to manage spatial variation. One weakness, which could be reduced by a combination with science, is the inability of farmers to change management practices quickly. Under conditions of rapid, often unprecedented, change, such as climate changes or price fluctuations, farmers need to build decision models that explicitly and consistently account for soil processes in order to improve resource use efficiency.

Reliance solely on empirical observations is not enough to cope with rapid change. In order to enable efficient soil management, prevailing agronomic uncertainties have to be identified. Then the analyses of existing local knowledge can help scientists to provide relevant information in order to link observations to processes for the development of useful management indicators for hillside farmers. Indicators need to be precise, but pragmatic, to account for the tendency of farmers to use classification systems that are utilitarian rather than taxonomic and analytical.

Rowe's (1994)[9] uncertainty scheme, in conjunction with an analysis of cropping strategies using Cohen's (1985)[10] classification, can be used as a framework to explore the potential opportunities for the contribution of local and scientific knowledge to a certain agronomic management problem.

Output

Enabling improved management of agro-ecosystems in hillside environments through relevant and specific scientific and local knowledge.

Contributors: Thomas Oberthür; Edmundo Barrios (PE-2); Simon Cook
Collaborators: Herman Usma, German Escobar, Fernando Sevilla; Patricia Ceron (Universidad Nacional, Palmira); Farming communities in Cauca

[9] Rowe, W.D. 1994. Understanding uncertainty. Risk Anal 14:743-750.
[10] Cohen, P.R. 1985. Heuristic reasoning about uncertainty: An artificial intelligence approach. Pitman, London, GB.

6. Collaborations developed with institutions in Agropolis and at La Maison de la Télédétection

Objectives

This out-posting aimed to stimulate bonding with scientists of French institutions, joint methodological research, the elaboration of joint special projects, and transfer of capacity to CIAT support staff and to partners in Colombia. Because the scientists continued with their CIAT projects, the collaboration aimed at improving or consolidating the methods they were using, and identifying opportunities for them to contribute, in the future, to common projects.

Results

Nathalie Beaulieu and Grégoire Leclerc were out-posted to Montpellier in September 2000 for a period of 2 years through agreements with the International Network for the Improvement of Banana and Plantain (INIBAP) and Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement (CEMAGREF), and were hosted at La Maison de la Télédétection. In addition to continuing their research with data of Honduras and Colombia, they participated in various discussion groups and seminars. They also participated in proposals for funding of projects led by European institutions.

Although the fundraising efforts were not very successful (out of five proposals submitted, one remains under examination, one was accepted for the operation of a network, but the three others were rejected), methodological development and strengthening was extremely fruitful. Among methodologies developed, two are described in this report.

In addition to this, the methodology "Visions-actions-requests across administrative levels" (Beaulieu et al., 2002[11]), initially developed in 2000, was significantly simplified while strengthened after discussions with colleagues at CIRAD-TERA, CEMAGREF, IRD, the International Center for development-oriented Research in Agriculture (ICRA), and the International Support Group. It is used as a framework to facilitate the analysis of remote sensing imagery through the formulation of questions for monitoring and evaluation, action planning, and adaptive management.

Socioeconomic data analysis methods were significantly improved, and were used to analyze census data of Honduras. These and other methods of data analysis, when fed into regional strategic planning and policy decisions, are included in an Integrated Regional Development Approach (AIDeR), which is the object of a joint project of IRD and CIRAD. A Memorandum of Understanding was elaborated and involves the secondment of IRD's Hubert Mazurek to CIAT at the beginning of 2003. The AIDeR Project will initiate with the Institute of Rural Innovation, and will most probably have its first test sites in Bolivia and Colombia. Within the scope of this collaboration, Jaime Jaramillo obtained a grant from IRD to work for 3 months in Montpellier with Hubert Mazurek on mechanisms to facilitate linkages between regional policy and local rural communities, especially focusing on territorial approaches.

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11 Beaulieu, N.; Jaramillo, J.; Leclerc, G. 2002. The vision-action-requests approach across administrative levels: A methodological proposal for the strategic planning of rural development. Internal report, CIAT- Maison de la télédétection (MTD), Cali, CO-Montpellier, FR. 30 p.

Juan Gabriel León, a Colombian and former research assistant in CIAT's Land Use Project, completed a Diplôme d'études approfondies (DEA, a 1-year program) at the doctoral school on water sciences in the continental environment at ENGREF. His 6-month internship and report, completed in September, focused on the application of decision support concepts to the planning of irrigation projects, especially concerning the search for robust cultivation strategies (León, 2002[12]).

A proposal submitted by the Institut national de recherche agronomique (INRA) to the Centre national de recherche scientifique (CNRS) program on Networks on Information and Communication Technologies was accepted. It was entitled "The reasoned use of spatial representations in territorial development", and included CEMAGREF, CIRAD, CIAT, and various universities. Our contribution will be the use of remote sensing in territorial development, in collaboration with CEMAGREF.

Nathalie Beaulieu was invited by CIRAD-TERA for a 2-week visit to Brazil, and participation in the 1eras Jornadas Amazônicas, in Brasilia and Redenção, Pará. Collaborations with CIRAD-TERA and CIRAD-EMVT will continue through her involvement in the elaboration of the Plano direitor of the municipality of Uruara, near the Trans-Amazonian highway. This work will develop the actions for two of the concept notes that were presented at the CIAT-CIO[13] meeting in June 2001, which were "Methods and tools for management of pastoral areas", and "A vision-based learning approach to the construction of territories". The third concept note that was presented in June 2001 and entitled "An integrated approach to regional development for the sustainability of rural territories", will be executed through the AIDeR project mentioned earlier.

A training program in remote sensing has begun this year in benefit of CIAT support staff and Colombian partners. Mauricio Alvarez from the Corporación Colombiana de Investigación Agropecuaria (CORPOICA) visited Nathalie Beaulieu and CIRAD-EMVT colleagues during 2 weeks in November 2001.

This link with advanced research centers in Montpellier will help CIAT provide its partners with better quality and cross-tested methods for land management. Very favorable impact on institutional relationships between CIAT and French institutions is already measurable through an increase in the number and quality of joint concept notes and submitted projects in the natural resource management (NRM) area.

Contributors: Grégoire Leclerc, Nathalie Beaulieu
Collaborators: Hubert Mazurek (IRD); Pierre Maurel (CEMAGREF-ENGREF); Gérard De Wispeleare, René Pocard Chapuis (CIRAD-EMVT); Jean Francois Tourand, Jacques Imbernon, Emmanuel Torquebiau, Jean-Philippe Tonneau, Patrick Carron, Yves Clouet (CIRAD-TERA)

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[12] León, J.G. 2002. Méthodologie de recherche de stratégies robustes pour des projets d'irrigation communautaires; application pratique sur le village El Turpial en Colombie. Mémoire de DEA en sciences de l'eau dans l'environnement continental, Ecole nationale du génie rural des eaux et des forêts (ENGREF), Montpellier, FR. 93 p.

[13] CIO, CIRAD-INRA-Institut français de recherche scientifique pour le développement en coopération (formerly Office de la recherche scientifique et technique d'Outre-Mer) (ORSTOM).

7. Work conducted within the scope of the agreement between CIAT and the Colombian Ministry of Agriculture

7.1. Rule-based image processing methods to facilitate the use of remote sensing images in local planning and adaptive management

Objectives

?? Develop a methodology allowing local institutions to use satellite imagery for monitoring, evaluation, and adaptive management of their agriculture and natural resources
?? Develop a methodology allowing national institutions to provide data sets to local institutions in a format that they can use for their purposes

Materials and Methods

The framework to link image analysis to processes of planning and adaptive management was based on the approach of visions-actions-requests across administrative levels (Beaulieu et al., 2002[10]). The locally derived visions of desired future conditions are used to define questions for monitoring and evaluation (M&E), whereas the actions and the requests are used to formulate questions for action planning. Imagery, combined with other sources of data, is then used to answer two types of questions, such as "How far are we from the desired conditions; why, and how fast are we getting there?" and "Where should we implement such and such management practices?" As a case study, this framework was applied in the municipality of Puerto Lopez, in particular in the indigenous reserve of Humapo and La Victoria in 2001 (Beaulieu et al., 2001)[14], and during the elaboration of the Plan de Desarrollo Municipal.

Image processing methodology, designed for national institutions to use in providing products to local users, was applied on a data set of images of Puerto Lopez, and was also used for training purposes. This geocoded data set included Landsat-4 TM images of December 1987 and January 1988, and Landsat-7 ETM+ images of March 2000, December 2000, and March 2001. We calculated the reflectance at top of the atmosphere (TOA) from the images' digital numbers by taking into account the solar zenith angle and solar irradiance, as well as processing gain and offset coefficients for each spectral band. Then, a relative atmospheric correction was applied to three of the five images, to allow the reflectance values of "pseudo-invariant" areas to be equivalent to those of the two clearest images. Pseudo-invariant image samples were collected in very clear water and forest areas. Image histograms under consistent image windows were also used to verify the success of the correction. In the case of Puerto Lopez, only an additive correction or "shift" in reflectance was necessary.

Meaningful "indices" were calculated from the red and near-infrared (NIR) spectral bands of each of the images through a simple linear transformation of the values in these bands. The axes of the new coordinate system in the Red vs. NIR space are the "soil line" and its perpendicular. The soil line is a diagonal line along which the reflectance values of bare soil samples tend to

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14 Beaulieu, N.; Jaramillo, J.; Fajardo, A.; Peñuela N. 2001. The use of remote sensing imagery in support to participatory natural resource management: A case study in the indigenous reserve of Humapo and La Victoria. Internal report, PE-4, CIAT, Cali, CO. 20 p.

align. The coordinates along the axis perpendicular to the soil line indicate the distance from this line, and increase with the cover of green or “chlorophyllic” vegetation. These coordinates are equivalent to the Perpendicular Vegetation Index (PVI) formalized by Richardson and Wiegand (1977[15]). The co-ordinates along the axis of the soil line are called the brightness values. We define the resulting new values or “indices” as brightness (BRI) and vegetation (PVI). The combined use of these indices differs from the use of normalized difference vegetation indices, such as the NDVI, because we retain the same information content as with the two initial spectral bands from which they were calculated. The resulting values are in reflectance units (%). This linear transformation is principally done to allow the Red vs. NIR space to be separated by diagonal thresholds through the use of decision rules, rather than by vertical and horizontal ones.

Many of the M&E or action planning questions that can be answered using satellite imagery require mapping of land cover, land use, or their variation through time. However, we believe it is important for the users to be able to derive their own final maps, because questions are different for each of them, and because they can incorporate knowledge that is inaccessible to the image-processing technician. We also think that results from rule-based classification techniques can be easier to interpret than those from automatic, supervised, or unsupervised classifications. For the identification of agricultural areas, it is often necessary to rely on a series of three images taken within 1 year, to avoid confusing very green crops with forests or plantations, or plowed fields with permanently bare areas. In the case of the classification based on a time series of images within the same year, classifications were based on minimum and maximum values of the PVI, the BRI, and the medium infrared reflectance. For multi- and single-date classifications, we derived decision rules through both logical and automatic approaches. The logical approach was based on visual interpretation of images and on the comprehension of the spectral behavior of terrestrial surfaces. The threshold values were then derived from the mean and standard deviation of samples of each class. For the automatic approach, the r-part library of the S+ statistical software was used to analyze a series of pixel values of the samples, and produce a decision tree. We then combined results of the logical rules and the automatically derived decision trees to obtain an adapted set of decision rules, eventually merging classes to obtain a very general classification. This can then be filtered and used to produce a vectorial coverage, which final users can then edit. For example, if agricultural statistics are sought, a knowledgeable person (e.g., an agricultural extension agent) can assign the type of crop to each agricultural area through this editing process.

Results

The questions that emerged from the Plan de Ordenamiento Territorial (POT) and the Plan de Desarrollo Municipal (PDM) are: How much area is being used under agriculture and how fast is the agricultural area increasing? Where is pasture degradation a problem that we could solve through improved varieties and agropastoral systems? Is there any forest regeneration in the reserves? Where could preventive burning be a good management option?

The time series of three images during 2002-2001 was therefore used as a baseline data set for the 2000-2009 POT, and the 2001-2004 PDM. The images from 1987 and 1988 unfortunately

[15] Richardson, A.J.; Wiegand, C.L. 1977. Distinguishing vegetation from soil background information. Photogram Engineer Remote Sens 43:1541-1552.

have very close acquisition dates, and in many cases it is not possible to distinguish ripe rice cultures from forest. While a reliable, municipal-wide comparison of land use was not possible between 1988 and 2000, these historical images were useful in forest reserves.

From this time series of images, the following classes were mapped from maximum and minimum values of the PVI, BRI, and medium infrared reflectance:

(1) Permanent water;
(2) Occasional or seasonal water;
(3) Perennial dense vegetation (forests or plantations);
(4) Perennial mediumly dense vegetation (shrubs, young forest plantations, orchards);
(5) Areas managed by burning (generally savannas);
(6) Occasional or seasonal cover of very chlorophylic vegetation (crops or strong vegetation growth during the wet season);
(7) Perennially bare soil;
(8) Occasional or seasonal bare soil;
(9) Sparse vegetation, with perennially high brightness (thus probably low ground cover of leaves, residue, and organic matter, if soils are bright) and chlorophyllic activity;
(10) Sparse vegetation, with perennially high brightness, but variable chlorophyllic activity;
(11) Sparse vegetation, with perennially low brightness;
(12) Sparse vegetation with variable brightness and chlorophyllic activity; and
(13) Irrigated crops or marshes.

Field data collected in 2001 and 2002 are allowing us to verify the accuracy of the general classifications. We are, however, still adjusting decision trees, combining the results of automatic tree generation through S+ with the ones obtained through visual interpretation and our understanding of the spectral behaviour of different land cover types. Extremely high classification accuracies are obtained when tolerating errors between types of grass (sparse vegetation), allowing agricultural areas to fall in either classes 3 or 4, and allowing marshes to fall either in classes 2, 3, 4, or 13. Errors in the classification assignment mostly resulted from a misassignment of field data, because these were acquired at single dates, while the image classification used three dates. In this case, the results of a classification based on the variations of spectral quantities can be more accurate about an area's behaviour than a single date observation in the field. Details about this classification and its validation can be found in Beaulieu et al. (2002[16]).

Class 6, when occurring in savannas, can be indicative of areas where preventive burning could be successful in natural reserves, because natural regeneration seems to be taking place during the wet season. However, visual interpretation is necessary to distinguish these areas from agricultural ones. Classes 7, 8, and 9 can be indicative of areas of degrading pastureland.

The algorithms for rule-based classifications were developed in the PCI software and were translated into the freely distributable SPRING software (developed by the Instituto Nacional de

[16] Beaulieu, N.; Leclerc, G.; Alvarez, M. 2002. Análisis de una serie temporal de imágenes de Puerto López para una clasificación general de la cobertura de la tierra. Internal report, CIAT- Corporación Colombiana de Investigación Agropecuaria (CORPOICA), Cali-Villavicencio, CO. 30 p.

Pesquisas Espaciales [INPE], Brazil) in order for the data set and programs to be distributed to a wide variety of users. Training courses were given in July 2002 to CIAT Land Use Project staff, with participants from CORPOICA and the Universidad del Valle. Another course was given in October in Villavicencio, Colombia, to end users in CORPOICA, the Gobernacion del Meta, and personnel from Unidades Municipales de Asistencia Técnica Agropecuaria (UMATAs) of the area and of municipalities. This course was aimed at interpretation and classification of the images rather than on the preparation of the data sets.

Outputs

Satellite images and aerial photographs can make important contributions to local NRM efforts, especially for M&E, and for adaptive management. The use of these images by natural resource managers could be facilitated by networks linking technical professionals and different types of users at different administrative levels, who can also share the costs and responsibilities of acquiring and processing data. Many of these networks exist, or are in the process of creation. We expect the methodological itinerary we provide will allow professionals of different institutions and disciplines to interlink effectively. In 2003, we will train national and regional institutions that can prepare the data sets for local users.

Contributors: Nathalie Beaulieu, Grégoire Leclerc; Gérard De Wispeleare (CIRAD-EMVT); Mauricio Alvarez (CORPOICA)
Collaborator: Joao Pedro Cordeiro (INPE)

7.2. Searching for robust strategies through *ex-ante* assessment of agricultural projects in communities under different scenarios

Objectives

?? Provide farmers and extension agents with examples of decision-making processes, where farmers plan their long-term strategy facing uncertainty in market prices, climatic conditions, and other factors
?? Develop a methodological framework to choose robust strategies, that is, those that produce relatively good results under a range of scenarios, without necessarily being the optimal strategy in any of them
?? Contribute to an ongoing effort to help five villages of the municipality of Puerto Lopez in the elaboration of their community development plan
?? Help farmers of the EL Turpial village and the UMATA to gauge the economic worth of planning for an irrigation project in the village, and to explore the best cultivation strategies to recuperate investments

Materials and Methods

We collected the various data necessary to run an economical analysis of agricultural projects in the municipality of Puerto Lopez through interviews with farmers and consultation of local literature published by CORPOICA, Corporación Colombia Internacional (CCI) and other national organizations (see Fajardo, 2002[17]). Much of these data were incorporated to update the Cultivos y Frutas para Colombia (CUFRUCOL) database (CIAT, 2001[18]; p 85-87). We calculated the net present value (NPV) and internal rate of return to investment for various strategies proposed by farmers at each farm in three peasant villages, El Turpial, Puerto Guadalupe, and Puerto Alicia, and for the communal lands of the two villages composing the indigenous reserve of Humapo-La Victoria.

In the case of El Turpial, the possibility of irrigation was considered in response to a farmers' request to consider the possibility of implementing an irrigation system (León, 2002[12]). In order to evaluate the economic viability of this irrigation under uncertain conditions, and to choose the most favorable combination of crops, we chose to evaluate and compare the results of a number of strategies under various scenarios (set of external conditions). As a first example, four contrasting scenarios were defined, using combinations of optimistic and pessimistic values for market prices and availability of water for irrigation. A set of cropping systems were chosen, most of which are presently included in at least one of the farms of the village. For each of these cropping systems, the yield of each component was estimated using a water balance and supposing a relationship between relative yield and relative evapotranspiration, both for irrigated and non-irrigated conditions. The NPV of each cropping system over a period of 5 years was estimated considering all production benefits, costs, and investments based on the data compiled by Fajardo (CIAT, 2001[18]; p 85-87), as well as the estimated investments for the irrigation system. A linear programming model was elaborated to find the optimal distribution of cropping systems under each scenario, under constraints of land (30 ha available for agriculture in the village), water for irrigation, and labor. A minimal cropping area was specified for cassava and plantain, as crops needed to insure food security.

A set of additional strategies were found by repeating the optimization routines under the same scenarios, but by adding additional constraints, such as removing the possibility of irrigation, or removing the possibility of planting watermelon, which appeared to be the most lucrative crop, both under high and low prices. For each strategy under each scenario, we calculated the NPV and the "regret" (i.e., the difference between the value obtained and the best strategy for each scenario). For each strategy, we then calculated the maximum value of this regret, considering the set of studied scenarios. Following the Savage Criteria (Vallin and Van der Pooten, 2001[19]), the most favorable strategy is that which presents the lowest value of the maximum regret. The most favorable robust strategies can be found by setting a minimum gain requested for pessimistic conditions (or a maximum loss tolerated), and then applying the savage criteria to the strategies meeting this condition.

[17] Fajardo, A. 2002. Análisis económico de opciones de producción para pequeños productores en los llanos orientales de Colombia. Internal report, CIAT, Cali, CO.
[18] CIAT. 2001. Project PE4 Annual Report 2001. CIAT, Cali, CO. 118 p.
[19] Vallin, P.; Van der Pooten, D. 2000. Aide à la décision, une approche par les cas. Editions Ellipses, Paris, FR.

Results

Detailed results can be found in reports by Fajardo (2002[17]) and León (2002[12]). Results obtained by Fajardo were discussed with farmers, and the methodology of cost analysis was taught to them in workshops carried out in the villages. The more recent results obtained by León will be discussed with farmers during a field visit at the end of October, 2002, which will certainly lead to the consideration of an additional number of strategies. Optimization exercises as an exploratory tool will also be conducted in the other four villages being studied.

For the *altillanura* area, the most lucrative cropping system under both high and low prices was found to be a rotation of maize in the first season with watermelon in the second, dryer season. This was caused by the high market price of watermelon. This is, in effect, a cropping system that is being used with success by farmers in Puerto Guadalupe and El Turpial, but with relatively high risks. Indeed, the farmers have no guarantee that they will be able to sell all their produce, and if they all start cultivating the same crop, the market could become saturated. Unexpected droughts also affect the crop's yield, which is why the farmers are interested in irrigation. This crop also requires a more intensive use of pesticides than do other, more traditionally cultivated crops, causing undesirable environmental impact. Under favorable prices, squash becomes a very interesting option when watermelon is not considered. In addition to being easier to cultivate, it can be stored longer and unsold squash can be consumed locally as a fruit, vegetable, or used to feed animals if they cannot be sold. Under unfavorable price conditions, cassava remains the most lucrative crop, when watermelon and irrigation are not considered. Over a 5-year time span, fruit trees do not have sufficient economic returns to be favored with respect to annual crops. However, this could be different if considering a larger time span and the positive environmental impact of trees on soil stability. Economic return can be considered only one of the factors in a multi-criteria analysis. We intend to continue this study with a multi-criteria analysis including economic return and regrets, environmental effects and services, and food security considerations.

Outputs

We expect farmers and farmer associations to be able to undertake their own economic analysis, combined with an ecological sustainability analysis, with the help of the UMATA. This will help them plan towards economic viability and ecological sustainability of their farms. The possibility of presenting such an analysis can facilitate their obtaining credits and the negotiation of contracts with buyers. Optimization techniques can help them decide how to distribute limited resources, such as labor and water, if irrigation is possible.

Contributors: Adriana Fajardo, Juan Gabriel León, Nathalie Beaulieu, Jaime Jaramillo; Bruno Barbier (CIRAD)
Collaborator: Libardo Rivas (BP-1)

7.3. GEOSOIL and "Arboles de decision": Decision support tools to make recommendations on land use and management practices in the Colombian Llanos, based on soil characteristics. Case study in Puerto López, Meta.

Objectives

?? Develop a simple methodology to allow farmers, extension agents, and agricultural project promoters apply knowledge developed through agricultural experimentation to data from soil maps or soil samples, to issue recommendations for the sustainable use and progressive improvement of soil qualities

?? Present an example of this methodology for the municipality of Puerto Lopez that can be repeated in other municipalities, or even for entire departments

?? Provide decision makers in the municipality of Puerto Lopez, which is where the government plans on focusing many agricultural development projects, with a tool to prevent unsustainable use of soil resources

Methodology

The GEOSOIL database was created in Microsoft ACCESS, allowing the storage of soil characteristics of points or soil types in a map. The biophysical limitations of the soils of the Colombian Llanos had previously been conceptualized into a decision tree (Hoyos et al., 2001[20]). A subset of GEOSOIL was created, containing only the relevant fields for the application of this decision tree. This subset was called ARBOLES.

Decision rules were programmed in visual basic inside ARBOLES, to allow diagnosis and recommendations to be issued regarding its data. These rules can be edited to include local knowledge or other considerations, and new fields can be created to include the relevant data to apply them. For the recent soil maps of the municipality of Puerto Lopez, soil characteristics were compiled into GEOSOIL and ARBOLES, for each of the soil types composing each of the land unit types.

We articulated GEOSOIL and ARBOLES with the digital map of land units that we integrated in the SPRING GIS developed by INPE, for the display of results. We generated grid coverages of soil characteristics from point measurements stored in GEOSOIL for portions of the Puerto Lopez municipality, through the geostatistical module of the SPRING software. Decision trees are then applied as a set of decision rules on these grid coverages. We applied threshold values of indicators of soil quality to various field-measured soil conditions in the GEOSOIL database, to allow a diagnosis.

Results

Only a limited number of land use types are adapted to the soils of the Llanos Orientales. Nevertheless, in the altillanura (high plains with flat topography), it is possible to transform soil

[20] Hoyos, P.; Amézquita, E.; Thomas, R.; Beaulieu, N.; Rubiano, Y. 2001. Propuesta de un árbol de decisiones para el uso potencial y productivo de los suelos de la altillanura plana bien drenada. Internal publication, CIAT, Cali, CO. 1 CD-ROM.

properties and to create an "arable layer", thus extending the spectrum of potential uses of the land. By applying management practices adapted to the textural group and the slope, the depth available for root growth can be increased, and soil fertility. This gradual improvement begins with the introduction of deep rooting pastures alternated with annual crops, and gradually includes agroforestry systems and perennial crops.

The land characteristics that are used in the decision rules are textural class (clayey, intermediate, and sandy), slope, and depth available for rooting. These are compared to the requirements necessary for a given land use type or management practice.

For each soil type, the first decision is made with regard to the type of texture because, contrary to other soil properties, it cannot be modified or adapted through management practices. According to the type of soil texture, the next decision will be taken with respect to the slope, and then the last with respect to the rooting depth. For each possible decision, or "terminal node", of the decision tree, a recommendation is made with regard to possible production systems and management practices. The range of possibilities becomes richer as the depth available for rooting is improved by management practices that allow the construction of an arable layer.

As mentioned in the methodology, soil characteristics entered in the database tool (Figure 36) can either result from measurements in the field or from the data associated with a soil map. The resulting recommendations correspond to each individual soil type. Given that land units in soil maps generally correspond to associations of various different soils, each occupying a given percentage of the land unit, recommendations cannot be mapped directly. In our maps of recommendations, the polygon corresponding to a land unit is assigned to the most restrictive cropping system that can be used in more than 60% of the area. It is implied that less restrictive systems can be used in those areas. It is also possible to produce maps of the level of restriction regarding texture, slope, and rooting depth, indicating the most restrictive decision category that corresponds to at least 60% of the land unit. The data related to soil maps include only the rooting depth before any management, and recommendations need to be adapted in areas where such practices have resulted in an improvement of soil characteristics. These also have to be adapted in areas where accelerated degradation of soil properties, such as soil erosion or compacting, has been observed resulting from inappropriate management.

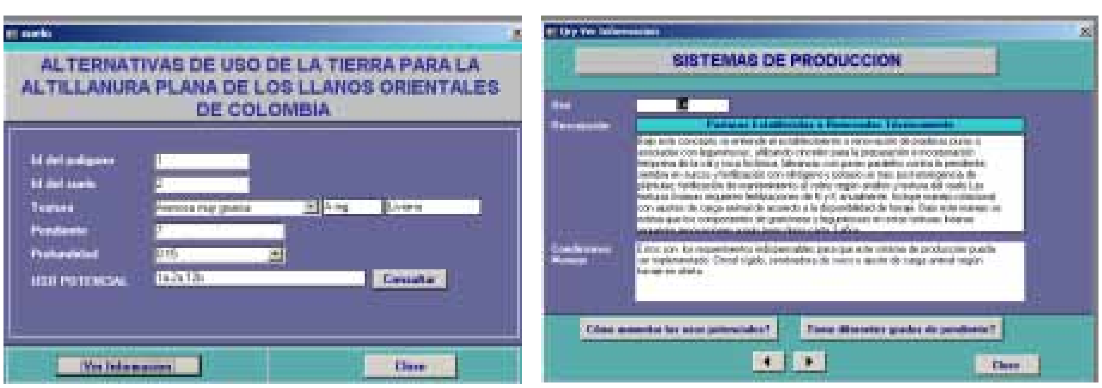

Figure 36. Decision support tool for making recommendations on land use and management practices in the Colombian Llanos, based on soil characteristics using Microsoft Access database software.

The database can be used as a decision support tool. It is versatile and could even be modified to include other land characteristics, such as climatic limitations or accessibility, provided new decision rules are established, and the data necessary for their application are available.

The final version of this tool will be submitted to field control at the end of 2002 with collaborators in CORPOICA, and the necessary adjustments will be realized. It will also be tested with the five village communities with which we are working towards the development of their community agricultural development plan. Then, it will be distributed to municipalities and municipal units of technical assistance in agriculture and livestock (UMATA).

Outputs

Recent development of maize varieties for acid soils, by CIMMYT and other institutions, has increased the interest of the Colombian government in developing this crop in the *Altillanura*, especially along the highway between Puerto Lopez and Puerto Gaitan, (an area included within the municipality of Puerto Lopez). If included in rotations with pasture, in soils with the adequate characteristics, and appropriate management conditions, maize cultivation can lead to an improvement of soil characteristics and sustainable crop systems. Otherwise, it can lead to a severe degradation of soil physical properties. Because agricultural project developers solicit CORPOICA scientists for advice, they wish to be able to direct these projects towards the appropriate geographical areas. They, and the UMATAs, also need a tool, such as CULTICORE, to be able to make simple recommendations using the results of long-term experiments in the altillanura. We expect the use of this tool to help prevent abuse in the use of the soils of the Llanos and to orient farmers towards sustainable agricultural practices.

The application of decision trees with farmers will also be useful to focus needs for more research on soil improvement practices. Undoubtedly, it will also lead to an adaptation of the decision rules to include the knowledge of farmers.

Contributors: Yolanda Rubiano, Marcela Quintero, Jaime Jaramillo, Nathalie Beaulieu; Edgar Amezquita, Phanor Hoyos, María Fernanda Jiménez (PE-2)
Collaborators: Jaime Bernal (CORPOICA); Dimas Malagón Castro (Subdireccion de Agrología, Instituto Geografico Agustin Codazzi [IGAC], and Universidad Nacional de Colombia).

7.4. Electronic version of the Plan de desarrollo 2001-2004, "Por la reconciliación y unidad de Puerto López", available on CD-ROM

Objectives

To comply with Colombian law 152/94, new municipal administrations must submit a Plan de Desarrollo Municipal (PDM) within 4 months of taking office. The elaboration of these plans is very often contracted out and has an insufficient participatory component. We are promoting the transformation of these bureaucratic exercises into participatory strategic planning opportunities. However, these are most profitable when the municipal administration takes ownership of them, and we are therefore developing a methodology that can be used by municipal administrations themselves. As a case study in Puerto Lopez, we offered to facilitate the process to allow the municipality to develop their plan while minimizing dependence towards outside help and maximizing popular participation.

Materials and Methods

The Plan basico de Ordenamiento Territorial (POT) of the municipality, approved in 2002, already contained a series of programs, projects, and norms to be carried through during the period of this municipal administration. To analyze these, a first series of meetings was conducted with the officers of the administration, who added some projects and programs when pertinent. A preliminary list of programs was therefore drafted under each of the themes of the planning. Then, a series of three meetings with the population was organized, one for the urban area, one for the villages of the western part of the municipality, and another for the villages of the eastern part. Most of the village community leaders attended these meetings, and so did a great number of individual members of the population. The visions-actions-requests method was used to facilitate the meetings in collaboration with the municipal planning officer, the cultural officer, and the director of the UMATA.

In each meeting, participants were divided into four subgroups, each of which handled two or three of the themes under consideration (environment, agriculture, health, education, employment, recreation, transportation, public services, culture, historical patrimony, environmental hazards). For each of these themes, they were asked to discuss and write down statements of their desired future conditions, for a time span of 10 years. Then, they were asked to discuss and write which were the actions that they could do to achieve those conditions, and then to discuss what they needed from other stakeholders, either in the rural area, the Mayor’s Office or in a higher administrative level. For this latter section, referred to as “requests”, participants were asked to discuss the content of the drafted list of programs and projects from the municipal office, and write down any request that was not already included. Each subgroup then read their results to the entire group, and participants discussed and added considerations when needed.

Another meeting was then conducted with the consejo territorial to harmonize all of the input from the meetings with the population and with municipal officers. All the visions and requests were read out loud, and all reasonable requests not included in the preliminary list were added to the municipal program. Objectives and indicators were defined for each action included in the plan. When the plan was completed, it was submitted to the municipal council and was approved, then submitted to the Gobernación del Meta in Villavicencio.

Results

The plan included a diagnosis, largely inspired on the discussions of why the desired conditions are not the actual conditions, and supported with data such as statistics. The different exposed visions of the future were very much compatible, and very often similar. The plan also included the proposed programs and projects, and a financial plan explaining the expenditures involved. The input from participants of the workshop was copied on tables in a word-processing program and included in the appendix of the plan. The Municipal Council approved the plan in February 2002 (Figure 37).

Figure 37. Electronic version of the Plan de desarrollo 2001-2004, “Por la reconciliación y unidad de Puerto López”, available on CD-ROM.

Outputs

The main outcome of this effort is the articulation of the long-term planning (POT, over 9 years) with the shorter term planning (PDM, over 3 years). The population, the producer associations, and the community in general have a legal engagement from the municipal office. They also have a concerted plan of actions that considers the sustainability of the natural resources, alleviation of poverty, increasing of productivity in the rural areas, and the solution of the main problems related to health and education.

The indicators defined in the plan will allow the Consejo Territorial to monitor progress in the planned actions, and their effect on the development of the municipality.

The most desired impact of this example is to change people’s perception of the PDMs, changing these bureaucratic exercises into participatory planning opportunities, and linking the rural population with policymakers at municipal and higher levels.

Contributors: Jaime Jaramillo, Nathalie Beaulieu, Rogelio Pineda; Ovidio Muñoz, Laila Chamila, Nelson Delgado (Alcaldia de Puerto Lopez); Nohemi Peñuela (Director of the UMATA de Puerto Lopez)

7.5. Training on “creating local capacity for *Ordenamiento Territorial*” in Ecuador, the use of the participatory planning methodology and MapMaker software

Objectives

Based on our experience on the *Ordenamiento Territorial*, some Ecuadorian institutions asked us to elaborate adapted training material and give our technical support through training courses. These aimed at orienting the processes of occupation and transformation of the provincial territory by allowing stakeholders to clearly identify their visions, possible actions, and partnerships, while considering the territory's strengths, weaknesses, opportunities, and threats. They were also aimed at developing a local capacity to plan development, using principles of equity, sustainability, and competitiveness.

Methodology and Results

We developed a CD-ROM containing the legal aspects of "*Ordenamiento Territorial*" in Ecuador, the methodology to follow up the process of the land use planning, the visions-actions-requests participatory planning methodology (VAR), and an introduction to cartography, remote sensing, and GIS using the MapMaker software. This was an adaptation to the Ecuadorian context of materials presented in Annex 32 of the PE-4 Annual Report 2000, which have otherwise been updated through the various training courses given since.

We gave four 1-week training courses, which are summarized in Table 5. Each course was the object of an evaluation by the participants. These courses were entirely funded by the provincial councils hosting the events.

Table 5. Summary of training courses given for *Ordenamiento Territorial*, how to use MapMaker software, and the participatory planning methodology developed in Ecuador, 2002.

Host organization	Location	Date	No. participants
Consejo Provincial de Tungurahua	Ambato	5-9 Aug	30
Consejo Provincial de Los Rios	Babahoyo	12-16 Aug	22
Consejo Provincial del Carchi	Tulcán	19-23 Aug	30
Consejo Provincial de Azuay	Esmeraldas	26-30 Aug	20

Outputs

Through this training, we provided potential planners with a synthesis of necessary steps, simplified approaches, and tools that can make the planning process easier and more straightforward. This should improve the pertinence and the quality of the land use plans prepared in Ecuador, and stimulate constructive reviews of previously elaborated plans ("Planes de Desarrollo Provincial").

Contributors: Ovidio Muñoz, Jaime Jaramillo, Rogelio Pineda

8. Looking Ahead

8.1. Consultancy work for the Challenge Program on Water and Food (CPWF)

The CGIAR CPWF is an ambitious research, extension, and capacity building program that will significantly increase the productivity of water used for agriculture. It is an 18-member consortium composed of five CG/Future Harvest centers, six National Agricultural Research and Extension Systems (NARES), four Agricultural Research Institutes (ARIs), and three international NGOs.

The program's aim is to allow more food to be produced, with the same amount of water that is used in agriculture today, as populations expand over the coming 20 years. This is to be done in a way that decreases malnourishment and rural poverty, improves people's health, and maintains environmental sustainability.

The CPWF has a minimum core budget of US$82 million for a first 5-year phase, and it is expected that projects will attract a further US$50 million. There are clearly defined roles for each consortium member. CG centers lead thematic groups. The Program consists of 5 themes and at 12 benchmark sites. CIAT has been nominated to lead Theme 2: Multiple Use of Upper Catchments, with Simon Cook of PE-4 nominated coordinator. We are hoping to promote our work in benchmark basins in the Andes, Honduras, and the Mekong. The program starts officially on 1st November 2002 with a 12-month inception phase during which competitively bidded proposals will be organized.

We are in the process of conducting preliminary workshops to enable scientists at CIAT to identify contributions that have the ultimate objective of improving the ability of the water resource to support sustainable livelihoods. This would be building on CIAT's earlier work in watersheds in Colombia and elsewhere.

Jorge Rubiano joined the team in June 2002 to support PE-4 in preparation for the CPWF, and has been developing the science behind Theme 2 and will be involved in competitive projects as the program moves from the initiation phase to the project implementation phase. He has been amassing data, making literature reviews, and organizing internal workshops.

A watershed-focused database is being organized to identify the similarities and differences between the currently selected CPWF catchments and the rest of the catchments in South America. Secondary information produced by the unit during recent years is being used together with freely available continental databases on the Internet.

In collaboration with the Stockholm Environmental Institute (SEI), a vulnerability study in Honduras started activities. The project will focus on three local communities seeking to understand the relationships between their local ecological and socioeconomic conditions and their vulnerability to natural hazards such as floods and droughts.

Contributors: Simon Cook, Jorge Rubiano

9. Red Ecorregional para América Latina Tropical (REDECO) Report

9.1. Diffusion and interchange of information

List server

Objectives

?? Receive, diffuse, and interchange information with Network users

?? Serve as a link for users so that they can contact others with common interests; this facilitates the exchange of experiences, lessons, tools, methodologies, and useful information for the development of activities

The network has over 3200 members and organizations in Latin America and some North American and European countries that receive and exchange information related with the management of natural resources and rural development. The work of the list server is combined with a Web page, where all information arriving from the different members and organizations is recorded (Table 6).

We receive information from REDECO users, and reply to their requests for information. We select, edit, and format the information for addition to the Ecoregional Bulletin

Networks, government organizations (GOs), NGOs, interested persons, and national and international agricultural research centers exchange information related to the management and conservation of natural resources and rural development.

Ecoregional Bulletin

Objectives

?? Diffuse information about activities being carried out by members of the Network and the results of CIAT and Land Use Project research

?? Support the information disclosure work that is carried out through the list server and Web site of the Ecoregional Network

On September 13th, the first Network electronic bulletin was released. It is given out at weekly intervals in html and pdf formats. Through the bulletin, information is diffused that is up-to-date, relevant, and timely, related to environmental themes on events, opportunities, information resources, contacts of interest, and information on CIAT and Land Use Project research and activities (http://www.redeco.org/boletin/boletinecorregional1.htm).

There has been an increase of about 30% in the number of inscriptions to the Network, thanks to the forms that are accessible through the bulletin.

Table 6. Red Ecorregional para América Latina Tropical (REDECO) Network exchanges from November 2001 to October 2002.

Type of message sent	Nov 2001	Dec 2001	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct
Events	25	9	14	23	41	44	14	30	31	27	22	12
Oportunities	7	3	5	10	9	4	4	10	9	8	6	6
Information resources	1										6	6
Contacts of interest								1			8	8
Requests for information	8	12	8	10	8			16		9	6	12
Information on activities and results of Land Use Project (PE-4) research								PE-4 Web			PE-4[a]	PE-4[b]
Information on activities and results of CIAT research					CIAT[c] CIAT[d]	CIAT[d]	CIAT[e]		CIAT[f]	CIAT[g]	CIAT[h]	CIAT[i]
REDECO Web site							Web site launch			updating	updating	updating

a. Rural Atlas of Nicaragua; CIAT-Node "Clearinghouse"; Database on Crops and Fruits for Colombia.
b. Participative Mapping with 3-dimensional Models; MarkSim: Software for generating daily climatic data for tropical zones; Cassava transformation: "Learning of Association-Community-Institution"; FloraMap; National Meeting of Geographic Information Systems (GIS) Tool Users.
c. Announcement of launch of new CIAT Web site.
d. Web site of the Documentation and Information Unit.
e. Web site of the Phytogenetic Resources Unit and the Participatory Research in Agriculture (IPRA) Project.
f. Web site of the Rural Agro-enterprise Development Project.
g. International Course on Bean Improvement.
h. Annual report, survey on genus and social capital; publication cassava biology, production, and utilization; Guide Market Identification and Opportunities for Small Producers; Institute for Rural Innovation; Guide for Manejo Integrado de Plagas (MIP) rice fieldwork.
i. Communities and Watersheds Project; publication The Community Organizes for Research (Comité de Investigación Agrícola Local [CIAL]); Tropical Pastures.

REDECO Web site

Objectives

- ?? Support the work of information diffusion that is carried out through the list and the REDECO electronic bulletin
- ?? Make known, to the community that visits the Web site, the products and activities that its users are carrying out and those of CIAT and the Land Use Project

Material and Methods

- ?? Selection, edition, and formatting of information that arrives through the electronic list
- ?? Documentation, maintenance, and updating of the site

Results

The Web site is one of the diffusion mechanisms that support the Ecoregional Network. The new version was released in April 2002 with a progressive increase in visits (Table 7) that places it as the most consulted site, at project level, on the CIAT Web site. In the last month, 422 pages have been consulted per day. The updating is effected from information given by Network members and CIAT personnel (http://www.redeco.org).

Table 7. Monthly visits, page hits, and downloads of the Red Ecorregional para América Latina (REDECO) Web site, 2002.

Date		Visits	Page hits	Downloads
April		1,408	3,091	420
May		3,060	6,618	2,853
June		4,092	7,507	5,851
July		5,768	9,568	8,940
August		6,543	9,446	10,792
September		10,296	12,417	10,800
	Total	31,167	48,647	39,656

The REDECO Web site is an alternative mechanism of consultation for users, thus supporting the development of their projects and research on environmental themes.

Contributors: Jenny Correa, Liliana Rojas
Collaborators: Claudia Perea, Germán Escobar, Jorge Cardona, Idris Jones, Paola Valero, Simone Staiger, Jorge Gallego, Freddy Ramiro Tello

9.2. Development of Phase I of the Directory of Experts

Objective

- ?? Systematize basic information of Network members, with the purpose of optimizing and facilitating the search for experts in Latin America

Material and Methods

Information is translated from original Word format to Excel and then to Access. Excel, Word, and Access bases are compared and missing information is added.

Results

The development of the Directory of Experts is in a development stage that includes complete information of the Network users. The compiled information will serve as input so that REDECO users and CIAT personnel can contact experts in related areas.

Three hundred and forty registrations have been included with complete information of users that replied to the "Evaluative Survey of REDECO Services". This facilitates a wider knowledge on the characteristics and preferences of users according to themes of interest.

Contributors: Humberto Becerra, Jenny Correa, Liliana Rojas
Collaborators: Yuviza Barona, Information Systems Unit

9.3. Analysis of the Evaluative Survey of REDECO Services

Objectives

- ?? Learn who are the users and institutions, beneficiaries of the information, and put together with them a Directory of Experts
- ?? Find out the utility of the services that REDECO offers at present and to identify needs in the area of information
- ?? Find out the utility of the information divulged through REDECO to the activities of CIAT and the extent of influence of this information upon the development of users' activities

Material and Methods

Surveys were codified and a base designed in Excel to store the answers. A descriptive analysis was made using the "Statistica" package. The information obtained was organized in tables and graphics in Excel.

Results

The results of the "Evaluative Survey of Services" were processed and analyzed in order to know the opinions of users about what REDECO offers. This experience of evaluation was presented at an international event in Venezuela, and another in Mexico, and to personnel of the Land Use Project.

The survey was sent to 2700 members; 340 replies were obtained (13% of total). The greatest number of responses was obtained by electronic mail, more than those obtained through the Web site. Those surveyed qualified the information that is diffused as being useful and interesting. The themes of management and conservation of natural resources had the highest percentage of interest as institutional research line and individual area of interest. REDECO was considered an adequate tool for gaining information generated in CIAT.

Outputs

The results on the interest and utility of the services offered by the Network permit us to infer that the information divulged is well accepted; nevertheless, the diffusion of financial sources, scholarships, and job opportunities needs to be strengthened. Themes of institutional interest as well as themes of individual interest agreed with the lines of work that the Network guides. The management of natural resources (plants, water, and soil) and participative research had the highest percentage of interest. The CIAT information diffused through the Network was considered both useful and of interest. However, links need to be strengthened with Center projects to drive the diffusion of their products, and attend the demand for information in Latin America.

Contributors: Liliana Rojas, Jenny Correa, Otoniel Madrid

9.4. Integration of the Network with Land Use Project activities

"News of the Week from the Land Use Project"

Objective

?? Strengthen internal communication and discussion of the activities of the Land Use Project and illustrate the activities carried out by each work group

Material and Methods

News is received, edited, and adapted to the presentation format. It is then diffused through electronic mail to the members of the Project and other CIAT personnel that have expressed interest in receiving it.

Results

The bulletin is released weekly; the first issue was launched on the 28th of April 2002. Through this informative bulletin, the work groups of the Land Use Project share information about their activities, achievements, and advances. Twenty-six issues have been released. The information serves to document other informative CIAT bulletins.

Outputs

Project members have been stimulated in sharing information. This has been seen in the progressive increase of support to the news bulletin, which has guaranteed the continuity of information, and the quality of contents.

Contributors: Jenny Correa, Thomas Oberthür, Liliana Rojas
Collaborators: Members of the Land Use Project

Documentation of the Participatory, 3-dimensional Model (P3DM) Project

Objectives

?? Document the work with communities selected for the development of P3DM
?? Compile and transcribe testimonies, uses, and adaptations of the methodology by producers according to local knowledge
?? Generate a task report for each as an input for the development of the publication of the P3DM

Material and Methods

Assistance is given to field excursions to document the activities carried out with the group. The information generated is transcribed in each session and an initial report produced. The report is edited with the P3DM group coordinator, and the final task report written.

Results

The documentation of the first phase of the project has been completed. The P3DM is a tool with which communities can visualize their region spatially and with greater exactitude. The process is based on the elaboration of a *maqueta* (3-dimensional model) on which the community places the most relevant geographic information, and participatively can monitor and plan management alternatives. When the "mental maps" have been made, the information is analyzed, georeferenced, and processed starting from a database within a GIS that will guarantee permanent updating of the information.

The permanent capture of information of producers' local knowledge facilitates additions and modifications to the initially planned methodology. Information obtained includes:

?? Rainfall pattern,
?? Definition of types of relief and classification of soil types,
?? Prioritization of indicators of soil quality,
?? Identification and prioritization of problems, causes, and implications in the zone,
?? Feedback to the community of the study area and PE-4 coordinators with a task report,
?? A workshop on oral expression and presentation in public directed at the students of the Alfonso Zawadski school for their participation in Expcreatividad, and
?? Diffusion of the P3DM methodology in communities adjoining the work area.

Contributors: Jenny Correa, Germán Escobar, Herman Usma, Thomas Oberthür
Collaborators: Daniel Villada, Gloria Ospina (FIDAR), communities of Veredas La Colonia and San Juan in Yotoco

9.5. Organization and participation in international events to promote the Network services and activities

II Reunión de Redes de Información para el Desarrollo Sustentable de América Latina (REDISAL)

Objectives

?? Interchange of information and experiences among those responsible for the networks
?? Construct principles to govern the future work of the Redes de Información para el Desarrollo Sustentable de América Latina (REDISAL)
?? Present REDECO activities and services with its diffusion mechanisms (Web site), and the results of the Evaluative Survey of Services

Results

The II REDISAL Meeting was carried out within the framework of the IV International Symposium for Sustainable Development in the Andes, “Andean Strategy for the XXI Century”, at the University of Los Andes, Mérida, Venezuela, in November 2001.

REDISAL was officially constituted to unite efforts in the diffusion of information and the sustainable development of the regions. The major networks of Latin America participated.

The principles governing the future work of REDISAL were defined:

?? Facilitate dialogue between the actors that use, live, and work with natural resources and the distinct governmental, academic, and environmental institutions;
?? Diffuse information that contributes to resolving the social and productive problematic of the rural sector and its relations with the urban environment; and
?? Continue the diffusion of experiences.

***Seminar-Workshop Manejo y Diseminación Electrónica de Noticias Agrícolas en América Latina a través del NEMS* (http://waicent.fao.org/events/redcapa/search/archive.asp)**

Objectives

?? Participate in the Seminar-Workshop on the Management and Electronic Diffusion of Agricultural News in Latin America through the News and Events Management System (NEMS)
?? Present activities and services of the REDECO diffusion and interchange of information, and the results of the Evaluative Survey of Services

Results

In April 2002, we participated in the NEMS Seminar-Workshop, at the Universidad Autónoma, Mexico. NEMS is a tool of easy access that can serve as a model to optimize the management and publication of information that circulates through the REDECO electronic list and Web site. Through this tool, constant publication of information related with products, news, and events is facilitated.

NEMS groups editors, Network administrators, and Web pages in various Latin American countries. It permits the storage of information so that it may serve as memory of the information that circulates through the Internet.

Transcontinental High Summit Multi-conference 2002

Objectives

?? Promote the interchange and diffusion of information
?? Present REDECO experience in the Dynamization of its electronic list

Results

We participated in the Transcontinental High Summit Multi-conference 2002, in Mendoza, Argentina, from the 6th to the 10th of May 2002. REDECCO participated in the theme of Policies of territorial integration: Networks of communication with articles and reports: Experience of REDECO – CIAT.

Outputs

Definition of the concepts: electronic list, types of list, structure and function, administration of a moderated electronic list, and main objectives of the REDECO electronic list and its promotion.

Contributors: Liliana Rojas, Jenny Correa; Silvia Pérez (Communications Unit); Ana M Ponce (InfoAndina- Consorcio para el Desarrollo Sostenible de la Ecorregión Andina CONDESAN)
Collaborators: Gloria S Torres; Rebeca Bolaños, Eduardo Figueroa, Julio C Martínez, Paola Valero, Camilo Oliveros (Communications Unit)

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List of Donors

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The World Bank, Washington, D.C.
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Network of partner organizations

As a work strategy, Project PE-4 acts in conjunction with considerable number of collaborating organizations worldwide. Below, we list collaborators alphabetically.

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List of Acronyms and Abbreviations Used

Acronyms

AIDeR	Integrated Regional Development Approach
ALCA	Area de Libre Comercio de las Américas
ArcWofE	Weights of Evidence extension for the GIS ArcView
ARI	Agricultural Research Institute
ASA	American Society of Agronomy
BMZ	Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (*Federal Ministry for Economic Cooperation and Development*), Germany
CAF	Corporación Andina de Fomento
CARDER	CorporaciónAutonomo Regional de Risaralda, Colombia
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CCGCP	Climate Change Global Challenge Program
CCI	Corporación Colombia Internacional
CDC	Corporación Centro de Datos para la Conservación del Ecuador
CELADE	Centro Latino Americano de Demografía
CEMAGREF	Institut de recherche pour l'ingénierie de l'agriculture et de l'environnement, France
CEPLAES	Centro de Planificación y Estudios Sociales, Ecuador
CG	Shortened form of CGIAR
CGIAR	Consultative Group on International Agricultural Research
CI	Conservation International
CIAL	Comité de Investigación Agrícola Local, Colombia
CIFOR	Center for International Forestry Research, Indonesia
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico
CIO	CIRAD, INRA, ORSTOM
CIP	Centro Internacional de la Papa, Lima, Peru
CIRAD	Centre de cooperation internationale en recherche agronomique pour le développement, France
CIRAD-EMVT	Département d'élevage et de médicine vétérinaire of CIRAD
CIRAD-TERA	Département territoires, environnement et acteurs of CIRAD
CMS	Conversational Monitor System of IBM
CNRS	Centre national de recherche scientifique, France
COLCIENCIAS	Instituto Colombiano para el desarrollo de la Ciencia y la Tecnología "Francisco José de Caldas"
CONDESAN	Consorcio para el Desarrollo Sostenible de la Ecorregión Andina
COOPI	Cooperazione Internazionale
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
CPWF	Challenge Program on Water and Food
CSI	Consortium for Spatial Information, a CGIAR systemwide initiative
CSIRO	Commonwealth Scientific and Industrial Research Organisation, Australia
CSSA	Crop Science Society of America
CUFRUCOL	Cultivos y Frutas para Colombia

CVC	Corporación Regional Autónoma del Valle del Cauca, Colombia
DEA	Diplôme d’études approfondies
DG	Director General
DICTA	Dirección de Investigación de Ciencias y Tecnología Agrícola, Honduras
DINAREN	Dirección Nacional de Recursos Naturales Renovables, Ecuador
DNP	Departamento Nacional de Planeación, Colombia
ECLAC	Economic Commission for Latin America and the Caribbean
EcoCiencia	Fundación Ecuatoriana de Estudios Ecológicos, Ecuador
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria
ENGREF	Ecole nationale du génie rural des eaux et des forêts (*French institute of Forestry, Agricultural and Environmental Engineering*)
EOLSS	Encyclopedia of Life Support Systems
ESPE	Escuela Politécnica del Ejército, Ecuador
ESRI	Environmental Systems Research Institute, Redlands, California
FAO	Food and Agriculture Organization of the United Nations, Italy
FIDAR	Fundación para la Investigación y el Desarrollo Agroindustrial Rural, Colombia
FIVIMS	Food Insecurity and Vulnerability Information and Mapping Systems program
FLSP	Forages and Livestock for Smallholders Project
GASSIA	Geospatial Applications to Support Sustainable International Agriculture
GCM	Global Circulation Model
GRID	Global Resource Inventory Database, Arendal, Norway
IARC	International Agricultural Research Center
ICASA	International Consortium for Agricultural Systems Application
ICRA	International Center for development-oriented Research in Agriculture, the Neths
ICRAF	International Centre for Research in Agroforestry, Kenya
IDB	Inter-American Development Bank, USA
IDEAM	Instituto de Estudios Ambientales, Colombia
IDRC	International Development Research Center, Canada
IGAC	Instituto Geografico Agustin Codazzi, Colombia
IIAP	Instituto de Investigaciones Ambientales del Pacífico
IIASA	International Institute for Applied Systems Analysis, Austria
IICA	Instituto Interamericano de Cooperación para la Agricultura, Costa Rica
IILA	Instituto Italo-Latino Americano, Italy
ILRI	International Livestock Research Institute, Nairobi
INIAA	Instituto Nacional de Investigaciones Agricolas y Agroindustrial, Peru
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Ecuador
INIBAP	International Network for the Improvement of Banana and Plantain, France
INPE	Instituto Nacional de Pesquisas Espaciales, Brazil
INRA	Institut national de recherche agronomique, France
INTA	Instituto Nacional de Tecnología Agropecuária, Nicaragua
IPGRI	International Plant Genetic Resources Institute, Italy

IRD	Institut de recherche pour le développement, France
IRRI	International Rice Research Institute, Philippines
IVITA	Instituto Veterinario de Investigaciones Tropicales y de Altura, Peru
IWMI	International Water Management Institute
MAG	Ministerio de Agricultura y Ganadería, Costa Rica
MAGFOR	Ministerio Agropecuário y Forestal, Nicaragua
MIP	Manejo Integrado de Plagas Project
P3DM	Participative 3-dimensional Mapping Project
MTD	Maison de la télédétection, France
NARES	National Agricultural Research and Extension Systems
NARS	National Agricultural Research Systems
NEMS	News and Events Management System
ODEPLAN	Oficina de Planificación de la Presidencia de la República del Ecuador
ORSTOM	Institut français de recherche scientifique pour le développement en coopération (formerly Office de la recherche scientifique et technique d'Outre-Mer), France
PDM	Plan de Desarrollo Municipal
PESA	Programa Especial de Seguridad Alimentaria, Ecuador
POT	Plan de Ordenamiento Territorial, Colombia
PRADERA	Proyecto de Apoyo Rural de la Amazonía
PVI	Perpendicular Vegetation Index
QUEFTS	Quantitative Evaluation of the Fertility of Tropical Soils
REDCAPAPA	Red Estratégica para el Desarrollo de la Cadena Agroalimentaria de la Papa
REDECO	Red Ecorregional para América Latina
REDISAL	Redes de Información para el Desarrollo Sustentable de América Latina
REDPESA	Network of Ecuadorian Food Security Projects
RIVM	Rijksinstituut Voor Volksgezondheid en Milienhygiene, Neths
SEI	Stockholm Environmental Institute
SIDA	Swedish International Development Agency
SIISE	Sistema Integrado de Indicadores Sociales del Ecuador
SINMAP	Stability Index Mapping
SLU	Swedish University of Agricultural Sciences
SoFT	Selection of Tropical Forages Project
SSSA	Soil Science Society of America
TBS	Tiputini Biodiversity Station, Napo, Ecuador
TCA	Tratado de Cooperación Amazónica, Peru
TROPILECHE	Sistemas de Alimentación a base de leguminosas mejoradas para pequeños productores con ganado de doble proposito en América Latina tropical (“Improved legume-based feeding system for smallholder dual-purpose cattle production in tropical Latin America”), a CGIAR project
UMATA	Unidad Municipal de Asistencia Técnica Agropecuaria, Colombia
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization, France
USAID	United States Agency for International Development, Washington
USDA	United States Department of Agriculture

USGS	United States Geological Survey
WFP	World Food Programme
WRI	World Resources Institute, Washington

Abbreviations

ANOVA	analysis of variance
BRI	brightness
DEM	digital elevation model
FSR	farming systems research
GCC	global climate change
GxE	genotype x environment
GIS	geographic information systems
GO	government organization
GPS	global positioning system
IPM	integrated pest management
LAP	low aerial photography
M&E	monitoring and evaluation
NDVI	normalized differential vegetation index
NGOs	nongovernmental organizations
NIR	near infrared
NPV	net present value
NRM	natural resource management
P3DM	participatory, 3-dimensional models
TOA	top of the atmosphere
VAR	visions-actions-requests participatory planning methodology

Appendix I. PE-4 Project Proposals 2002

Project Proposal	Person/s responsible	Donor approached	Duration	Total budget required (US$)	Total budget for PE-4 (US$)
1. Challenge Program on Water and Food (CPWF)	Simon Cook, Ignacio Sanz	IWMI Accepted	5 years	82,000,000	3,500,000
The CGIAR CPWF is an ambitious research, extension, and capacity building program that will significantly increase the productivity of water used for agriculture. It is an 18-member consortium composed of five CG/Future Harvest centers, six National Agricultural Research and Extension Systems (NARES), four Agricultural Research Institutes (ARIs), and three international NGOs. The program's aim is to allow more food to be produced, with the same amount of water that is used in agriculture today, as populations expand over the coming 20 years. This is to be done in a way that decreases malnourishment and rural poverty, improves people's health, and maintains environmental sustainability. There are clearly defined roles for each consortium member. CG centers lead thematic groups. The Program consists of 5 themes and at 12 benchmark sites. CIAT has been nominated to lead Theme 2: Multiple Use of Upper Catchments, with Simon Cook of PE-4 nominated coordinator. The objective is to improve sustainable livelihoods for people who live in, and downstream of, upper catchments through significant, unambiguous improvements of water productivity. This will be achieved through comparative research at benchmark sites (e.g., benchmark basins in the Andes, Honduras, and the Mekong) that will identify opportunities and incentives for measurable improvements in use of the water resource and by enabling the learning processes that influence groups of people to adopt them.					
2. Targeting comprehensive rural poverty reduction campaigns for Mesoamerica that integrate agricultural research and technology	Reed Hertford, Simon Cook	World Bank Rejected	1 year	270,000	90,000
This proposal is to develop a "uniform data set" for the Meso-American Region for two points in time (around 1990 and 1999), and to perform analyses of those data from which broadly valid conclusions about the determinants of poverty can be derived that will guide comprehensive regional rural poverty programs. Most importantly, as a result of the project proposed here, it will be possible to include efforts to generate improved pro-poor agricultural technologies in comprehensive rural poverty programs. Too, more comprehensible and useful indicators will be designed and estimated, which should help orient public policy and the analysis of poverty in the region.					
3. From small things big things grow: Reducing the risk of land use change in upland farming systems by calibrating process research with generally available terrain and climatic information	Thomas Oberthür, Simon Cook	IWMI Comprehensive Competitive Research Grant Scheme Pending	1 year	188,600	87,500
This project will enable communities in traditional upland farming systems to cope sustainably with change that is forced upon them by global economic, political, and biophysical drivers. Through an innovative data filtering approach, using widely available digital elevation models (DEMs) to "weld" knowledge of scientific processes with topographic information, research will demonstrate how to identify "hot spots" and low-risk areas in a form that is scientifically consistent, but of immediate meaning to farmers, allowing them to identify trade-offs thereby permitting pro-active responses. The conducted research will enable upland farmers to establish sustainable livelihoods by identifying opportunities to increase water productivity through environmentally sound intensification and extension of current farming systems.					

Continued.

PE-4 Project Proposals 2002 (Continued)

Project Proposal	Person/s responsible	Donor approached	Duration	Total budget required (US$)	Total budget for PE-4 (US$)
4. Maguaré: Empowering Latin American communities to harness fair-trade opportunities through information networking	Thomas Oberthür	European Commission Pending	3 years	4,200,000 EUROS	700,000 EUROS
Maguaré, an ancient instrument, linked remote Indian communities over long distances with its call for “la fiesta de las comunicaciones”. This project will enable Latin American farming communities in fragile hillsides and biodiversity hotspots to fair trade valuable, environmentally acceptable products in local, regional and global markets. It will do this by consolidating a telecentre-based network to link farmer to farmer, farmer to expert, and farmers to local and international buyers. The function of the network will be to define what products can be sold and grown to expand or contract production in line with conditions that are socially, environmentally and economically acceptable. Existing network infrastructure will be used wherever possible to implement a two-tier architecture of broadband satellite and telephone or wireless modem connectivity.					
5. Local knowledge, widespread impact: Enabling farmers in Latin American hillsides to diversify safely into fruits through ecological correlation	Thomas Oberthür, Andy Jarvis, James Cock	BMZ Pending	3 years	1,100,000 EUROS	600,000 EUROS
We aim to accelerate the adoption of fruit trees in hillside farming systems within geographically widespread, but environmentally similar areas, to alleviate poverty through diversification. We will do this by calibrating existing knowledge of fruit tree performance with local ecological knowledge about wild fruit species, fallows, forests, etc. to provide indicators of eco-physiological similarity. The purpose is to develop robust methods of providing relevant yet scientifically sound advice about opportunities and risk of adopting specific fruits in farming systems, thereby matching the diversity of fruit species with the diversity of habitat in Latin American hillsides.					
6. Reducing the risk of land use change in the Mekong uplands by diagnosing agronomic water management hot spots	Thomas Oberthür	IWMI Comprehensive Competitive Research Grant Scheme Pending	2 years	188,600	77,500
The project involves three distinct, but closely related, parts. The first is a global analysis where risk to land use change is assessed using documented research from detailed watershed studies. Having identified processes and systems components of land use change on a broad level, the second part of the project involves the identification of those processes that can be modeled using existing information and analytical techniques. These processes are then spatially and temporally modeled within a GIS to quantify risks to water productivity in large areas that arise from land The project will accelerate the adoption of sustainable intensification by poor farmers in complex tropical uplands environments by reducing the risks to water-increased water productivity associated with new land use practices. The new knowledge will sharpen awareness of the variable performance of land use options, and ultimately farmers will benefit from the more rapid implementation of intensification enabled by greater certainty about their effect.					

Continued.

PE-4 Project Proposals 2002 (Continued)

Project Proposal	Person/s responsible	Donor approached	Duration	Total budget required (US$)	Total budget for PE-4 (US$)
7. Reducing the risk of global climate change on local food production and environmental services by merging farmers' and scientists' insight	Thomas Oberthür, Rainer Wassman (Frauenhofer Institut), Andy Challinor (Reading)	VW Foundation Not yet submitted	2 years	Not defined	Not defined
It is widely accepted that global climate change will significantly change the conditions faced by farmers in most regions of the world. In many places, risks will be exacerbated; in some, they may be reduced. In all cases, farmers must adapt or lose. We propose research that aims first at revealing risks to food production and environmental services due to global climate variation at agronomically relevant geographical scales. Broad-scale predictions of climate change have already been produced for many areas, but these are unlikely to stimulate farmers into making the necessary adjustments because of a lack of detail and lack of communicative ability needed to take practical action. By coupling simulation modeling of climate with participatory resource mapping, this project will help organize the observations farmers already have about the variable risks they face. Through calibration with prior extreme events, a parallel approach may confirm their expectations of future conditions; hence stimulate adaptive change towards a more resilient system. Second, quantified risks will be used to design potential new cropping systems that attempt to accommodate production and environmental services. These suggested scenarios of cropping systems are then evaluated through economic modeling and assessed with local land managers.					
8. Conservation of soil biodiversity in Southern Honduras	Thomas Oberthür, Edmundo Barrios; Natasha Pauli, Arthur Conacher (University of Western Australia)	BP Conservation Fund Pending	1 year Pending	17,000	Not defined
The study will investigate soil macroinvertebrate communities in different land use areas. A wide array of organisms are expected to occur, including earthworms, ants, beetles, termites, centipedes, millipedes, spiders, and isopods. Soil communities are extremely diverse, yet they are poorly understood, and in great need of further study.					
9. Improved mapping and spatial analysis of food security and poverty in Ecuador	Andrew Farrow, Manuel Winograd, Gregoire Leclerc, Steffen Schillinger	CSI/FAO/GRID Accepted	1 year	220,000	33,000
Through the application of innovative spatial analysis, this project will identify the current condition, environmental drivers and sensitivity to external shocks of poverty and food security in Ecuador. Our analysis will complement existing studies and add value to them by focusing on geographical processes and patterns. We will analyze food security and poverty conditions, the driving forces behind these problems, and vulnerability and risk of affected sectors of the population. We will synthesize our results into a model of poverty and food security that can be used to simulate future scenarios. We will share our work through an Internet-based communication strategy that includes dynamic mapping on the web and links to multiple networks of stakeholders interested in food security and poverty problems.					

Continued.

PE-4 Project Proposals 2002 (Continued)

<table>
<tr><th>Project Proposal</th><th>Person/s responsible</th><th>Donor approached</th><th>Duration</th><th>Total budget required (US$)</th><th>Total budget for PE-4 (US$)</th></tr>
<tr><td>10. Hotspots of climatic change in the tropics: Impacts on agricultural systems and poor people in the tropics</td><td>Peter Jones, Phil Thornton (consultants)</td><td>Included in CGIAR Global Challenge Program on Climate Change Proposal Pending</td><td>5 years</td><td>2, 600, 000</td><td>Not defined, but about half</td></tr>
<tr><td colspan="6">The project purpose is to increase food security and decrease poverty among the rural poor in the face of climate change in the coming decades. To achieve this, we will identify areas of the tropics where households are particularly vulnerable and formulate possible adaptations that can help to mitigate or exploit the increased temperatures and changing patterns and variability of rainfall that such households may experience. This analysis will provide information for a wide variety of impact assessments. It will help the IARCs assess how farming systems may change. This will allow more appropriate interventions to be better targeted, help inform policy makers of possible shifts in the patterns of production, and help give indications of where policy and infrastructure adjustments might be needed in the future. It will also assist in redirecting breeding efforts and natural resource management research activities.</td></tr>
<tr><td>11. Farming futures under climate change: Impacts on agro-ecosystems and poor people in the tropics</td><td>Peter Jones, Phil Thornton (consultants)</td><td>Not defined</td><td>3 years</td><td>Not defined</td><td>Not defined</td></tr>
<tr><td colspan="6">The project involves two distinct, but related, parts. The first is a global analysis where system vulnerability to climate change (and human population change) is assessed, using a broad-brush approach. Having identified some hotspots on a broad level, the second part of the project involves the use of existing systems models to assess what impacts climate change may have at the household level, and to investigate management and technology options for coping with them. The output of this project will provide information for a wide variety of impact assessments. Information on likely changes in ecosystems will allow more appropriate interventions to be better targeted, help inform policymakers of possible shifts in the patterns of production, and help give indications of where policy and infrastructural adjustments might be needed in the future. It will also assist in redirecting breeding efforts and research activities in natural resource management.</td></tr>
<tr><td>12. Farming Futures Lite: A tool to target the investment in agricultural research to counter the effects of global climate change</td><td>Peter Jones, Phil Thornton (consultants)</td><td>USAID and IDRC Pending</td><td>18 months</td><td>150,000</td><td>Not defined, but about 100,000</td></tr>
<tr><td colspan="6">The CGIAR system has underway a major system-wide project on climate change and how it affects agriculture in the tropics. Within this project is a multi-million dollar project called Farming Futures to model these effects and feed the information back to CGIAR and national scientists to assist them in formulating research goals and priorities. However, the short-term need is to help in the first stages of this project—to sort out where the first priorities are. This is where the Farming Futures Lite project can help. This will take a restricted range of four to five typical crops and run the same simulations as have been done for a maize example. These would include other cereal, legume, and root crops to get an approximate response to the environmental change we can expect. From that we could construct index maps of where we could expect the major problems, and, from these, target the efforts of a very short-funded CGIAR system to where they could produce the most good.</td></tr>
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Continued.

PE-4 Project Proposals 2002 (Continued)

Project Proposal	Person/s responsible	Donor approached	Duration	Total budget required (US$)	Total budget for PE-4 (US$)
13. Impact of climate change on the centers of diversity of wild relatives of major crops: long-term management of plant genetic resources in Latin America	Peter Jones, Andy Jarvis, Luigi Guarino	Included in CGIAR Global Challenge Program on Climate Change Proposal Pending	Not defined	Not defined	Not defined
The conservation of biodiversity is important in terms of food security and poverty alleviation; and may even be considered a moral obligation. Efficient conservation of germplasm and strategic location of protected areas will allow future generations to benefit from continuing crop improvement. National programs will be strengthened in their capacity to manage their genetic resources, permitting future economic benefits for countries in the developing world and in the inevitable global exchange of genes. The modeling component will provide scenarios for the potential impacts of climate change on plant genetic resources in Latin America. Specific action plans will be identified for their efficient management. Close collaboration with Latin American national programs will be required as they will need to act on the results in the re-location of species to refugia and in *ex situ* conservation of important germplasm. This germplasm may prove important in the generation of improved cultivated varieties that are less susceptible to losses in yield as the climate changes.					
14. Understanding the implications of global climate change for pest and disease management in the tropics	Peter Jones, Phil Thornton	Included in CGIAR Global Challenge Program on Climate Change Proposal Pending	Not defined	Not defined	Not defined
Many insect pests and disease vectors, as well as bacterial and fungal diseases are strongly influenced by climate. This project will use FloraMap to map the environmental range of pests and diseases of CGIAR-mandated crops, and estimate how they will react to GCC. Outputs will include descriptions of GCC on the population dynamics of the effect of pests and diseases, such as cassava green mite, whitefly, anthracnose in common beans, web blight in common beans, and vectors of animal diseases such as tse tse fly in Africa. This analysis will provide information for a wide variety of impact assessments. It will help the IARCs assess how IPM in farming systems may change. This will allow more appropriate interventions to be better targeted.					
15. Dry times: Improving common bean for drought resistance in poverty-endemic tropical environments	Peter Jones, Phil Thornton	Included in CGIAR Global Challenge Program on Climate Change Proposal Pending	4 years	1,500,000	Not defined
The proposal will launch an international effort to improve bean for drought resistance, combining the expertise of scientists on three continents, which has not been attempted before in common bean, and which will encourage exchange of germplasm. For example, varieties developed at medium latitudes in Mexico could be useful at similar latitudes in southern Africa. Red-seeded varieties for Central America would be useful in tropical eastern Africa. The proposal will maintain the advances in disease resistance while recovering drought resistance in bean types that are acceptable to farmers with regards to grain type, plant habit and growth cycle. Molecular markers will be employed in novel breeding schemes to maintain resistance genes in populations and lines, while greater attention will be placed on drought selection by both traditional and molecular techniques. Combining gene tagging with physiology and GIS analysis of drought patterns will permit more precise definition of the genetic basis of physiological traits responsible for drought resistance and the best ways to deploy them.					

Continued.

PE-4 Project Proposals 2002 (Continued)

Project Proposal	Person/s responsible	Donor approached	Duration	Total budget required (US$)	Total budget for PE-4 (US$)
16. Dynamic access to information on population, agriculture, and environment	Glenn Hyman	IDB Pending	1 year	195,027	88,880
The proposed project promotes visualization of population, agriculture, and environmental data and maps using the Internet and registered spatial data clearinghouse nodes for Central American institutions. This portal will help Central American decision makers and others outside of the region become more aware of the value and benefits of a Spatial Data Infrastructure to encourage data sharing and compatibility. At the same time, it will enable dynamic, on-line integration of socioeconomic data with a range of biophysical and political themes, such as administrative boundaries, watershed boundaries, electoral boundaries, climatic zones, and flood zones.					
17. Assessment of development of water system for irrigation in Chile	Jorge Rubiano, Simon Cook	IWMI Comprehensive Competitive Research Grant Scheme Pending	2 year	137,000	35,000
The aim of this project is to document the evolution of water systems, water markets, and their role in alleviating rural poverty in the Limarí Basin, Chile. We will make use of quantitative (spatial regression analysis of socioeconomic and irrigation scheme indicators) and qualitative (historical analysis, surveys, in-depth interviews, policy analysis) methods. Expected results include (1) an inventory of public expenditures in irrigation infrastructure and subsidies; (2) the description and synthesis of the evolution of (a) economically active population; (b) poverty indexes; (c) distribution of water rights, (d) government policies on water resources and agricultural development, and (3) Guidelines and recommendations aimed at policymakers and decision makers for improving public policy on irrigation water systems and rural poverty alleviation. Hence, we will illustrate the general problem of inequitable distribution of irrigation benefits using a well-documented case study.					
18. Automated identification of faunal indicator species of soil fertility using high resolution kite-based aerial photography	Andrew Jarvis	COLCIENCIAS Accepted	1 year	6,000	3,700
This research will allow producers to better manage soil fertility on hillside farms, based on the soil macrofauna. We will develop a solid and transferable methodology that combines high-resolution images with ground truthing for the rapid identification of groups of macrofauna that indicate soil fertility. Our method will minimize the time and resources required for follow up in the field and will permit producers to make opportune and correct decisions about practices in soil fertility management.					